I. SECHENOV

# SELECTED PHYSIOLOGICAL AND PSYCHOLOGICAL WORKS

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# Selected Physiological and Psychological Works

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FOREIGN LANGUAGES PUBLISHING HOUSE
Moscow

Translated from the Russian by S. Belsky
Edited by G. Gibbons

The present book includes Sechenov's physiological and psychological works prepared for print by the Academy of Sciences of the U.S.S.R. and published in the first volume of the two-volume *Selected Works* by I. Sechenov (Moscow, 1952-1956).

The Notes are by S. Gellerstein.

И. СЕЧЕНОВ

ФИЗИОЛОГИЧЕСКИЕ
И ПСИХОЛОГИЧЕСКИЕ ПРОИЗВЕДЕНИЯ

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# I. M. SECHENOV

## (1829-1905)

All major landmarks in the history of world and Russian physiology are closely linked with the name of Ivan Mikhailovich Sechenov. Pavlov, who carried forward Sechenov's scientific work, called him the "father of Russian physiology".

Appraising Sechenov's role in the development of the natural sciences in Russia in the nineteenth century, his friend Kliment Arkadievich Timiryazev, an outstanding biologist and science historian, wrote: "History will recognise that no other Russian scientist has had such a far-reaching and beneficial influence on Russian science and on the development of scientific thought in our society as Sechenov."

Timiryazev's words have been fully justified: Sechenov's name has become immortal in the history of Russian science.

* * *

Sechenov was born on August 1 (13), 1829 in the village of Tyoply Stan (now Sechenovo), Simbirsk Province (now Arzamas Region). He attended the Military Engineering School in Petersburg where he acquired a sound knowledge of physics and mathematics. Concerning this period of his life Sechenov wrote in his *Autobiographical Notes:*

"...I had a distaste for engineering with its accessories, all kinds of drawing; physics was my favourite subject in the senior grade. My progress in it can be seen from the fact that I was chosen by my physics teacher to be questioned at the final public examination in the presence of Gerua, Chief of the Military Engineers, and other generals. My teacher had just obtained from Germany an electromagnetic machine made by Stehrer and taught me at his home how to operate it. I demonstrated the working of this machine at the examination.... In the junior officer class I conceived a liking for chemistry which was lectured by Ilyenkov (we studied only inorganic chemistry). I remember my examination in this subject as well. I was good at mathematics, and had I entered the Faculty of Physics and Mathematics at the University immediately after leaving the Military Engineering School, I think that I might have become a rather good physicist; however, as we shall see, my destiny proved to be quite different."

The upsurge of social life in Russia towards the middle of the nineteenth century and the tremendous tasks confronting the advanced Russian youth of that time prevented Sechenov from contenting himself with the career of a sapper officer which awaited him after finishing the military school. He decided to enter the Medical Faculty of the Moscow University which greatly attracted progressive young people, since, on the one hand, the profession of physician provided the best opportunities for serving the country, and, on the other hand, the Medical Faculty provided an all-round natural-scientific education and good knowledge of nature, including the nature of man in all its manifestations.

The knowledge of mathematics, physics and chemistry acquired at the Military Engineering School was of great help to Sechenov in his future scientific work. When investigating the organism's intricate vital activity, he always made use of physical and chemical laws.

Among his teachers at the Medical Faculty were outstanding natural scientists and clinicians. One of them was Professor Rulye, biologist and materialist who already in the pre-Darwin period had advocated the idea of the evolutionary development of organisms conditioned by their environment. Sechenov studied the fundamentals of experimental and theoretical physiology under Glebov and Orlovsky, outstanding physiologists of the Moscow University; his first published work was the result of his studies in the clinic headed by the well-known therapeutist Inozemtsev.

Not only the Medical Faculty with its best professors, but the University of the fifties as a whole with its turbulent activity, the lectures by Granovsky so eagerly attended by Sechenov, and the ideological atmosphere created by the brilliant theoretical works of Herzen—this was the school which shaped the outlook of the young physician and physiologist. Upon graduating from the University Sechenov was sent abroad where he spent three-and-a-half years acquainting himself with the great naturalists of the nineteenth century. He worked in the laboratories headed by Du Bois-Reymond, Ludwig and Helmholtz, attended J. Müller's lectures on comparative anatomy and physiology, studied physiological chemistry in Hoppe-Seyler's laboratory and problems of physics in the laboratories of Bunsen and Magnus. During his second sojourn abroad he worked in the laboratory of the renowned French physiologist Claude Bernard.

Already during his first stay abroad the young Sechenov won the respect of his teachers—venerable physiologists—for his initiative and for his ability independently to pose scientific problems and to solve them by way of experimentation.

The period of his preparation for independent scientific activity coincided with a number of highly important events in the development of natural science. The achievements of synthetic organic chemistry, and, above all, the discoveries made by the Russian chemists Zinin and Butlerov, revolutionised physiological thought—they upset the theories about all kinds of "special forces" in organic nature and made it possible to ascertain and master the synthesis of the very substratum of life—organic substances. Ideas testifying to the unity of all chemical processes on earth began to spread all over Europe. Two basic natural laws—the laws of conservation of matter and energy—became the credo of all progressive scientists in the fifties of the last century. Sechenov's stay abroad also coincided with two notable dates in biology—the year 1858, when Charles Darwin read his first paper at a meeting of the Linnaeus Society, and the year 1859 when Darwin's immortal *Origin of Species* first appeared. These highly important events in the history of science greatly influenced the entire development of physiology.

Sechenov's independent research developed under the influence of the philosophical and social ideas advocated in Russia by Herzen, Chernyshevsky and their adherents. In the struggle waged by these men for progressive philosophical and social ideas the development of natural science occupied a prominent place.

Sechenov was one of the first of the physiologists who sided with this great movement in Russian social thought; throughout his scientific life he waged an uncompromising struggle against those who tried to restrict the possibilities of objective physiological study of the complex manifestations in the vital activity of animals and man, including the so-called mental or psychical activity.

Most of the outstanding European physiologists, Sechenov's contemporaries, whose experimental researches paved the way for disclosing the nature of blood circulation, digestion, metabolism, respiration and other processes, were quite helpless when it came to the so-called psychical activity; in their view this activity could not be studied by physiological methods. Sechenov, however, asserted that this form of vital activity was, likewise, subordinated to physiological laws and should be subject to objective experimental analysis.

This conviction logically resulted from his consistent materialistic outlook. Already in his doctor's thesis *Data for the Future Physiology of Alcoholic Intoxication*, which was published in 1860, Sechenov, along with conclusions drawn from his experimental research, set forth a number of philosophical propositions; in particular, he advanced the idea of the material unity of the world, unity of the forces operating in organic and inorganic nature, unity of the organism and of the conditions of its existence, finally, he expressed the idea of the possibility of unravelling the great mystery of consciousness by means of the objective methods of natural science.

Waging a bitter struggle against philosophers and naturalists of the idealist camp, Sechenov already in 1861 formulated the postulate which in those days was of revolutionary significance and which still retains its validity: "The organism cannot exist without its supporting external environment; hence, a scientific definition of the organism should include also the environment which influences it."*

* *Meditsinsky Vestnik (Medical Herald)*, No 26, 1861, p. 242. Two concluding lectures on "The Role of the Vegetative Acts in Animal Life." Lecture one.

In the course of more than forty years of scientific work Sechenov developed and substantiated this important theoretical postulate in numerous researches devoted to the fundamental problem of the correlation between physiology and psychology and to the origin and development of the functions of the nervous system. This postulate governed his experimental investigations in physiology. In all his experiments he proceeded from the idea of the decisive importance of perception of external stimulations by definite sensory elements for the reflex activity of the central nervous system. Sechenov's work in the sphere of the physiology of the higher nervous activity which derives from his fundamental definition of the significance of the unity and interaction of organisms and their environment, was crowned by the major discoveries and generalisations made by his pupil and follower, I. P. Pavlov.

Sechenov's first theoretical research, where he urged the necessity of applying the method of strictly scientific, objective analysis to complex processes designated as psychical, was his treatise "Reflexes of the Brain", which is rightfully considered the pride of Russian physiology.

This work was sent to the magazine *Sovremennik*, organ of the revolutionary democrats and edited at the time by the famous poet Nekrasov. The original title of the article "An Attempt Physiologically to Explain the Origin of Psychical Phenomena", failed, as was to be expected, to pass the censor, so Sechenov changed it to "An Attempt to Establish the Physiological Basis of Psychical Processes". The two titles clearly revealed the profound concepts of the scientist which conflicted with the prevailing outlook. The censor regarded the title, to say nothing of the content of the article, as a manifestation of extreme materialism and decided that it could not be published in the *Sovremennik*; they permitted its publication only in a special magazine and under a different title. The treatise appeared in 1863 in the weekly *Meditsinsky Vestnik* under the title "Reflexes of the Brain".

Sechenov remained true to himself: he could not accept a dictated title; nor the cutting by the censor of the last two paragraphs. In the copy which he presented to his wife he erased in thick black ink the title "Reflexes of the Brain" and replaced it by the original "An Attempt to Establish the Physiological Basis of Psychical Processes" and inserted the paragraphs killed by the censor.

In "Reflexes of the Brain" Sechenov developed the thesis that from the point of view of their origin, all acts of conscious and unconscious life are reflexes.

He advanced the idea—quite novel for those days—that the entire psychical life with all its motor manifestations is stimulated and maintained by environmental influences which are perceived by the nervous system. He brilliantly substantiated his conclusion that psychical life is inconceivable without stimulation of the sense organs. The propositions that the initial cause of any human action lies *outside man*, and that without external sensory stimuli psychical activity is impossible even for a single moment, were set forth by Sechenov most convincingly.

Proceeding from his fundamental postulate concerning the influence exerted by the environment on psychical activity Sechenov drew far-reaching conclusions which sharply contradicted the contemporary social and pedagogical views. Nor did he stop at the conclusion, which for those days was revolutionary, that all men are equal, that the most backward nationalities can be raised to a high cultural level by means of education and instruction.

Painstakingly elaborating the problems raised in his "Reflexes of the Brain" Sechenov, naturally, arrived at a number of conclusions directly related to the sphere of psychology and introduced into that sphere the method of the physiological analysis on an ever wider scale.

His views, which took final shape within a period of ten years after the publication of his "Reflexes", were expressed in the course of the controversy known in the annals of Russian culture as the dispute between Sechenov and Kavelin. Kavelin's book *The Tasks of Psychology*, which appeared in 1871, was actually directed against the psychological principles expounded in *Reflexes of the Brain*.

In an article devoted to this book Sechenov, with all his customary straightforwardness and bluntness, subjected Kavelin's idealist views to trenchant criticism. Later, he wrote the article "Who Is to Elaborate the Problems of Psychology, and How?" which caused a sensation.

In this article Sechenov sharply criticised the assertions of *most of the idealist psychologists that man as a corporeal being* is subordinated to the laws of the material world, while as a spiritual being he is independent of them. He again stressed the importance of objective, natural-scientific, physiological study of the complex psychical phenomena, and the possibility of an analytical study of "all the main aspects of the various forms of psychical activity".

The same article contained a masterly outline of a plan for radically revising contemporary psychology with the aim of freeing it from the conglomeration of insufficiently substantiated theories and metaphysical concepts, and of bringing it into the highway of "positive science". Sechenov wrote: "*Only physiology can achieve this, because it alone holds the key to the truly scientific analysis of psychical phenomena.*"*

In his controversy with Kavelin, Sechenov maintained that the conclusions revealed in the *Reflexes of the Brain* were correct, and advanced a number of new propositions of great significance for the scientific analysis of psychical phenomena. According to Sechenov, "*by its very subject-matter scientific psychology cannot be anything but a series of theories concerning the origin of the various forms of psychical activity*".**

The idea that the principal forms of psychical activity can *be regarded as reflex processes had already been expressed in Reflexes of the Brain*; in his new work he set himself the task of examining the *history* of psychical processes both in the individual evolution of man and in the evolution of the animal world as a whole. He attached particular importance to the study of the laws governing the formation of psychical activity in the course of man's individual development. He stated: "I shall examine the history of the psychical development of man (individual, of course) from birth and try to establish the main

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* See page 198 of the present edition. Underlined by Sechenov.

** See page 211 of the present edition.

phases of this development at different periods, showing that each consecutive phase derives from the preceding one."*

Outlining the prospects of further research into the qualitative distinctions between the psychical processes in man and animals Sechenov, proceeding from the history of physiology, showed that acknowledgement of qualitative distinctions, recognition of complex phenomena not yet decomposed into their component elements, in no way signifies acknowledgement of the existence of any special forces. Being a consistent materialist Sechenov left it to the metaphysicians and vitalists to seek explanation in special vital forces; for him any phenomenon developing in the human organism, no matter how complex, could not be divorced from the material processes and should be decomposed into its elements. For the purpose of this decomposition he considered it important to apply the method of comparative study of psychical manifestations in animals. Since the material accumulated by this branch of knowledge at that time was limited, Sechenov merely sketched a programme of research in this direction; he stated that real work on this problem had just begun, adding that this comparative study would be of special importance for the classification of psychical phenomena, as, in his opinion, it would in all probability reduce many complex forms of these phenomena to less numerous and simpler types and, besides, would establish the transitional stages from one form to another.

Sechenov, however, did not overestimate the importance of the comparative method for the investigation of the nature of psychical phenomena in man. As a naturalist and thinker, he constantly had in mind all the aspects of a complex phenomenon and directed attention to the cardinal problem of the essence of human psychical phenomena, namely, the subjective aspect, the so-called conscious element. His statements concerning the qualitative distinctions between the psychical manifestations in animals and man help to formulate the tasks of scientific research.

"But with what are we to compare human psychical phenomena?" he wrote. "To compare them with higher, more complex

* See page 213 of the present edition.

phenomena is impossible; just below them lies the psychical life of animals which cannot be analysed, and still lower begins the sphere of matter. Should we compare psychical life with the life of rocks, plants and even of the human body?"* In posing this profound question, Sechenov advanced the following important proposition: "*Physiology provides a number of facts which establish the affinity of psychical phenomena to the so-called nervous processes in the body, i.e., to purely somatic acts.*"**

The key to comprehension of the essence and significance of this proposition is contained in his formulation of the concept of a nervous process. He regarded a nervous *process* as "a partial molecular process taking place in the nerves and nervous centres and inaccessible to our senses",*** whereas by the term nervous *phenomena* he designated the external manifestations of the nervous activity.

"Unfortunately," he pointed out, "our knowledge of the nervous processes, even in the case of the most elementary reflexes, is negligible. All we know is the material form in which the particular phenomenon develops, some of the conditions of its normal variability, we can artificially reproduce a phenomenon possessing certain characteristics, and we know the role played by some of the parts in the phenomenon as a whole, etc. But the nature of the processes taking place in the nerve and nervous centres is still a mystery. Elaboration or at least elucidation of this aspect of the nervous and psychical phenomena belong to the distant future; we are compelled at the moment to confine our research to external manifestations. Nevertheless, *the concept of a psychical act as a process or motion having a definite beginning, course and end, must be retained as fundamental....*"****

Sechenov emphasised the significance of Darwin's teaching for the materialist interpretation of psychical phenomena, pointing out that it leads logically to the necessity of acknowledging the evolution of psychical activity in principle. Proceeding from his evolutionary concept that development of the functions of

* See page 184 of the present edition.

** See page 185 of the present edition. Underlined by Sechenov.

*** See page 206 of the present edition.

**** See page 206 of the present edition. Underlined by Sechenov.

the nervous system is interconnected with the development of psychical activity, he stated that all aspects of organic life, including the psychical activity of animals and man, derive from the transformation and development of *corresponding substrata*. Since the feature of Sechenov's viewpoint was his daring attempt to link the processes of consciousness with the basic processes (with their development and course) in the nerves and nervous centres, his evolutionary concept raised the question of an historical connection and succession of the basic nervous processes and the processes of consciousness.

Sechenov's writings substantiated the conclusion reached by Engels that Darwin's teaching makes it possible to establish the pre-history of human spiritual activity at different stages of its development—from the elementary forms of irritability of the structureless, but sensing protoplasm of lower organisms up to the thinking brain of man.

Sechenov decided to issue his articles "Who Is to Elaborate the Problems of Psychology, and How?", "Observations on Mr. Kavelin's book *The Tasks of Psychology*", and his treatise "Reflexes of the Brain" in book form under the title *Psychological Studies*. The book appeared in 1873. A French edition came out in Paris in 1884.

The book added to the ferment created by the controversy between Kavelin and Sechenov. Since the very title of Sechenov's book (to say nothing of the contents!) was "an encroachment" on the holy of holies of his opponents—psychology—the attacks on him were numerous. The idealist metaphysicians could not understand how a physiologist, who admitted that his knowledge of various psychological theories was limited, could dare to try and refute these theories and evolve a new psychology based on purely physiological experimental methods.

N. N. Strakhov, an anti-Darwinist and one of the pillars of metaphysics, sharply criticised *Psychological Studies* in a review in the reactionary magazine *Grazhdanin* (*Citizen*). Opposing Sechenov on all of his principal points, Strakhov formulated his own view thus: "The point is that of the *duality* of our world, of a *cardinal difference* between physical and psychical phenomena."

Strakhov did not confine himself to criticising Sechenov's book; he returned to the attack in a special work of his own *Fundamental Concepts of Psychology*, published in 1878. It was diametrically opposed to Sechenov's book. This was understandable, since Strakhov, being an idealist and anti-Darwinist, proceeded from the principles which were the reverse of those advocated by Sechenov. For Strakhov man was the centre of the world, whereas for Sechenov man was a link in the development of nature. *According to Strakhov, the "spirit" exists independently* of the body—the two elements being subordinated to different laws; according to Sechenov, unity of "spirit" and body is the principal factor. That which is called spiritual activity was for Sechenov the property of matter at a definite stage of development of organic nature.

Sechenov's struggle for a genuine materialist elaboration of the problems of psychology, so strikingly reflected in his controversy with Kavelin, met with a wide response all over Russia in the seventies and eighties of the last century. This found its reflection in the memoirs, diaries and letters of his contemporaries, and even in the literature of the day. As the famous satirist Saltykov-Shchedrin figuratively expressed it, Sechenov's voice in the controversy was that of a deep bass, Kavelin's that of a gentle tenor.

*The question of the importance of human practical activity in the process of knowledge, a question which was alien to idealist psychology, arose before Sechenov, who reconstructed psychology on a materialist basis.*

In his article "Impressions and Reality" he referred to the viewpoint which claimed that "we receive via our sense organs only a series of conventional signals from the objects of the external world". In this connection Sechenov posed the following question: "How is it possible to reconcile this apparently conventional cognition of the external world with the achievements of natural science, thanks to which man is acquiring more and more power over the forces of nature? How is it that natural science, which deals only with conventional sensory signals emanating from inaccessible reality, *creates an increasingly harmonious system of knowledge*, knowledge which is most effective, being constantly justified by its brilliant application—by its success in the sphere of technology?"*

Sechenov reached the height of theoretical generalisation in his treatise "The Elements of Thought", which contains an historical analysis of the formation of complex psychical phenomena beginning with the most elementary manifestations of irritability and sensation. He skilfully analysed the laws governing the formation of abstract notions of objects of the external world on the basis of man's perceptions, on the basis of the signalling activity of a number of sense organs; in other words, he was the first in the history of science to advance the idea of the formation of so-called abstract thought in the course of man's development, in the process of his interaction with objects of the external world. In this work he again reverted to the problem—which he had posed previously—of the unity and interaction of organisms and the conditions of existence, the latter being regarded by him as a decisive factor in the evolution of the structure and functioning of the nervous system.

In "The Elements of Thought" he formulated in an absolutely new way a number of important generalisations concerning the role of the so-called "muscular sense" in the physiological analysis of perception of time and space. The writing of "The Elements of Thought" was an extremely arduous task. On February 27, 1878 he wrote to I. Mechnikov: "At last, I have finished 'The Elements of Thought'. This long-drawn-out work called for such a tremendous effort that it is doubtful if I shall ever tackle a job like it again. Personally, I think that it will greatly facilitate the study of logic; if so, I should consider it a great merit from the practical point of view. Besides, it contains some points which have matured deep within me (for instance, the ideas concerning the role of muscular sense in the analysis and measurement of space and time). But people are often poor judges of their own work."**

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* See page 423 of the present edition.

** *The Struggle for Science in Tsarist Russia.* A Collection of unpublished letters by I. Sechenov, I. Mechnikov, L. Tsenkovsky, V. Kovalevsky, S. Vinogradsky, M. Kovalevsky and others. P. 96. State Publishing House of Socio-Economic Literature, 1931.

Later he revised and considerably supplemented the work which appeared in book form in 1903.

Sechenov devoted more than thirty years to a profound study of psychical phenomena. K. Timiryazev, in an appraisal of the fundamental achievements of world natural science in the nineteenth century, emphasised the outstanding contribution made by Sechenov. According to Timiryazev, Sechenov was one of the most profound researchers in the sphere of scientific psychology, a researcher "who did not falter at its most complex problems and who undertook their solution with ... the caution of the scientist and the insight of the thinker...."

In his old age, at the end of the nineteenth century, Sechenov conceived a grandiose plan for further researches which opened up broad vistas for materialist elaboration of psychology. The ideas contained in his lectures, and later in his book *An Essay on the Working Movements of Man*, are of great importance for an exhaustive comprehension of his views on psychology.

To analyse from the physiological aspect the various forms of the influence exerted by man on the objects of the external world and thus draw new conclusions concerning the formation of human thought in the process of labour—such was the task which Sechenov set himself. Unfortunately, this research was interrupted at its very outset. It was Sechenov's swan song.

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With the publication of the second edition of *The Elements of Thought* in 1903, Sechenov no longer reverted to the problems of objective, natural-scientific study of psychical processes so thoroughly analysed by him. In that year at the International Medical Congress in Madrid Ivan Pavlov read his first paper on conditioned reflexes.

Following the trail blazed by Sechenov, Pavlov staunchly and consistently advocated the objective study of the higher nervous activity. Sechenov's ideas, statements, and brilliant conjectures were thoroughly substantiated by Pavlov and corroborated by a multitude of incontestable facts. He not only developed Sechenov's theory, he inaugurated the Pavlovian trend in physiology and medicine, and elaborated classical methods by means of which the objective study of the physiology of the brain could be accomplished.

And so Sechenov's dream, expressed as early as 1863 in his *Reflexes of the Brain*, came true; addressing his readers Sechenov wrote: "In view of this, the reader will agree that the time will come when men will be able to analyse the external manifestations of the functioning of the brain as easily as the physicist analyses now a musical chord or the phenomena of a freely falling body."*

Pavlov repeatedly stressed the significance of Sechenov's work in developing research in the sphere of the physiology of the higher nervous activity. In the introductory chapter of his classical *Twenty Years of Objective Study of the Higher Nervous Activity (Behaviour) of Animals* he wrote tracing the history of the problem under his elaboration: "... the chief impetus to my decision (although I was not conscious of it at the time) came from the brilliant pamphlet by Ivan Mikhailovich Sechenov, the founder of Russian physiology. It was entitled *Reflexes of the Brain* (1863) and influenced me as a youth.... This pamphlet was an attempt, brilliant and truly extraordinary for the time (though, of course, only a theoretical one in the form of a physiological outline) to picture our subjective world in a purely physiological aspect."**

It is not merely the identity of scientific problems tackled which brings Pavlov close to Sechenov, but chiefly the militant spirit of his research in the sphere of the physiology of the higher nervous activity. Like Sechenov, Pavlov used all his knowledge and all the facts obtained in his struggle for a truly scientific solution of the age-old problem concerning the correlation between the physiological and the psychical, against all the idealist distortions in this important branch of science. Like Sechenov, Pavlov foresaw the future of science and was firmly convinced that a solution of this problem based on materialistic monism would be found. Almost a quarter of a century has passed since Pavlov's last paper on achievements in the sphere of the physiology of the higher nervous activity was read at

* See page 34 of the present edition.

** I P Pavlov, Complete Works, Vol. III, Book 1, p 14, 1951.

the International Congress of Physiologists in Rome, at which I and other Soviet scientists had the good fortune to be present. I vividly recall the fervour with which Pavlov read his paper that contained a number of profound ideas, basically akin to those to which Sechenov had devoted his thoughts and aspirations. "I am convinced," said Pavlov, "that an important stage in the development of human thought is approaching, a stage when the physiological and the psychological, the objective and *the subjective, will really merge, when the painful contradiction* between our mind and our body and their contraposition will *actually* be solved and disappear in a natural way."*

Appraising Sechenov's classical work in the field of physiology of the central nervous system Pavlov wrote: "Mere impartiality impels us to acknowledge the fact that it was Ivan Mikhailovich who laid the real foundations of the teaching concerning *the mechanism of the central nervous system....*"**

One of the most important of Sechenov's achievements in this field was his discovery of the phenomena of central inhibition. His fundamental conclusion was that in the central nervous system there are special apparatuses the stimulation of which leads to suppression of spinal reflexes. Thus, Sechenov's theory of central inhibition came to life, and his concept of in*hibition took its place in physiology.*

Sechenov not only established the fact that in the brain of the frog there is a special region the stimulation of which evokes a pronounced suppression of spinal reflexes; he also found that a combined stimulation of sensory nerves from various areas can lead to suppression of the reflexes of the spinal cord in a reflex way.

*Sechenov's discovery of special inhibitory effects of the* central nervous system on the reflex acts accomplished by the lower parts of the nervous system greatly influenced the development of the physiology of the nervous system, an influence that is felt to this day. Basing themselves on Sechenov's works, N. Bubnov, R. Heidenhain and N. Wedensky carried out their

* I. P. Pavlov, *Selected Works*, p. 256. State Publishing House of Political Literature, 1951.

** I. P. Pavlov, *Complete Works*, Vol. VI, p. 266, 1951.

classical investigations in the eighties of the last century and showed the great importance of the inhibitory effects of the brain in the complex acts of co-ordination of movements.

Sechenov's ideas and his discoveries in the physiology of inhibition of the nervous system became the starting-point for the important generalisations of the Petersburg (Leningrad) school of physiology concerning the nature of the inhibitory process as a form and stage of the process of excitation.

Pavlov highly appraised Sechenov's deductions and data relating to the physiology of central inhibition; he regarded Sechenov's treatise and the facts described therein as the first triumph of Russian physiological thought, as the first independent and original work which directly introduced important new material into physiology.

In the process of the further elaboration of Sechenov's work physiology has been enriched with important generalisations in the sphere of the physiology of the nervous system such as Pavlov's theory of external and internal inhibition in the activity of the cerebral cortex, Wedensky's theory of excitation and inhibition as stages of a single excitatory process, the theory of protective inhibition which is of great scientific and practical significance, etc.

Sechenov's "Electrical and Chemical Stimulation of Sensory Spinal Nerves in the Frog", appeared in 1868. In this work Sechenov for the first time in the history of physiology proved that the nerve centres can "summarise sensory stimulations, which are ineffective when applied singly (induction shocks applied to the sciatic nerve), converting them into an impulse producing locomotion provided the stimulations follow one another at a sufficiently high frequency".*

Naturally, the establishment of this important phenomenon entailed a number of new tasks which had not confronted the physiology of the nervous system prior to Sechenov's discovery of the phenomena of summation. In one of his letters concerning this discovery Sechenov wrote: "I am simply dizzy with the mass of accumulating facts which await solution."

* I. M. Sechenov, Selected Works, p. 161. Published by the All-Union Institute of Experimental Medicine, 1935, Russ. ed.

It was at this time that A.I. Tyshetsky, basing himself on Sechenov's discovery of the ability of the nervous system to summarise subthreshold stimulations, began, on Sechenov's advice, to analyse the problem of electrical excitability of the frog's brain, a problem which had had a long history.

Working in Sechenov's laboratory, Tyshetsky for the first time in the history of physiology proved that the cerebral hemispheres of amphibians are susceptible to stimulation and that electrical stimulation of the cerebral hemispheres evokes a motor reaction provided Sechenov's rule of summation of stimulations is observed.

Sechenov's discovery of summation assumed universal significance when a number of researchers demonstrated the frequency and functional role of these phenomena in the nervous system both of vertebrates and invertebrates.

Appraising Sechenov's discovery Pavlov wrote:

"This discovery of Ivan Mikhailovich is a fact of paramount importance in the theory of the central nervous system. The faculty of the central nervous system slowly to come into motion and as slowly to calm down underlies the entire development of nervous activity as revealed in the psychical manifestations of the human brain."*

In 1881, Sechenov published his classical work on so-called galvanic phenomena in the central nervous system of the frog. Using the relatively simple methods of electro-physiological analysis, Sechenov, with his keen eye of experimenter and theorist, was able to detect the so-called rhythmic bioelectrical phenomena in the central nervous system. The string galvanometer, and subsequently amplifying devices and modern oscillographs, enabled later physiologists to describe bioelectrical phenomena in different parts of the central nervous system with the utmost precision, which at present is not only of theoretical but also of practical, clinical importance.

Sechenov's views on the nature and role of rhythmic bioelectrical phenomena in the central nervous system have acquired a special significance in our days. Proceeding from the theoretical proposition that there is a close interaction between

* I. P. Pavlov, *Complete Works*, Vol. VI, p. 266.

organisms and the environmental conditions, and regarding causality as the guiding principle for any naturalist, Sechenov endeavoured to establish the causes which stimulate and maintain rhythmic bioelectrical phenomena.

His views on the nature of the so-called spontaneous or automatic rhythmic activity are of particular importance in our days since more and more often there appear physiological researches and theoretical generalisations claiming the existence of a specific form of vital activity of organisms, supposedly inborn and independent of any environmental influences and opposed to reflex activity. Many of these researches relate to comparative physiology of the nervous activity, the general conclusion being that at early stages of phylogenetic development this form of non-reflex activity allegedly played an independent role. It is in this branch of physiology that the attacks against the reflex theory of vital activity of animal organisms, i.e., against the materialist physiology of Sechenov and Pavlov, are of a particularly violent nature.

Characteristic of Sechenov as a physiologist and experimenter was his desire to link the results of his investigations on animals with problems relating to the physiology and pathology of the human organism. More than any other researchers, he constantly emphasised that scientific data obtained from experimentation on animals should not be transferred to man uncritically. Experimenting on himself he tried to verify the results which he had obtained on frogs when studying the inhibitory influence of the brain on the reflexes of the spinal cord. It is impossible to read without emotion the letters which he wrote to the famous Russian artist Alexander Ivanov then living in Rome describing his life in Leipzig where after experimentation on animals he tried to study on himself the effects of acute alcoholic intoxication. He described, in particular, the strict diet which he had prescribed for himself with the aim of investigating metabolic changes in the human organism under the influence of large doses of alcohol and unvaried diet.

His desire to bring together physiology and medicine was strikingly revealed in his classical works devoted to the absorption of gases by salt solutions. These researches carried out over a period of more than thirty years not only opened a new chapter in the history of physiological chemistry, but made possible precise analysis of gas metabolism in the human and animal organisms under different conditions. Sechenov used all his theoretical knowledge and all his experimental skill to analyse—at the dawn of modern aeronautics—the effects of altitude on respiration and the reasons why aeronauts die in open balloon-cars.

At the Sixth Congress of Naturalists and Physicians held in 1879 after reading his paper that dealt with respiration in conditions of rarefied air and contained an analysis of the causes which led to the death of French aeronauts in the open car of the balloon "Zenith", he was given an ovation by the audience. Commenting on the scene, the magazine *Vrach* (*Physician*) wrote: "There is no need to add that by their ovation the members of the section expressed their deep respect for the author of the paper, the respect which he has long commanded among Russian physicians as a scientist and public man whose word and deed are never at variance."

During half a century Sechenov successfully combined research with teaching. He lectured at the Military Medical Academy, and later at the Petersburg, Moscow and Novorossiisk (Odessa) universities. In these establishments Sechenov not only conducted his experimental and theoretical investigations, making an invaluable contribution to Russian and world science and culture, he also trained a galaxy of scientists—physiologists and physicians. Among his pupils were: N. Wedensky, B. Verigo, N. Kravkov, V. Pashutin, M. Shaternikov and many other outstanding scientists. His pupils, in turn, taught a new generation of scientists many of whom are now well-known Soviet physiologists.

Throughout his life Sechenov ardently popularised the achievements of science among the public; this, in his opinion, was the sacred duty of the scientist. He devoted the last year of his life exclusively to the noble work of popular enlightenment. In 1903, at the age of 74, now a renowned scientist, the founder of Russian physiology, he lectured on human anatomy and physiology at the Prechistenka classes for workers. In his *Autobiographical Notes* he recalls this period with feelings of great affection for his audience which consisted of Moscow factory workers.

However, the last thing the tsarist government wanted was close contact between a materialistically-minded scientist and an audience of workers. The Director of Elementary Schools refused to confirm Sechenov as a teacher at the Prechistenka classes.

Thanks to the researches of outstanding physiologists in the second half of the nineteenth century, including the highly important contribution of Sechenov and his school, the physiology of the nervous system made such headway that at the beginning of the twentieth century the question of establishing special scientific institutes in a number of countries arose. In 1904 the International Association of Academies was discussing the question of opening special scientific centres for the study of problems relating to the morphology and physiology of the central nervous system. The matter was raised in the Russian Academy by Academician F. Ovsyannikov.

However, in the conditions of tsarist Russia the opening of a centre of this kind was impossible—the state allocations for science were too miserly; besides, it was hopeless to expect an allocation for a scientific centre which would busy itself with problems connected with the materialist analysis of the functioning of the brain, as clearly intimated by the works of Sechenov and Pavlov.

It was only after the Great October Socialist Revolution that all branches of science, including physiology, were given free rein for development. It can be said that special attention was paid to physiology, and this was because physiology in Russia was headed by Pavlov, the continuer of Sechenov's work, whose researches were considered by V.I. Lenin as being "of enormous significance for the working people of the world".

* * *

Sechenov died on November 2 (15), 1905. He caught a chill on a wet and cold autumn day and was laid low with pneumonia. The illness undermined his strength. Three hours before his death he said to the nurse at his bedside: "I know I am dying." Shortly afterwards he lapsed into unconsciousness and never recovered.

His remarkable heart ceased to beat; the brain which had penetrated into the innermost secrets of nature no longer functioned.

Right up to the day of his death Sechenov devoted himself to creative work for the good of the people. "We must work, work and work"—these words were said by Sechenov to Timiryazev at the last meeting of the two great scientists, two weeks before Sechenov's death and on the eve of the great events of 1905. "Those were the last words I heard from him," wrote Timiryazev, "the behest of a mighty generation upon leaving the stage to the generations to come."

*K. Koshtoyants*

I. SECHENOV

# SELECTED PHYSIOLOGICAL AND PSYCHOLOGICAL WORKS

## REFLEXES OF THE BRAIN[1]

§ 1. *I take it that my readers have had a chance to be present* at debates concerning the substance of the spirit and its dependence on the body. As a rule the debaters are a young man and an old man, if they are both naturalists, or two young men, if one of them is more preoccupied with problems of matter and the other with problems of the spirit. The argument becomes really heated when the debaters are to some degree dilettantes on the subject. In this case one is usually an expert at generalising about things which are not susceptible of generalisation at all (this being a feature of the dilettante), and the audience is treated to a performance which resembles carnival fireworks on the Petersburg Islands. Bombastic phrases, broad views and bright ideas crackle and cascade like rockets. During the debate some people in the audience—young and timid enthusiasts—feel a *cold shiver* now and then pass down their spines, some sit with bated breath, while others are covered with sweat. But at last the performance comes to an end. *Columns of fire go up into the air, burst with a sparkle and* die out, leaving in the mind only dim memories of lucid phantoms. Such is the usual fate of all private debates between *dilettantes. They stir the imagination of the listeners for a time,* but fail to convince. We get a different picture, however, when the taste for dialectical gymnastics spreads in society. In this *case the debater with a reputation of a kind easily becomes an* idol. His opinions become dogmas and imperceptibly creep into literature. Anyone who has followed the intellectual development in Russia during the last decade *has undoubtedly witnessed* such spectacles and has observed that our society is extremely fickle in these matters.

There are those who utterly dislike this trait of our society. They usually regard the fluctuations in public opinion as a chaotic fermentation of unsettled thought; they fear the uncertainty likely to accrue from the ferment; finally, in their view, the pursuit of apparitions merely distracts society from business at hand. These gentlemen are, of course, right in their way. Undoubtedly, it would be much better if society, always modest, quiet and respectable, moved directly towards attainable and useful goals without deviating from the straight path. Unfortunately, in life, as in science, almost any goal is attained by devious paths; the straight road to the goal becomes clear only when the goal has been achieved. Besides, these gentlemen forget that there have been cases when unrestrained fermentation of minds eventually led to the emergence of truths. They should recall, for example, what mankind gained from the mediaeval thought which gave rise to alchemy. It is terrible to think what would have become of mankind if the rigid mediaeval guardians of public opinion had succeeded in burning and drowning as sorcerers and evildoers all those who worked hard at imageless ideas and who were unconsciously creating chemistry and medicine. People who value truth in general, i.e., not only present, but future truth, will never ridicule any popular idea, no matter how strange this idea may seem to them.

It is with such selfless seekers of future truth in mind that I venture to communicate to society some of my ideas concerning the psychical activity of the brain, ideas which have never been expounded in the physiological literature on this subject.[2]

The matter stands thus. Human psychical activity, as we know, finds expression in external manifestations; as a rule everyone —layman and scientist, the naturalist and people studying the problems of the spirit—judge psychical activity by these external manifestations. But so far the laws governing external manifestations of psychical activity have not been thoroughly elaborated even by physiologists on whom, as we shall see later, this duty devolves. And it is these laws that I wish to discuss.

Let us, then, enter the world of phenomena engendered by the functioning of the brain. It is generally said that this world embraces the entire psychical life; few people can be found now who would not accept this idea with greater or lesser reservations. The difference in the views of the various schools consists merely in the fact that some regard the brain as the organ of the spirit, thus divorcing the latter from the former, while others declare that the spirit is the product of the functioning of the brain. Not being philosophers, we shall not discuss these differences here. We, physiologists, are satisfied that the brain is an organ of the spirit, i.e., a mechanism which, if brought into action by a certain cause, ultimately produces a series of external phenomena which are expressions of psychical activity. Everyone knows how vast the world of these phenomena is. It includes the infinite diversity of movements and sounds of which man is generally capable. But is it necessary to embrace the entire mass of these facts? Is it important not to lose sight of any of them? Of course it is, since without doing so the study of the external manifestations of psychical activity would be a mere waste of time. At first sight the task seems infeasible, but in reality it is not so, and for the following reasons.

The infinite diversity of external manifestations of cerebral activity can be reduced ultimately to a single phenomenon—muscular movement. Whether it's the child laughing at the sight of a toy, or Garibaldi smiling when persecuted for excessive love for his native land, or a girl trembling at the first thought of love, or Newton creating universal laws and inscribing them on paper—the ultimate fact in all cases is muscular movement. To help the reader reconcile himself to this thought I shall remind him of the framework which has been created by the popular mind and includes all the manifestations of cerebral activity; this framework is "word" and "action". Under "action" the popular mind undoubtedly visualises every external mechanical activity of man which can be accomplished exclusively with the aid of muscles, while "word", as the reader will readily appreciate, implies a certain combination of sounds produced in the larynx and in the mouth cavity also by means of muscular movement.

Thus, *all external manifestations of the functioning of the* *brain can be reduced to muscular movement.** Because of this, the question is simplified to a considerable degree. Indeed, milliards of diverse phenomena which seem to bear no relation to one another can be reduced to the work of a few dozen muscles (it should not be forgotten that most muscles are pairs similar in structure and action; consequently, if we know how one muscle functions we thereby know the functioning of a pair). Moreover, the reader will readily grasp that absolutely all the properties of the external manifestations of brain activity described as animation, passion, mockery, sorrow, joy, etc., are merely results of a greater or lesser contraction of definite groups of muscles, which, as everyone knows, is a purely mechanical act. Even the confirmed spiritualist cannot but agree with this. Indeed, how can it be otherwise, when we know that in the hands of the musician a soulless instrument produces sounds full of life and passion, that stone becomes animated under the hand of the sculptor? The life-giving hands of musician and sculptor perform purely mechanical movements, which, strictly speaking, can be subjected to mathematical analysis and expressed by formulas. How, then, could they express passion in sounds and images, unless the expression were a purely mechanical act? In view of this, the reader will agree that the time will come when men will be able to analyse the external manifestations of the functioning of the brain as easily as the physicist analyses now a musical chord or the phenomena of a freely falling body.

However, this happy time is still a long way off, so, instead of indulging in guess-work, let us turn to the basic question and see in what way the external manifestations of brain activity develop insofar as they express psychical activity.

Now, since the reader presumably agrees that externally this activity is always expressed in the form of muscular movement, my job is to determine the ways in which muscular movements originate in the brain.**

* The only phenomena in this sphere which so far cannot be explained by muscular movement are the changes of the eye expressed by the words "sparkling", "languor", etc.

** Since respiratory and cardiac movements are not directly related to our subject, we shall not deal with them here.

Let us pass directly to our subject. Modern science divides all muscular movements into two groups according to their origin—*involuntary* and *voluntary*. Consequently, our task is to analyse the origin of the two groups. We shall begin with the first group—it being the simplest—and, for the sake of clarity, deal not with the brain, but with the spinal cord.

## Chapter One

### INVOLUNTARY MOVEMENTS

Three types of involuntary movements —1) Reflexes (in the narrow sense) in decapitated animals; the movements of man in sleep and when his brain is, so to speak, inactive.—2) Involuntary movements in which the end of the action is to a greater or lesser degree weakened compared with the onset (inhibited involuntary movements) —3) Involuntary movements with an intensified end—fright, elementary sensual enjoyment. —Cases in which the interference of the psychical factor with the reflex does not change the nature of the latter.—Somnambulism, alcoholic intoxication, delirium, etc.

§2. Pure reflexes, or reflex movements can be best observed on decapitated animals, especially on the frog, since in the latter the spinal cord, nerves and muscles continue to function long after decapitation. Cut off the head of a frog and place the decapitated animal on the table. For a few seconds it seems to be completely paralysed; but before a minute has passed you see that it has recovered and assumed the posture peculiar to the frog when in a state of rest on dry land: its hind legs are tucked under it and it supports itself on the front legs like a dog. If you leave it alone, or to be more precise, if you do not touch its skin, it will remain motionless for a very long time. But the moment you touch its skin, it starts and then resumes its quiet posture. Pinch it somewhat stronger and it will, in all likelihood, jump as if trying to escape from the pain.*

* Actually a decapitated animal does not feel pain as a conscious sensation in those parts of its body which have been separated from the head. This has been proved by observations of people the upper part of whose spinal cord has been destroyed to a greater or lesser extent, in this case the skin of the lower half of the body is rendered completely insensitive

But when the pain passes it will sit without movement for hours. The mechanism of these phenomena is extremely simple: sensory nerve fibres stretch from the skin to the spinal cord, while from the latter motor nerves extend to the muscles; in the spinal cord itself the two kinds of nerves are connected by means of the so-called nerve-cells. Intactness of all the parts of this mechanism is indispensable for the accomplishment of the above-mentioned phenomenon. Indeed, if you transect the sensory or the motor nerve, or if you destroy the spinal cord, stimulation of the skin will not produce any movement whatever. Such movements are called *reflex*—because here excitation of the sensory nerve is reflected in the motor nerve. Further, it is clear that these movements are involuntary—being caused only by obvious stimulation of sensory nerves. But when this stimulation takes place, the movements are as inevitable as the fall of a body left without support, or the explosion of powder when it comes into contact with fire, or the work of a machine which has been set in motion. Consequently, these movements are mechanical in their origin.

Excitation of the sensory nerves, excitation of the spinal centre linking the sensory nerves with the motor nerves, and excitation of the latter, expressed in contraction of muscles, i.e., in muscular movement—such are the acts that comprise reflexes or reflex movements.

The reader should not, however, conclude that reflex movements are inherent only in decapitated animals; on the contrary, they exist when the brain is intact, both in the sphere of the cranial nerves and in the sphere of the spinal nerves. To come under the category of reflex movements it is only necessary that the movement should clearly result from stimulation of a sensory nerve and be of an involuntary nature. Such at any rate is the point made by the present-day school of physiology.

In this sense, for instance, an involuntary start caused by a sudden sound, by an unexpected touch on the body, or by the abrupt emergence of a certain image before our eyes, can be described as a reflex movement. And it should be clear to everyone that when the brain is intact the sphere of reflex movements is immeasurably wider than in a decapitated animal; the reason is that in the decapitated animal of all the sensory nerves the excitation of which produces reflex movements only the cutaneous nerves remain intact, whereas the normal animal possesses, along with cutaneous nerves, optic, auditory, olfactory and taste nerves. In any case the reader can see that all so-called reflex, involuntary, mechanical movements exist not only in decapitated animals, but in the normal man as well. Consequently, the brain, or the organ of the spirit can, in certain conditions (according to this school), produce movements as inevitably as any machine, just as, for example, the hands of a clock inevitably move when the clock wheels are turned by the weights.

This idea of the mechanical nature of the brain, irrespective of these or other conditions, is a real find for the naturalist. He has seen many diverse and intricate machines—from a simple screw to complex mechanisms which to an ever-increasing degree replace manual labour; he has meditated so much on these machines that, if you confront him with a new machine without letting him see its interior but showing him only the beginning and the end of its work, he will form a more or less correct idea both of the design of the machine and of its operation. But though we have the good fortune to belong to this category of naturalists, we shall not rely too much on our powers when we come to examine the brain, because the brain is the most intricate of all machines. We must be modest and cautious in our deductions.

We have found that the spinal cord in the absence of the brain *always*, i.e., *inevitably*, produces movements when a sensory nerve is subjected to stimulation; this circumstance is regarded by us as the first sign of the mechanical nature of the functioning of the spinal cord in accomplishing movements. Further study of this question has shown, however, that the brain, too, may under definite conditions (*but not always*) act like a machine, its functioning being manifested in so-called involuntary movements. In view of these results, it is only natural that we should try to determine the conditions under which the brain acts like a machine. As mentioned above, any machine, no matter how intricate, can be subjected to investigation. Consequently, strict analysis of the conditions under which the brain acts as a machine will give us a clue to an understanding of the brain. Let us, then, begin.

§3. Everyone knows that involuntary movements originating in the brain arise only when a sensory nerve is subjected to unexpected stimulation. This is the first condition. Now let us see whether there are other conditions; for the sake of clarity we shall resort to examples. You are in the company, say, of a nervous lady. You warn her that you are going to bang the table, and then proceed to do so. In this case the sound acts on the auditory nerve of the lady not suddenly or unexpectedly; nevertheless, the lady starts. From this fact you can easily draw the conclusion that sudden stimulation of the sensory nerve is not an indispensable condition for the emergence of an involuntary movement, or that a nervous woman is an abnormal, pathological person in whom phenomena develop reversely. However, refrain for a moment from drawing conclusions and go on with your experiment. With the lady's permission you continue to knock on the table with the same force, bringing the number of knocks to several per minute. Ultimately a stage will be reached when the knocks no longer affect the lady: she will not start any more. This is usually explained either by the adaptation of the sensory organ to the stimulus, or by a decline in its sensibility, i.e., by fatigue. We shall return to this explanation later; now let us continue the experiment. When the lady has got used to knocks of a certain strength, you add to the strength warning the lady beforehand. She will start again. When knocks of the same strength are repeated, the reflex movements disappear again. Any subsequent increase in the strength of the knocks results in their reappearance, and so on. It is obvious that for every person in the world there is a sound which is strong enough to make him start even if the sound is anticipated. The only condition is that the stimulation of the auditory nerve should exceed in strength all stimulations ever experienced before. Any veteran of Sevastopol, for example, who by force of habit calmly endured the cannonade of a thousand guns would undoubtedly start if a million guns opened fire. I shall not cite similar examples relating to the sphere of other sense organs, since now the reader himself can easily imagine the effects of gradually intensified excitation of the optic, olfactory and taste nerves. In all cases he will come, of course, to the same conclusion: *if excitation of the sensory nerve is stronger than those previously experienced, it will in all conditions inevitably evoke reflex*, i.e., involuntary movements. This is the second and last category of cases where the brain acts like a machine in producing movements. In all other cases muscular movements effected under the influence of the brain are described by physiologists as voluntary. We shall discuss these movements below, in the meantime we shall revert to the conditions under which involuntary movements arise and shall try to express them in the language of physiology.

If we examine these conditions more closely, we shall easily establish their similarity. Indeed, in the first case it was the absolute suddenness of the sensory stimulation which produced the reflex movement, in the second it was merely the relative suddenness. Whereas in the first case the strength of stimulation increased, so to speak, instantaneously from zero level, in the second it merely exceeded that which was already familiar to the sensory organ and which was expected by it. However, notwithstanding the seeming resemblance, there is an essential difference between these conditions; the difference can be best illustrated by an example. A man standing in the centre of the room is wholly unaware of what is taking place behind him. If pushed slightly in the back he jumps a little from the point where he stood. The picture will be quite different if the man expects the push; in this case he so adjusts his muscles that even a stronger push will not move him from his place. It is clear, however, that in this case too he will not be able to retain his position should the push be much stronger than he expected. This example shows that there is a tremendous difference between the state of a person when an external influence affects him suddenly and the state when he is prepared for this influence. In the latter case, the person offers active and purposeful resistance to the external influence; in our example it is expressed by the so-called *voluntary contraction of a* definite group of muscles. Nevertheless, I shall try to prove that this active counteraction on the part of the person manifests itself *invariably* when he is keyed to meet a certain external influence.

It is easy to see that this is an *extremely frequent* occurrence. Let us recall the nervous lady who could not resist a light noise, even an expected one. In the expression of her face and in her entire pose there is something which we usually designate as determination. This, of course, is the external, muscular manifestation of the act by which she tries, though vainly, to overcome the involuntary movement. You can easily observe this manifestation of will (though it is not sufficiently pronounced to be described in words), having seen similar manifestations a thousand times. For example, you often see in pictures men whose appearance and pose distinctly tell you that they are threatened by certain external influences and are keyed to resist them. The face and the pose of such a figure enable you to judge of the degree of counteraction as well as the degree of danger. Thus, counteraction appears quite frequently if an external influence is expected. But how are we to explain the following facts: a person is prepared for the external influence, and the latter does not evoke any involuntary movements; moreover, confronted with the hostile influence he remains absolutely calm, i.e., his appearance does not betray even a trace of the above-mentioned counteraction. You, for example, are not a nervous person and know that someone intends to frighten you with a knock which makes only nervous ladies start. Naturally, you will remain calm both before and after the knock. Your friend, for example, takes cold showers and is able to refrain without difficulty from involuntary movements if he uses water with a temperature of 8°C. A third person is used to the smell of the dissection-room, and, naturally, he will not feel any strain or make a wry face when entering a hospital ward. Is the above-mentioned counteraction to external influences present in these cases? Of course, it is; the reader can gauge this by very simple reasoning. For the sake of clarity, let us again take the example of the nervous lady who is frightened by knocks. We have seen that when the knocks are repeated with the same force, she finally ceases to start. Watch her facial expression and her pose during the experiments. You will see a look of grim determination, though the lady is still unable to overcome her fright; later, the same determination is sufficient to resist stronger sounds; finally, the moment comes when she endures the knocks without her pose of grim and resolute determination. This phenomenon is, apparently, best explained by fatigue of the auditory nerve; this, though partly true, does not explain the matter fully. Indeed, if you test the lady's hearing at the time when the loud knocks no longer act upon her, you will find that it has not dulled to any appreciable degree even to the weakest sounds. Consequently, there is another cause, commonly known as habit. In the given case the habit consists in the fact that in the course of the experiments the lady develops resistance to the knocks. Another example will show that this interpretation of habit is not arbitrary. Anyone who has observed a person beginning to study the piano is aware of the strain he undergoes when he learns to play the scales. The poor beginner not only acts with his fingers; he also moves his head, mouth and the entire body. But look at the same person when he has developed into an artist. He runs his fingers over the keys with absolute ease; the movements are so rapid that they seem to be independent of the musician's will. Meanwhile, here, too, it is a matter of habit. In this case habit conceals from your eyes the efforts exerted by the musician when moving each finger separately, just as in the case with the nervous lady habit disguises her efforts to counteract the knock. So as not to overburden the subject with further examples, I shall ask the reader: Is there anything in the world so loathsome or so horrible that a human being could not become accustomed to it? Everyone will undoubtedly answer that no such thing exists; and yet it is common knowledge that the process of getting accustomed to many things requires protracted and strenuous effort. To become accustomed to something horrible or disgusting does not mean to endure it without any effort (this would be obvious nonsense), it means skilfully to control such effort.

Thus, if a person is keyed to meet an external influence, he *invariably* exhibits resistance to it, irrespective of the ultimate effect (i.e., no matter whether there is an involuntary reflex movement or not); at times this resistance is expressed externally in a muscular movement, sometimes it remains without any perceptible external manifestation.

We are now in a position to clearly differentiate between the two sets of conditions indispensable for the emergence of involuntary movements when the brain is intact. When the impression is absolutely unexpected the reflex movement is effected exclusively through the nervous centre connecting the sensory and the motor nerves. But if the stimulation is expected, a new mechanism interferes with the phenomenon seeking to suppress and inhibit the reflex movement. In some cases this mechanism suppresses the power of stimulation, and then no reflex (involuntary) movement takes place. In others, on the contrary, the stimulation overpowers the obstacle and then the involuntary movement appears.

This, of course, is the simplest and easiest explanation; but it requires a physiological foundation, since it is a question of the existence of new mechanisms in the brain whose action can, apparently, be observed also in animals. We shall, therefore, turn to the question whether there are physiological grounds for admitting the existence in the human brain of mechanisms that inhibit reflex movements.

§4. About twenty years ago physiologists still believed that excitation in a nerve terminating in a muscle invariably causes the muscle to contract. But quite unexpectedly *Eduard Weber*[3] demonstrated by direct experiments that excitation of the vagus nerve, the branches of which lead also to the heart, far from intensifying the activity of this organ, on the contrary, paralyses it. Weber's contemporaries were at first greatly surprised at this discovery and then decided (in any case, most of the physiologists of the day) that this abnormal action was due to the fact that the nerve does not end directly in the muscle fibres of the heart, as in the muscles of the body, but in the nervous ganglia dispersed in the tissue of the walls of the heart. Ten years after *Weber*'s discovery *Pflüger*[4] established that *n. splanchnicorum* exerts a similar influence on the small intestine. Here, in the muscular walls, were found the same nervous ganglia as in the heart. Later, *Claude Bernard*[5] expressed the idea that *chorda tympani*, stimulation of which unable to overcome her fright; later, the same determination is sufficient to resist stronger sounds; finally, the moment comes when she endures the knocks without her pose of grim and resolute determination. This phenomenon is, apparently, best explained by fatigue of the auditory nerve; this, though partly true, does not explain the matter fully. Indeed, if you test the lady's hearing at the time when the loud knocks no longer act upon her, you will find that it has not dulled to any appreciable degree even to the weakest sounds. Consequently, there is another cause, commonly known as habit. In the given case the habit consists in the fact that in the course of the experiments the lady develops resistance to the knocks. Another example will show that this interpretation of habit is not arbitrary. Anyone who has observed a person beginning to study the piano is aware of the strain he undergoes when he learns to play the scales. The poor beginner not only acts with his fingers; he also moves his head, mouth and the entire body. But look at the same person when he has developed into an artist He runs his fingers over the keys with absolute ease; the movements are so rapid that they seem to be independent of the musician's will. Meanwhile, here, too, it is a matter of habit. In this case habit conceals from your eyes the efforts exerted by the musician when moving each finger separately, just as in the case with the nervous lady habit disguises her efforts to counteract the knock. So as not to overburden the subject with further examples, I shall ask the reader: Is there anything in the world so loathsome or so horrible that a human being could not become accustomed to it? Everyone will undoubtedly answer that no such thing exists; and yet it is common knowledge that the process of getting accustomed to many things requires protracted and strenuous effort. To become accustomed to something horrible or disgusting does not mean to endure it without any effort (this would be obvious nonsense), it means skilfully to control such effort.

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§4. About twenty years ago physiologists still believed that excitation in a nerve terminating in a muscle invariably causes the muscle to contract. But quite unexpectedly *Eduard Weber*[3] demonstrated by direct experiments that excitation of the vagus nerve, the branches of which lead also to the heart, far from intensifying the activity of this organ, on the contrary, paralyses it. Weber's contemporaries were at first greatly surprised at this discovery and then decided (in any case, most of the physiologists of the day) that this abnormal action was due to the fact that the nerve does not end directly in the muscle fibres of the heart, as in the muscles of the body, but in the nervous ganglia dispersed in the tissue of the walls of the heart. Ten years after Weber's discovery *Pflüger*[4] established that *n. splanchnicorum* exerts a similar influence on the small intestine. Here, in the muscular walls, were found the same nervous ganglia as in the heart. Later, *Claude Bernard*[5] expressed the idea that *chorda tympani*, stimulation of which manifestly increases the secretion of saliva, should be regarded not only as a stimulus, but also as an inhibitor (or regulator) of salivation. Finally, *Rosenthal*[6] proved that respiratory movements, essentially involuntary, cease or become retarded when the fibres of the superior laryngeal nerve are stimulated. These facts gradually led modern physiologists to the belief that there may be nervous influences in the animal body which lead to suppression of involuntary movements. On the other hand, everyday life offers a multitude of examples when human will appears to act just in the same way: we are able, for example, to stop at will our respiratory movements in any phase of their development even after expiration when the respiratory muscles are relaxed; man can also suppress screams and any other movements caused by pain, fright, etc. It is remarkable that in the latter cases, which presuppose the presence of considerable moral power in the given person, the effort of will aimed at suppressing involuntary movements externally find little or no expression at all in accessory movements; the person who remains absolutely calm and motionless in these conditions is regarded as possessing strong will power.

In the face of these facts contemporary physiologists could not but admit the existence in the human body—namely, in the brain through which man's will acts—of mechanisms which inhibit reflex movements.

This hypothesis turned into an almost indubitable truth when at the end of 1862 it was proved by direct experiments that in the brain of the frog there are mechanisms which, when subjected to stimulation, suppress painful reflexes from the skin.

Thus there can be no doubt that any resistance to sensory stimulation is caused by mechanisms that inhibit reflex movements.

This settles the question of the origin of involuntary movements arising in the brain. In both cases (that is, when stimulation of the sensory nerves is absolutely or relatively unexpected) the mechanism of the origin of reflex (involuntary) movements must be essentially the same, differing in no way from the mechanism which exists in the spinal cord. The best proof of this can be had by comparing the apparatus which produce involuntary movements in the decapitated and in the normal animal, and which have been thoroughly studied in the frog. In the decapitated animal the reflex apparatus for each point of the skin consists of the cutaneous nerve *a* (Fig. 1) entering the spinal cord and ending in cell *b* of the posterior horns; this cell is connected with another cell *c*, situated in the anterior half of the spinal cord and, together with cell *b* forms the so-called reflex centre; the motor fibre *d* issues from cell *c* and ends in the muscle. The reflex, being the product of the functioning of this apparatus, is none other than continuous excitation of *a*, *b*, *c*, and *d*, always beginning with the stimulation of *a* in the skin. As to the reflexes of the brain, they are effected by a mechanism consisting of the following parts: cutaneous fibre *o* terminating in the nervous centres *N* which produce the walking movements (as shown by Berezin,[7] there is a difference between cutaneous fibres ending in the brain and in the spinal cord); path *Nc* along which the voluntary motor impulses proceed from the brain; and, finally, components *c* and *d* which enter the spinal mechanism. This apparatus is also brought into action by excitation of *o*, i.e., of the cutaneous nerve. Both reflexes are, apparently, identical as to their origin so long as the excitation follows the above-mentioned path; they remain identical even when the inhibitory apparatus *P* comes into action, since this apparatus is effective for *N* as well as for *bc* and is located in the brain, in front of *N*. Those who hold that the resistance to external influences is voluntary, must, of course, admit that the will acts directly on *P*; later, however, we shall see that the inhibitory mechanisms

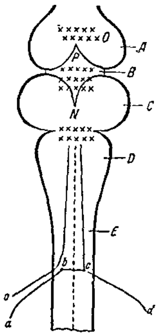


Fig. 1 illustrating the *spinal cord and the brain* of the frog
*A*—hemispheres; *B*—visual chambers; *C*—corpora quadrigemina; *D*—medulla oblongata; *E*—spinal cord

can be excited also by stimulating the sensory nerves of the skin.

§5. Now let us continue with our study of the brain as a machine, and establish the relationship between the intensity of stimulation and the reflex movement, that is, between the stimulus and its effect. In doing so we shall again take the phenomena presented by the spinal cord, since they have been thoroughly investigated. Here it can be said in a general way that with intensified stimulation the tension of the movement gradually grows and extends simultaneously to an ever-increasing number of muscles. For example, a slight stimulation of the skin of the hind leg in a decapitated frog results in the contraction of the muscles of this leg only. If the stimulation is gradually intensified, reflex movements appear also in the foreleg of the same side, and finally in the hind and forelegs of the opposite side.

The same can be observed in the cranial nerves when the brain, so to speak, is inactive.

For example, if the face of a sleeping person is slightly brushed (where the trigeminal nerve divides) with a feather, only the facial muscles will contract. If the irritation is intensified, reflex movements will appear also in the hand and, given very strong irritation, the man will wake up and jump out of bed, i.e., reflexes will be manifested in practically all the muscles of the body. This shows that with the intensification of the stimulus the reflex movement becomes more pronounced and simultaneously more widespread.

It is a different matter altogether when the brain is active. In this case the relationship between intensity of the stimulation and its effect is much more complex. As far as I know, this matter has as yet not been scientifically investigated; in view of this, I deem it necessary to dwell on it in more detail.

Let us analyse cases of absolutely unexpected stimulation of the sensory nerves in animals and man when the brain is intact. Suspend a frog by its snout vertically and wait until it has ceased to struggle and is motionless; then lightly touch its hind leg with your finger. The frog will display what is usually called "fright": it will begin to struggle again, i.e., bring all its muscles into action. It is commonly said that bears subjected to sudden fright (i.e., when the sensory nerves are subjected to unexpected stimulation) begin to run as fast as they can, sometimes even exhibiting a bloody flux. Thus, the fact that exceptionally pronounced involuntary movements are observed in animals as a result of slight sudden stimulation of the sensory nerves is well known. In man this phenomenon is even more pronounced, especially in the case of a hysterical woman: a sudden knock or unexpected touch to the skin may induce convulsions of the whole body (i.e., reflex movements).

But apart from this extreme case, everybody knows that sudden fright, no matter how insignificant the cause (i.e., stimulation of the sensory nerve), always evokes in man pronounced and extensive reflex movements. It is also well known that fright may result from stimulation both of the spinal and cranial nerves. Indeed, we experience fright at the unexpected touch to our trunk (which is innervated by the spinal nerves) as easily as we do at the unexpected emergence of a strange image before our eyes, i.e., excitation of the optic nerve issuing from the brain.

In any case there is no doubt that fright deranges the relationship between the intensity of stimulation and its effect (i.e., movement), in favour of the latter. Can we, then, assume that the involuntary movement occasioned by fright is of a mechanical nature? In this case a psychical element, namely, the sensation of fright, interferes with the phenomena; the reader will have heard of the miracles wrought by people under the influence of fright: for example, persons suffering from short breath run for miles without stopping, feeble individuals carry heavy loads, etc. True, in such cases the unusual energy of the muscular movements is generally attributed to the moral effect of fright; however, nobody will, of course, believe that this really explains the matter. Let us see whether it is possible to imagine a machine where the impulse to action is slight while the effect of the action is very great. Given a machine of this kind there would be no grounds for denying the mechanical nature of the origin of the involuntary movement caused by fright. Here is an example. Electric wires leading from a powerful galvanic battery are coiled round a horseshoe-shaped piece of soft iron. Placed underneath at either end at a distance is a lump of iron weighing about ten poods. The circuit is opened and the machine is motionless. At the point where the circuit is interrupted one lead is submerged in mercury, while the other reaches almost to the surface of the mercury, but without touching it. It suffices to blow on the second lead for it to dip into the mercury. The circuit will then be closed; the horseshoe becomes a magnet and attracts the lump of iron. Thus, the impulse (the blowing) is weak, while the effect (the raising of the iron) is quite considerable. The same thing is observed when a spark comes into contact with gunpowder. True, the spark itself constitutes a certain force (it can be approximately measured provided the incandescent substance and its temperature are known); but it is nil compared with the force of the exploding gunpowder.

Consequently, it is not only possible, but even necessary to reconcile the fact of the machine-like nature of the origin of involuntary movement caused by fright with the disparity between strength of stimulation and intensity of movement observed in these cases; otherwise we should fall into an absurdity inexcusable even for a spiritualist, since we should have to admit that purely material (muscular) forces are engendered by moral forces.

But in connection with the foregoing the reader is entitled to demand that we reveal in the human brain a mechanism that would explain the phenomena of fright.

This is precisely what we are going to do.

The scheme of the mechanism is as follows: fright is equally inherent in man and in the simplest animal organisms which, according to our belief, are governed by instinct alone. Fright, therefore, is an instinctive phenomenon. This sensation originates in the brain, being the inevitable result of sudden stimulation of a sensory nerve just as a reflex movement is the inevitable consequence of fright. Such are the three, causally interconnected activities of one and the same mechanism. Stimulation of the sensory nerve constitutes the onset of the phenomenon, the sensation of fright—its continuation, and the intensified reflex movement—its end.

Let us take a case when fright follows from stimulation of a spinal nerve.

Here excitation proceeds to the brain (since conscious sensations[8] originate in this organ alone), namely, to its anterior parts —the so-called cerebral hemispheres; when the latter are removed the animal no longer experiences fright.* Consequently, the processes which intensify the final effect of a reflex compared with its beginning take place in the cerebral hemispheres. This can be explained in two ways: either the mechanism which intensifies the final effect of the reflex is in its structure a reflex apparatus itself, and therefore acts simultaneously as the end of sensory nerves and the beginning of motor nerves; or it is an appendage to the reflex apparatus *N* (Fig. 1) already known to the reader, the apparatus which in the frog is situated far behind the hemispheres and produces brain reflexes. The second assumption is much more probable than the first, since all the points of the skin without exception are reflexly connected with the striated skeletal muscles through the midbrain, i.e., independently of the cerebral hemispheres. Moreover, direct experiments have shown that of all the parts of the brain the hemispheres alone do not produce muscular movements when subjected to artificial stimulation; in other words, they do not contain any fibres with properties similar to those of the motor fibres.

Thus, it appears that the brain mechanism producing involuntary (reflex) movements of the trunk and extremities possesses two appendages also situated in the brain; one suppresses movements, while the other, on the contrary, intensifies them, depending on the strength of the stimulus. In all probability the second appendage is brought into action exclusively by stimulation of the sensory nerves and, together with the reflex apparatus, *N*, constitutes the mechanism of fright. From this point of view, it can be admitted, for the sake of simplicity, that the sensation of fright and excitation of the apparatus which intensifies the final effect of a brain reflex are identical. In any case, a close causal relationship between them is beyond any doubt.

* In this case the animal becomes, as it were, drowsy; though it is still able to respond to stimulation of the skin, the movements are of an automatic nature, sharply distinguishing them from the movements of a normal animal.

The scheme which explains the mechanism of fright as being the result of sudden stimulation of spinal sensory fibres can be applied without the slightest modifications also to stimulation of the cerebral nerves, for example, of the optic, auditory and other nerves.

Thus, the reader is now confronted with a case where a psychical phenomenon becomes part of a chain of machine-like processes. The approach which has been developed here is probably new to him; perhaps the analogy of the magnet and the mechanism of fright does not satisfy him and he still doubts.

I shall repeat once more: if a man is subjected to the action of an external agent and is not frightened by it, then the intensity of the ensuing reaction (whatever muscular movement it may be) will conform to the intensity of the external influence. But when the latter produces fright the man's reaction assumes a violent character. What I assert is that in the latter case the activity of the new mechanism intensifying the reaction is added to the activity of the old mechanism which produces the reaction. It makes sense, doesn't it? But do we know of any laboratory experiments with a machine capable of intensifying reflexes similar to the experiments already carried out with mechanisms which inhibit them? Yes, experiments of this kind have been carried out,* and I shall gladly describe them here—they are simple, clear and should convince anyone who approaches the given question without prejudice. G. Berezin,[9] assistant in the physiological laboratory of the Petersburg Academy, has found that if a frog is kept in room temperature (i.e., at 17-18°C) for several hours and if its hind legs are then immersed in ice-cold water, it will immediately withdraw them. The frog feels the cold which gives an unpleasant sensation and makes a definite movement in order to get away from it. It should be pointed out that the movement is always a pronounced one—as if the frog were frightened. But if the immersion in ice-cold water is repeated after the hemispheres have been removed, the frog remains absolutely quiet. The effect is different, however, when the skin surface subjected to cooling is

* In 1863, when the first edition of *Reflexes of the Brain* appeared, none of the experiments described below had as yet been performed.

increased, i.e., if, for example, the entire posterior half of the body is immersed in ice-cold water: the frog will then move its legs. Is it not obvious that in producing movements by cooling the skin the cerebral hemispheres act in the same way as the extension of the cooled skin surface? Anyone knows that the latter condition intensifies the effect of cooling in general (the sensation of cold becomes unbearable): consequently, *the hemispheres, too, intensify the effect of cooling, i.e., the movements.* Another experiment proving the existence in the frog's brain of mechanisms which intensify involuntary movements was carried out by *Pashutin*[10], a student. He found that the movements of a frog in response to a touch to its skin are greatly intensified when its mid-brain is stimulated by electric current. In this case, the frog acts in exactly the same way as a man who is touched unexpectedly: it starts, bringing its muscles into play. But when its brain is not subjected to stimulation, it often remains motionless when touched.

Leaving aside these direct experiments, the idea of the existence in the body of mechanisms which intensify involuntary movements is corroborated by similar phenomena taking place in respiratory and cardiac activity. Each of the nervous mechanisms controlling the respiratory movements or the heart beating is supplied with two antagonistic nervous regulators: one suppresses respiration and heart beating up to complete stoppage, the other, on the contrary, intensifies them.

Do we need any other proofs that the mechanism of involuntary movements which we are considering here also possesses two antagonistic regulators—one suppressing movements and the other intensifying them.

I will conclude this part by saying a few words about two consequences which can be brought on by extreme fright: fainting, and the state which is figuratively called "petrifaction". Both phenomena, despite their ostensible dissimilarity, belong to the category of intensified reflex movements. Indeed, fainting *occurs as a result of a reflex from a sensory nerve on the vagus* nerve; the latter, when greatly excited, weakens the contractions of the heart to a considerable degree, or even stops them completely for a time. As a result, the supply of blood to the brain ceases (paleness of the face), leading to loss of consciousness. Fainting is usually preceded by a state of depression of the muscular and nervous systems known as fright paralysis. This explanation is in no way far-fetched. I take it that everybody knows that at the moment of fright the heart stops and only subsequently begins to beat strongly. As to people petrified by fright I have seen them only in pictures, where this state is usually expressed by an intensified and protracted contraction of the facial muscles, as well as of some of the body muscles (stupor). Consequently, here too the effect of fright is an intensified reflex movement.

I shall not dwell on cases of fright connected with anticipated sensory stimulation. The reader will be aware that in this case the disparity between the strength of the stimulus and the intensity of the resulting movement is greater than in the case just described; this is due to the fact that here, along with mechanisms intensifying the reflex movements, mechanisms come into play which inhibit them. It is likewise clear that our presentation of this process, based on analysis of absolutely unexpected stimulations and of their effects, remains valid also in those cases when the stimulation is not unexpected.

§6. Numerous reflex movements, where sensual enjoyment in the broad sense of the term constitutes the psychical element, should also be included in the category of involuntary movements, being due to the predominant activity of the reflex-intensifying mechanism. To avoid misunderstanding, I shall illustrate by examples what kind of phenomena I have in mind. They are: the laugh of a child at the sight of a brightly-coloured object; the muscular contractions which impart a characteristic expression to the face of a hungry man when he eats, or to the face of an amateur of delicate perfumes when he smells his favourite aroma, etc. In a word, they include all the muscular movements deriving from elementary sensual pleasures.

Naturally the development of these phenomena is the same as in the case of any involuntary movement in general: excitation of the sensory nerves constitutes the beginning, the activity of the centre (or enjoyment) its continuation, and muscular contraction the end. But the conditions under which reflexes of this kind arise are quite different.

Everybody knows that one and the same external influence acting on one and the same sensory nerves can in some cases engender pleasure, in others—not. For example, when a man is hungry he enjoys the smell of food; when sated he is indifferent to it and, if overfed, he even has an aversion for it. Take another example. When a man who lives in a dimly lit room enters a brightly lit room he experiences pleasure; when he returns to his own room the reflex is reversed. But let our man spend some time in a dark cellar and he will return to his room with an expression of happiness on his face. The same is true for any sensations yielding positive or negative satisfaction, that is, in all spheres of the senses. What, then, is the cause of these phenomena and can it be expressed in physiological language? First of all, is it possible to grant the existence of special mechanisms for every change in sensation? Of course not, since in our example with the influence of the smell of food on a hungry man and on a sated person we should have to accept in this case alone the existence of at least three separate mechanisms, namely, for pleasure, indifference and aversion. We should likewise have to accept the existence of such mechanisms for all the smells in the world. But it is much simpler to assume that the nature of sensation is modified by the *changes taking place in the physiological state of the nervous centre.*[11]

This change can even be presented—hypothetically, of course —in a mechanical form. Suppose, for example, that the central part of the mechanism, which begins in the nose with the olfactory nerves perceiving the smell of food, is at a given moment in a state that the reflexes from these nerves proceed predominantly to the muscles producing laughter; then, naturally, excitation of the olfactory nerves will make the person smile. If, on the contrary, the centre is in such a state that the reflexes develop only in the muscles which pull the corners of the mouth down, then the smell of food will result in a wry face. Now it only remains for us to admit that the first state of the centre conforms to the case when a person is hungry, the other to the case when he is sated, and the whole matter becomes clear.

Thus, it is quite reasonable to admit that involuntary movements resulting from sensual pleasure are simply ordinary reflexes, whose greater or lesser complexity, i.e., greater or lesser degree of development, depends on the physiological state of the nervous centre.

But the reader may ask: Why are these phenomena included in the category of the reflex movements engendered by the activity of an element intensifying reflexes? In the past the generally accepted view was that besides excitatory effects there were also inhibitory effects, and that, for example, all kinds of aversion belong to the latter. To answer this question, I shall revert to the example of food. I regard as normal the manner in which the sated person responds to the smell of food. Here the reflex is weak—the muscular movement is barely perceptible (when satisfaction is complete it may be even null). Compared with the normal, the reflexes taking place both in the hungry and the oversated person are, of course, very acute, i.e., in both cases the reflex movements are strong. It is clear that, physiologically, aversion is the same intensified reflex as pleasure.

Consequently, the anatomical scheme of fright is equally applicable to the explanation of reflexes caused by sensual pleasures

I feel that despite the foregoing the reader is still not convinced that absolutely all involuntary movements in the human body can be explained by means of the above-mentioned anatomical scheme. Let me try to prove that this is actually the case. Separate examples of involuntary movements taken at random cannot prove anything; indeed, it is impossible to consider all the examples since there are millions of involuntary movements If we omit even ten cases, the sceptic would be justified in saying that precisely these ten do not fit into our scheme The question, therefore, should be considered only from the most general point of view. And that is what we intend to do.

Properly speaking, we have divided all involuntary movements into two principal categories: pure reflexes, i.e., cases when the activity of accessory mechanisms inhibiting or intensifying the reflex movements does not interfere with the phenomenon, and reflexes with a predominant activity of the intensifying accessory mechanism, i.e., reflexes caused by fright and sensual pleasure. There is no need to dwell on the first category. *It is clear that it includes phenomena of movement* exhibited by people in a state when the brain is, as it were, excluded, such as sleep, alcoholic intoxication, somnambulism, deep concentration on a particular thought with resultant abstraction from all external influences, etc. Here the psychical element is completely absent. But is it possible—the reader may ask—that fright and elementary sensual pleasures are the *sole psychical elements of the second vast category of involuntary* movements? Yes, that is exactly the case, if by involuntary movements in the strict sense of these words one implies —as we do—only those movements that are known to science and society as "instinctive", i.e., phenomena in which there is no room for reason or will.* The explanation is this: All instinctive movements in the animal body without exception are aimed exclusively *at preserving the integrity of the indivisible organism* (only the sex instincts lead to the maintenance of the species as a whole). Preservation of integrity is fully ensured if *the indivisible organism avoids noxious external influences and* enjoys pleasant (i.e., useful) influences. Fright helps to avoid the first, while pleasure is the spur to the second.

This concludes my analysis of the quantitative side of involuntary movements. The reader has seen that almost half of all the external manifestations of the cerebral activity are explained by a very simple mechanical scheme. It is true though that in reality the phenomena are immeasurably more complex than in our scheme. Whereas most involuntary movements manifest themselves not in a single muscle fibre and not even in *a single muscle, but in groups of muscles, in our scheme the* complex phenomenon is reduced to the activity of a single

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* In view of this, cases of the following kind should be excluded from this category: A humane, kind person, a non-swimmer, is walking along a river bank and sees a person struggling in the water; without hesitation, he plunges *into the water and is drowned in attempting the rescue*. People will, probably, say that this was an involuntary movement. But it is *impossible to agree with that*. The man jumped into the water because he was humane and kind. Hence, a thought must have flashed through his mind before he acted.

in definite ways? Formulated in this way, the question can be tackled experimentally; and experiments on decapitated animals (frogs) indicate that the reflex elements are linked in the second of the above-mentioned ways. The entire body of the animal can be divided, for example, into four main reflex groups: the head group (the skin and the muscles of the head with their nervous linkage); the trunk group (the skin and the muscles of the trunk with their nervous linkage); the group of the upper extremities; and the group of the lower extremities. Each group can, when separated from the others (by decapitation and by transection of the spinal cord) act independently, but at the same time it is linked with the other groups in a definite way. For example, the group of excised upper extremities of the frog can be induced to react to stimulation of the skin of these extremities by a forward movement, in the direction of the head, as well as a backward movement in the direction of the hind legs. But if we consider *this group in conjunction with all other parts of the body*, we shall see that the movement of the upper extremities in the direction of the head can be induced by stimulation of any point of the skin situated above them, whereas stimulation of any point of the skin on the trunk and lower extremities below the *upper extremities induces movement of the latter in the opposite* direction. If we consider the group of lower extremities of the frog from the same point of view, we will see that stimulation of any point of the skin above the hind legs causes the latter to move upward, i.e., towards the point of stimulation. Consequently, all the points of the skin on the frog's head are reflexly linked with the muscles which move the upper and lower extremities upward, and all the points of the skin on the belly are linked with the muscles moving the fore extremities downward and the hind extremities upward, etc. The interconnection of the reflex groups can be even more definite: if, for example, we smear the skin of the belly of a decapitated frog with acid near the middle line of the body, then the leg will move upward in the direction of this line (i.e., towards the point of stimulation); but if we smear the side of the belly, the leg, being raised again, will move in another direction. In short, every point of the skin is more intimately and extensively linked with the muscles of its group, its connection with the neighbour-hand, they indicate that the integrity of this conduction is maintained by the frequent repetition of the reflex in one and the same direction.

Finally, this group of mechanisms includes the nervous apparatus which co-ordinates the movements of the hands and legs in walking. This apparatus, which in vertebrates is situated in front of the medulla oblongata, is in some animals (for example, in the horse, the chamois, and others) an inborn apparatus; it can be brought into action by stimulation of the skin. In grown-up animals it is, apparently, induced to action only under the influence of will and psychical activity; nevertheless, experiments connected with removal of the cerebral hemispheres clearly show that walking can also be a perfectly involuntary movement in animals, because only stimulation of the skin, or some other external influence can bring decerebrate animals out of the state of drowsiness. On the other hand, there are lesions of the brain when the animal begins to walk or to run irresistibly, apparently contrary to will. Physiologists even call these phenomena forced movements.

Is it not obvious from the foregoing that the walking movements of animals can be involuntary? In man the matter is, apparently, quite different: Man's walking belongs to movements which are acquired by learning, i.e., accomplished under the influence of mentality and will. Besides, everybody knows from personal experience that walking is a highly voluntary act; at any rate, it can be discontinued at any moment, accelerated, etc., at will. And yet later, when we discuss habitual movements and somnambulism, the reader will, I think, agree that in man, too, walking can be an involuntary act.*

It is also interesting to note that if a child which has just learned to walk becomes ill and remains in bed for a long time, it forgets the previously acquired art of walking. *In this case the co-ordinated activity of the reflex groups which participate in the act of walking becomes deranged. This fact testifies once again to the great importance for nervous activity of frequent repetition in one and the same direction.*

* There are cases of brain diseases when the patients run unconsciously, being unable to stop, until they stumble against an object and fall.

very simple, and nobody will doubt their automatic character, i.e., the mechanical nature of their origin. But here are experiments in which the reflex movements may seem to the observer more rational. Remove the entire anterior part of the brain of a frog, almost up to the medulla oblongata, and place the animal on the table. Give it time (about five minutes) to recover from the shock of the operation and then lightly pinch its leg; the frog will creep away in the opposite direction, in an endeavour to escape from the irritation. If this frog is placed in water, pinching will make it swim. It is obvious that the frog cannot reason, since the thinking part of the brain (i.e., the cerebral hemispheres, according to physiologists) has been removed; nevertheless, it reacts as rationally as in the case when the brain is intact, i e., when it possesses will and capacity for thinking; the animal is conscious of the environment: on the table it creeps, in the water it swims. Pfluger, who studied the qualitative side of these phenomena, describes an experiment with a decapitated frog (even the presence of the medulla oblongata is not necessary in this experiment) where the seeming rationality of the reflex movements was of an even more pronounced character. A decapitated frog is suspended vertically. The skin of its belly is irritated by acid on one side, for example, the right. Under ordinary conditions the frog rubs the irritated place with its right hind leg, and sometimes also with the right foreleg if the irritated point is near this leg. But if the right hind leg is cut off, the frog will begin to rub the irritated place with its left hind leg despite the fact that this movement appears to involve some difficulty. From this one would think that a kind of intellect is located in the spinal cord of the frog. And this, of course, is true, at least to the extent that a movement arising in the spinal cord can be called rational. Not the name but the essence of the phenomenon is of importance to us, i.e., the question whether the movement is involuntary, inevitable, i.e., mechanical. The question can be easily answered. The movement is involuntary because a decapitated frog cannot perform voluntary movements It is inevitable because it invariably follows an obvious sensory stimulation. Finally, it is mechanical by origin for the very reason that it is inevitable. Thus, the reader can see that in the cases considered by us all the reflex movements are expedient and that in some of them the expediency reaches such a degree that to the observer the movement no longer seems automatic and acquires a rational character.

On the basis of the experiments with stimulation of the skin of a decapitated frog and of the sleeping man the following general rule can be established: excitation of any point on the sensory surface of the body can induce reflex movements depending on the given conditions; these movements are diverse as to the groups of muscles participating in them, but their purpose is invariably the same—to protect the body from certain external influences. In this sense, the reflex mechanisms of the spinal cord constitute an apparatus which partly ensures protection of the organism as a whole from noxious influences acting directly on the skin. This protection is partly ensured also by the nervous mechanism of walking inasmuch as it is induced by sensory stimulation of the same skin; the existence of this mechanism in the body of the animal provides the latter with additional means of escaping from external harmful agents. If, in addition, we consider the animal's eyes and ears, i.e., the visual and auditory sensations as connected with this mechanism, we shall see that the animal is enabled to avoid even remote noxious external influences. It is precisely from this point of view that we should consider vomiting which frees the stomach from irritating substances, coughing and sneezing which remove foreign substances from the throat and nose respectively, as well as the acts of defecation and urination in response to the stimulation of the rectum and the urinary bladder. All these movements are involuntary and at the same time expedient, because they are aimed at ejecting noxious agents from the body.

The nervous mechanisms, by means of which the body frees itself both of external and internal noxious influences form, in the aggregate, part of the apparatus that ensures the intactness of the organism as a whole, an apparatus whose activity reveals the presence in all animals of the instinctive (i.e., involuntary) sense of self-preservation.

§ 9. Nobody, of course, will doubt the self-preservation instinct in man. And everyone has undoubtedly heard of human actions which can be explained only by the presence of this instinct.

Facts are even cited which indicate that the interference of reason sometimes harmfully affects the expediency of the instinctive movements. It is well known, for example, that somnambulists climb up roofs in sleep, with a dexterity that is inconceivable in fully conscious persons. It is also said that the tipsy horseman passes dangerous parts of the road more skilfully than the sober rider. In these cases the presence of consciousness can affect the expediency of the movements, because it evokes fear which causes a new series of involuntary movements interfering with the expedient ones. In any case, the reader will appreciate that sometimes involuntary movements are not only equal to conscious movements in seeming rationality but even surpass them in this respect. The main point is that involuntary movements are less complex and, consequently, their expediency is, so to speak, of a more direct character.

Thus—I repeat—the apparent rationality of a movement (from the point of view of preserving the body) does not exclude the mechanical nature of its origin.

Those with a disposition towards strict systematisation may say that the above-mentioned examples of the somnambulist and the tipsy horseman are irrelevant in the case of involuntary movements. Indeed, as I have already said, one of the features of an involuntary movement is its independence of mentality, of thought. But in the last two examples the absence of thought can still be doubted, although the somnambulist and the drunken man usually do not remember what happened to them in sleep or in the state of intoxication. In support of his objection the reader might cite the example of the sleeper who screams and moves under the influence of a terrifying dream, though upon awakening he has no recollection of the dream, or the example of the delirium and violent movements of a maniac during an attack of his disease. In all these cases a psychical element interferes with the phenomenon, that is, some kind of imagination, which, of course, is as real as any reasonable notion.

The objections would be justified if I included all the external manifestations of the somnambulist and the drunk in the category of involuntary movements. That, however, is not my purpose; I designate as involuntary only the remarkable ability of equilibration displayed by a person, if he is not an equilibrist, only in the absence of consciousness. Consequently, if a certain movement is impossible in the presence of thought and, on the contrary, is effected exclusively in the absence of consciousness, the movement can be only of an involuntary, reflex, instinctive nature. I would ask the reader to pay special attention to the following aspects of the examples just cited.

1) *Involuntary movements may be combined with movements induced by what is usually called definite psychical notions* (for example, the balancing of the somnambulist and of the drunken rider is connected with the acts of walking and horse-riding, which are caused by a certain psychical motive).

2) *Involuntary movements may represent a series of acts* (for example, during the dangerous walk of the somnambulist, or during the ride of the inebriated horseman); these acts *are expedient for preserving the body and are, therefore, rational from this point of view.*

3) Finally, *there are cases of involuntary movements where the presence of sensory excitation, which gives rise to a reflex, is understood, though it cannot be clearly determined.*

All these aspects have such an important bearing on our discourse that I deem it necessary to dwell on them in greater detail.

*The equilibration, or involuntary movement of the somnambulist may be combined with walking—an act caused by a psychical motive and not, therefore, instinctive.* This is absolutely true for the case where the maintenance of balance (equilibration) can be separated from the act of walking, i.e., from the periodical movement of the legs. But what about those cases where the entire equilibration consists exclusively in firm and correct walking, when the somnambulist, for example, fearlessly crosses a narrow plank which is thrown over a yawning precipice and which hardly gives room for his feet? A person who is not an equilibrist would never do this in a conscious state. Consequently, according to our definition, this movement, i.e., walking, should be included in the category of involuntary movements. Let the reader thoroughly consider the foregoing, and he will undoubtedly understand that this is by no means juggling with words, but real truth. How, then, is it possible to regard as involuntary an act such as walking which is learnt in childhood and which, consequently, develops under mental influence? The following argument may reconcile us to this idea. Man can rightfully be placed on a level with animals as regards the structure of the central nervous mechanism of walking, since the young of some animals are also unable to walk immediately after birth and have to learn this art. Nevertheless, in these animals, too, the nervous centres of walking are located not in the cerebral hemispheres where impulses are originated for all the so-called voluntary movements, but in the mid-brain (in the frog, for example, in the medulla oblongata); hence, the same must be true for man. It follows, therefore, that man's walking may also be an involuntary act. But how, then, do we explain the continuous nature of walking? What are the impulses, i.e., the sensory stimuli which cause this series of periodical movements? It has been stated above that a reflex movement corresponds in duration to the stimulus which evokes it. I shall now give a definite answer to that question: in the process of walking sensory excitation accompanies every step, that is, every time the foot contacts the surface on which the person is walking sensation of support arises; excitation is also caused by sensations which arise during the contraction of corresponding muscles (the so-called muscular sense). The importance of these sensations in the act of walking can be best illustrated by the example of patients suffering from loss of sensibility in the skin and muscles of their legs. In the day-time, when they see the floor, they are able to move with difficulty, because visual sensations compensate to a certain extent for the loss of tactile and muscular sensations; but in the dark these people completely lose the ability to move. Feeling no support under their feet, they cannot make a single step, nor can they stand even for a few seconds without falling. If the reader has ever missed his footing while walking he can easily visualise the state of these people. You are walking, say, along a dark corridor and quite unexpectedly come across a staircase which leads downwards; your foot suddenly falls, as it were, into an abyss; your fright disappears only when you regain firm support under your foot. In people who suffer from paralysis of the skin and muscles this sensation of falling into an abyss makes itself felt the moment they close their eyes, hence they are unable to make even a single step. Besides, how can the patient know in the dark when his foot has left the floor and when he must place it on the floor again. In performing these movements which are repeated at each step by each foot we are, apparently, guided exclusively by sensation. It is noteworthy that the gait becomes much more deranged owing to loss of muscular sense (a sense, which is more vague[12] and hardly reaches consciousness) rather than to paralysis of the considerably more pronounced tactile sensations.

The reader may object to this pathological example by asserting that fright alone prevents walking in the dark. Although at first sight this objection seems to be valid, in reality it is groundless. Indeed, watch an absolutely normal person walking on even ground, uphill, or along a road full of pot-holes. In all cases the gait of the same person is different. This means that he adapts the movements of his body to the particular conditions of the locality in which he is moving, and which can be ascertained only by means of his visual sensations or the sensations of his feet. But imagine a person who is absolutely unable to sense the surface of the road along which he is walking; how, in these circumstances, can he adjust his gait?

Thus, in some cases walking can be an involuntary movement. Since it belongs to the category of movements which are acquired by habit and learning, i.e., movements which develop under mental influence, it can be assumed that all such movements may become involuntary, provided, of course, the mind (at least in relation to these acts) is in a state similar to that observed in somnambulists and intoxicated people.

Unfortunately, we cannot describe this state of mind physiologically. Observations on phenomena of intoxication, brought on by alcohol, opium, chloroform, etc., make it only possible to state with certainty that in all these cases, just as in normal sleep, somnambulism, delirium and attacks of mania, *normal* sensibility is dulled to a considerable degree if not eliminated altogether (recall the insensibility to acute pain observed in persons under chloroform, alcohol and opium, or the lowered sensibility of a man in a deep sleep, to every external influence, etc.).I do not maintain that this decline of *normal* sensibility fully summarises the states of intoxication, sleep, etc. (of course, only with regard to the state of the brain); however, I think that the decline constitutes the chief and most important element of the states under consideration; in any case, physiological investigations do not reveal in the nervous activity of drunkards, sleepers, maniacs, etc., any changes as manifest as the decline of sensibility. Now let us see what ensues therefrom.

If sensibility is lowered, this means that the functioning of the parts of the brain, the intactness of which as shown by physiological experiments is indispensable for the emergence of sensations (and consequently of consciousness), has weakened, or has ceased altogether (when sensibility and consciousness are fully lost). In both cases the effect produced by the sensory stimulus (sound, light, a prick of the skin, etc.) is either very dull or does not reach consciousness at all, though it is able to induce a series of movements in the body. And these movements are, of course, involuntary according to the mechanism of their origin

For the sake of greater clarity we will examine somnambulism from this aspect. The beginning of the act is a certain sensory stimulation which is not susceptible of definition; its continuation is a sort of psychical notion which is vague and dull, owing to decline of sensibility; and the end is a climb over the rooftops. Does this not strikingly resemble the mechanism of fright? The only difference is that in the latter case the fright is the psychical element, while here it is probably a psychical formation of a higher order, some kind of notion. But it is only a *probability*; besides, the psychical notion is, apparently, felt less distinctly than fright. Consequently, both phenomena are indisputably similar.

At the same time this proves that all movements performed during normal sleep and in a state of delirium, even if they accrue from what is commonly called "dreams", i e., from definite psychical acts, are involuntary in the strict sense of the word, that is, reflex movements.

Since the entire psychical life of a person can be reproduced in sleep and in delirium (of course, in a distorted form), all movements acquired by learning under the influence of the mind and all habitual movements can become involuntary as regards the *mechanism of origin. I shall not* cite many examples in support of the aforesaid; let me limit myself to two that I witnessed myself. In my student days I once saw in a Moscow clinic a cook who had fallen on his head from a height and died without recovering consciousness. Early in the afternoon when the physicians were making their usual rounds, that is, at the time when before his accident the patient would be preparing meals, he could be seen making movements with his hands as if he were chopping meat with two knives, as is usually done by cooks. Here we had a movement which had been acquired by habit before the accident and which, undoubtedly, was a reflex movement by mechanism of origin. This example also indicates what it was that constituted the beginning of the reflex act; in the given case it was a sensory excitation (caused, of course, by the diverse properties of noon, inasmuch as these properties can act on the sensory nerves); the stimulus, however, cannot be exactly determined.[13] Now for the second example. A close acquaintance of mine had a habit of folding his fingers in a most peculiar manner when absorbed in thought; this habit was quite familiar to me. I happened to be present at his death, and when all the external symptoms showed that he had lost consciousness, his fingers became folded in his usual way.*

Thus decline of sensibility is a highly important factor in the brain functioning of sleepers, drunks, somnambulists, etc. Let us now see whether this factor plays any role in the functioning of the same organ under quite different conditions.

As is known, in the absent-minded person, or in a person whose mind is concentrated on a strictly definite thought, the capacity for sensation is in many respects (though not in all)

* There is a highly illuminating experiment with a decapitated frog which shows how the habitual movements of the normal frog are manifested in the nature of its reflexes upon decapitation. A decapitated frog sitting with its hind legs tucked under its belly will, in response to a pinch on the legs, immediately extend them. On the contrary, if the hind legs are extended, the pinch will cause the frog to bend them and to pull them up under the belly. If the pinch is a strong one, the frog will in both cases make a jump. The point is clear: under normal conditions any pinch would impel the frog to escape; but in the given case its reaction is proportionate to the strength of the sensory stimulation: when it is weak, the frog makes, as it were, a half jump. Hence, when the legs are bent it extends them, and, on the contrary, when extended it bends them. Essentially both movements represent the beginning of a jump.

more or less dulled. If, for example, a person is listening attentively to something, he hardly notices what is going on before his eyes, and vice versa.

In people possessing the faculty of profound concentration, sensibility to external influences is sometimes dulled to a surprisingly high degree. It is said, for example, that a man in the grip of a fixed idea feels neither cold, hunger nor acute pain when his mind is concentrated on the idea. Generally speaking, dulled sensibility to certain external influences is always observed in man when his mind is preoccupied. On the other hand, it is a well-known fact that it is precisely those influences to which the sensibility is dulled that induce movements with particular ease. These movements are either completely unnoticed by the individual who is absorbed in his thoughts, or they produce in him very vague sensations. In any case the movements are involuntary to such a high degree that even the layman usually calls them "automatic". And it will be appreciated that from the point of view of their mechanism of origin all such movements must be included in the category of involuntary, no matter whether they produce sensations or not.

From what has been said the reader will probably agree that habitual contractions of the muscles of the body which generally impart a definite mould to each individual and which in most cases are fully independent of mind and will, also belong to the category of reflexes despite the fact that the two afore-mentioned factors (mind and will) participate in their development. Such, for example, are the habits of an open mouth, protruding lips, blinking, holding the head sidewise, nail biting, nose picking, winking, etc.

From the point of view of their mechanism these movements are always involuntary, if they are effected without participation of the intellect.

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I have now exhausted the sphere of involuntary movements in our interpretation of the term.

To conclude the chapter I shall briefly summarise the results of our study of these phenomena.

1) Every involuntary movement is the result of a more or less distinct excitation of a sensory nerve.

2) A sensory excitation which induces a reflex movement, may, at the same time, evoke certain conscious sensations; the latter, however, are not indispensable.

3) In a pure reflex, which is not accompanied by any psychical elements, the relationship between strength of excitation and intensity of the resulting movement remains the same in the given conditions.

4) If the reflex is complicated by a psychical factor the relationship may fluctuate in one or in the other direction.

5) The reflex movement comes quickly in the wake of the sensory excitation.

6) The reflex movement more or less corresponds to the sensory excitation in duration, especially if the reflex is not complicated by the psychical elements.

7) All reflex movements are expedient from the point of view of preserving the integrity of the organism.

8) The specific properties of involuntary movements described above are equally peculiar to the simplest and to the most complex reflexes—to abrupt movements of several seconds' duration as well as to a series of successive reflexes.

9) Frequent repetition of a reflex in one and the same direction is caused either by the presence in the body of a definite inborn mechanism (for example, the mechanism of sneezing, coughing, etc.), or is the result of learning (for example, the act of walking) which is achieved with the participation of the intellect.

10) If normal sensibility is dulled in the sphere of one, several or all senses (sight, hearing, smell, etc.), then all the movements caused by these senses—no matter whether acquired by learning or not, whether connected with psychical notion or devoid of it—are, invariably, reflex movements from the point of view of the mechanism of origin.

11) This mechanism is formed by sensory and motor nerves, by cells located in the cerebral centres and originating these nerves, as well as by processes which these cells project into the brain and along which the latter influences the reflex movement, intensifying or weakening it.

12) The functioning of this mechanism constitutes the reflex.

13) The mechanism is brought into action by excitation of the sensory nerves.

14) Hence, all involuntary movements are mechanical in origin.

All the above-mentioned properties of involuntary movements must be kept in mind if we do not want to get lost in the extremely intricate world of voluntary movements to which we shall now proceed.

## Chapter Two

## *VOLUNTARY MOVEMENTS*

Solving the question of the onset of a psychical act—Inhibition of conscious movements.—Emotions.

§ 10. Before turning to voluntary movements I must warn the reader that the lack of physiological experience in this sphere will be felt *very frequently and that at times I shall have to deviate* from the role of physiologist. I believe, however, that even in these difficult cases I shall adhere to the custom of naturalists—frankly admit my lack of knowledge and frame my hypothesis only on the basis of strictly established facts. Hence, much will remain unsaid; however, that which I shall expound will be fairly well grounded. I hope that the complexity of my task will dispose the reader to show forebearance to this first attempt to interpret the phenomena of voluntary movements as *the machine-like activity of a relatively simple mechanism. My* task, then, will be: to explain by means of the anatomical scheme already known to the reader *the external activity of a man with* an ideally strong will (it should be borne in mind that this external activity always boils down to muscular movements), acting according to some high moral principle and perfectly conscious of everything he does—in short, activity which is voluntary in the highest possible degree.

Thus, we have to prove:

1) *that this particular human activity consists of reflexes which* begin with sensory stimulation, continue in the shape of a definite psychical act and end in muscular movement;

2) that given definite external and internal conditions, i.e., the environment in which the action takes place and the physi-

ological state of the individual performing the action, one and the same sensory stimulus inevitably calls forth the other two elements of the phenomenon and always in the same direction.

But before outlining a scheme which may help us to accomplish these tasks, I shall try to show in a few words that the final component of any voluntary act—muscular movement—is essentially identical with the activity of muscles in pure reflexes, i.e., in elementary involuntary movements. Physiology maintains that there are no special motor nerves and muscles for voluntary movements. The same nerves and muscles which produce the purely involuntary movements act also in the case of voluntary movements. If there is any difference between the two acts it is solely in the external character of muscular contraction, i.e., in a more or less rapid contraction of one muscle and in a greater or lesser contraction of another. The reader is already aware that the countless animated features of complex muscular movements can be reduced to diverse combinations of the above-mentioned mechanical properties of muscular activity.

Consequently, that part of the reflex mechanism which consists of the motor nerve and muscle is likewise capable of producing voluntary movements.

Let us first try to find out how a voluntary movement is evoked, i.e., how excitation of sensory nerves begins.

Then we shall establish whether the process projecting into the brain and inhibiting reflexes, participates in the voluntary movement and how this participation is effected.

We shall investigate the same with regard to similar processes which intensify reflexes.

And if all the features of the most voluntary of all voluntary movements are established as a result of this examination, we shall consider our task as having been completed.

The reader will require first of all a list of the properties of a typical voluntary movement. Here is a key which will help in the matter: the reader should keep before him the properties of involuntary movements enumerated at the end of the preceding chapter; he should simultaneously clearly imagine the manifestation of a certain external activity of a person with an ideally volition, and, on the other, because I did not want prematurely to approach this phenomenon from the standpoint of an observer, believing, as is customary, in the voice of self-consciousness. I will now, however, approach the problem critically and proceed to examine the first point.

§ 11. Is it really the case that voluntary movement does not derive from sensory excitation? And if there is sensory excitation, why is it disguised in typical manifestations of voluntary movement?

I must warn the reader that my answer will not be a brief one, because instead of directly analysing the highest type of voluntary activity I shall have to trace its development from birth and investigate the less perfect types.

The reader will, of course, insist that I should first of all justify this method, i.e., prove that it will really lead to our goal.

Here are my arguments in favour of it. All people without exception judge a man by his external activity. But character, according to the generally accepted point of view, develops gradually from the cradle, and it is contact with life, i.e., upbringing in the broad sense of the term, which is of greatest importance in this development. Hence, voluntary movements develop in the same way.

Man is born with a tiny number of instinctive movements in the sphere of the so-called animal muscles, i.e., muscles of the head, neck, arms, legs, as well as those muscles of the trunk which cover the skeleton from the outside. He can open and close his eyes, suck, swallow, scream, cry, hiccup, sneeze, etc. All other movements of the arms, legs and trunk are undoubtedly also of a reflex origin.

The sphere of sensations in the new-born child is also limited, because the infant cannot see, hear, smell or touch. This is easily proved: these acts require the activity of definite groups of muscles which cannot be controlled by the new-born child. For example, to see an object before the eyes it is essential that the optical axes of both eyes should cross on the object; but this can only be effected with the help of the muscles which turn the eyes in all directions. The new-born child cannot do this: its look is always uncertain, i.e., it is not fixed on definite objects.

Neither, of course, has anyone ever observed smelling movements in an infant. But with the passage of time the child learns to perform these movements. I shall now dwell in detail on the process by which the child learns to see objects clearly, since it serves as an example of elementary training of the senses.

But before doing so I shall dwell on some facts relating to the structure of the eye, otherwise the reader would have difficulty in understanding me.

At the bottom of the eye, opposite the pupil, the optic nerve ends in the shape of a continuous membrane. Objects situated before the eye are impressed on this membrane just as on a photographic plate, these impressions being an indispensable condition for vision. However, not all parts of the membrane are equally sensitive to light; the most powerful sensation of light arises only when the image of the object falls on that part of the membrane which lies on a line determined in the following way: if an adult looks with both eyes at an object situated before him and if straight lines are drawn from the object to the centres of his pupils and then mentally prolonged into the eye, the lines will fall on that part of the membrane which is most sensitive to light. These lines are known as the optical axes. Consequently, to direct the optical axes of both eyes to the given object, i.e., to learn to see it clearly, means focussing the eyes in relation to the object in a way that gives the clearest possible perception of the object. The process by which this art is acquired is obvious. Brightly coloured objects are usually held before the child's eyes; roaming in all directions the eyes receive light sensations of varying intensity; the strongest sensations arise when the optical axes fall on the object. The infant's brain is so constructed that the brighter the light the greater the pleasure. Because of this the child, without thinking, i.e., involuntarily, tries to keep its eyes in the position from which it derives the greatest pleasure. This is repeated not once or twice, but thousands of times until the art of seeing objects clearly is mastered.* Muscular movement, which here plays a decisive role, is always an involuntary act developing in the given direction under the

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influence of habit, i.e., frequent repetition of the movement in one and the same direction. Consequently, the primary act of vision even in the adult is involuntary, though it is acquired by learning.

The structure of the optical membrane, certain parts of which perceive light better than the other parts, is responsible for another involuntary act the psychical aspect of which, in its highest degree, is described as "attention in the sphere of visual sensations". It is expressed by the clarity of perception of the image on which the attention is focused (at which the person is looking, or to which his optical axes are directed), as well as by decline in sensibility to the surrounding objects sometimes resulting in their complete disappearance from the field of vision. I will cite an example concerning the physiology of the eye, one that convincingly proves what I have just said. If the reader has never read anything about the physiology of the eye, he will, naturally, doubt my statement that when we look closely at a certain object all other objects lying nearer or farther than the fixed one seem doubled. He can convince himself easily enough: it suffices to pay attention to this phenomenon and focus one's look on a definite object without moving the eyes from one object to another. Once you become convinced that what I have said is correct, try to recall whether there were moments in your life or in the life of any of your acquaintances (with normal sight, of course) when conscious efforts had to be applied against double perception of objects in the vicinity of the one on which the eyes were focused. No one has ever experienced such moments; hence, the disappearance of these objects from the field of vision is due to a certain organic cause which does not depend on will. Hence, that which is described as attention in the sphere of visual sensations is an involuntary act. In essence, visual attention is simply convergence of the optical axes of the eyes on the object observed. Attention to an object situated before the eyes evokes, according to experimental psychology, a clear sensation; according to physiological investigations, this sensation includes the colour, configuration and corporeity of the object, which means that it can be rightfully raised to the level of notion

Thus, the development of notion does not depend on will. This psychical act is caused by stimulation of that part of the optical membrane which is most sensitive to light.

*Let us now see what follows sensory stimulation of the optic* nerve.

An impression of light always produces in the infant a more or less extensive reflex muscular movement. When, for example, *a brightly coloured object appears before its eyes, it yells, laughs,* flails its arms, legs, and the entire body; clearly, then, reflexes from the optic nerve are possible in all the animal muscles of the child's body. This is a highly important factor: it means that infinitely diverse body movements, induced by endless combinations of the muscles into groups, can develop under the influence of visual sensations; besides, this condition makes possible *the association of visual sensations with the tactile and muscular sensations.* Actually the hand is the chief tactile organ in man; by means of reflexes from the optic nerve the hand is brought into motion and when encountering external objects calls forth tactile sensations in the broad sense of the word. A long period must pass, however, before the child learns to feel with its hand; at first it cannot even hold an object which is *placed in its hand, although the hand clutches at the object involuntarily.* In any case, it is a well-known fact that visual sensations are easily associated with tactile sensations, with the result that in our notions of the form of bodies (round, cylindrical) as well as of their smoothness or roughness, etc., both kinds of sensations merge. Moreover, it is clear that in essence these complex notions do not differ from the most *elementary sensations. But before going further I shall enumerate* the processes which take place in the development of a complex optical notion.

| | |
|---|---|
| *Impression of light.*<br>Vague sensation of light.<br>Contraction of the muscles which move the eye and adapt it to distance. | First Reflex |
| The action of light continues.<br>Clear sensation.<br>Movement of arms and legs. | Second Reflex |

The hand encounters the visible object.

Hence:

Tactile impression and—<br>Tactile sensation producing<br>the movement of the hand<br>which grasps the object } Third Reflex

This example does not necessitate further explanation. Any optical notion already complicated by tactile sensations can be further complicated by sensations belonging to the sphere of other sense organs. Among these associations the optico-acoustic plays a particularly important role in the development of man. So let us now pass to the process by which hearing is trained.

Aural attention, or listening, is an involuntary movement acquired by learning. Its outward manifestation is approximately the same in man and animals: the ear is placed in a position which is most favourable for the action of sounds on the ear-drum. This act is similar to the act of convergence of the optical axes on an object in vision. Aural attention is manifestly confined to this external act when separate simple sounds, even the faintest, are perceived. It is a different matter when the sounds are combined into words. In this case the mere external act of listening does not suffice for clear perception. You have, for example, learned the English language perfectly; you understand what you read and pronounce the words correctly, but you have never lived among Englishmen. When you listen to their speech, you do not understand a single word, no matter how intently you listen, but should you spend a month among English people you would soon begin to understand every word. How this occurs we shall see later; but now the reader will agree that attention of this kind is also a matter of habit and a perfectly involuntary act.

From what has been said it is clear that the hearing of the new-born child is approximately in the same state as, say, the hearing of a Russian peasant in the society of Englishmen. In both cases a long time passes before they learn to listen to words. In the case of the child this state is expressed in the fact that it begins to babble. To put it in another way, reflexes from the organ of hearing to the muscles of the breast, larynx, tongue, lips, cheeks, etc. (i.e., muscles participating in speech), hitherto unco-ordinated, begin to assume definite shape. As is known, persons who are deaf from birth never learn to combine sounds into words; this proves what I have just said in a most convincing way[14]. However, the faculty of hearing words is but one of the conditions necessary for articulating sounds. Recall how much time passes from the child's first word "mamma"* until it begins to speak. A decisive role in speech development is played by the child's instinctive desire to imitate the sounds acting upon its ear—by mimicry which in respect of hearing it shares, among animals, particularly with birds. The process of articulation of sounds and their combination into words is, of course, similar in the child and in the parrot. Essentially it consists in association of sensations caused by the muscles of speech during contraction with aural sensations induced by the sounds of the individual's own speech. In any case there is no doubt that such acts, being involuntary as to the mechanism of their origin, belong to the reflexes acquired by learning.

In the vocabulary of the child, as well as of the overwhelming majority of adults, there is not a single word that has not been acquired by learning—either orally, or in written form. That, I think, needs no proof; it suffices to compare, say, the vocabulary of a ten-year-old boy who is being taught foreign languages and other subjects, and the vocabulary of an eighty-year-old illiterate peasant who has never left his native village.

Thus, the process of articulating sounds is actually the same in the child and in the parrot. But what a difference in their faculty of speech! While the parrot learns to pronounce only a few phrases in ten years, the child learns thousands. The parrot pronounces the words in a purely mechanical way, whereas the speech of the child, even at a very early age, bears, so to speak, an intelligent character. The latter is determined mainly by the association of aural impressions with visual and tactile ones;

* From the standpoint of the mechanism of its origin the word "mamma" is the simplest; to produce the syllable *ma* it is sufficient simultaneously to make a sound with the larynx and to open the mouth, while all other muscles regulating sound and speech remain absolutely inert.

the more diverse the forms of this association, the more pronounced is the intelligence of speech.

When an animal or a child hears a sound, the reflexes from the stimulated auditory nerve include the turning of the face in the direction of the sound and the movement of the muscles which turn the eye-ball. The first movement is the act of listening, since sound acts best on both ears when the face is turned towards the source of the sound; the second movement leads to visual sensation. It is these two successive reflexes, acquired by learning, which constitute the elementary form of the visual-aural association. Consequently, the process is the same as in the combination of visual and tactile sensations. This can be illustrated by an example. I shall revert to the example of visual-tactile association and introduce into it an aural sensation (see page 79). Let us suppose that the object grasped by the child is a bell. In this case along with the muscular-tactile sensation caused by grasping the bell there takes place stimulation of the auditory nerve, followed by the sensation of sound and by a more or less extensive reflex movement. Thus a fourth reflex is added to the three previous ones. If this process is repeated many times, the child begins to recognise the bell both by its appearance and by its sound. Subsequently, when, as a result of learning, the reflexes from ear to tongue take definite forms, the child begins to call the bell "ding-ding". The same occurs when it learns the real name of the bell, because this name, like "ding-ding", is a conditional sound. But what is the sequel: the successive reflexes acquired by learning lead to a perfect notion of the object, to *knowledge in its elementary form.* Indeed, the scientific knowledge of external objects is simply an infinitely broad *notion* of each of them, i.e., the sum of all possible sensations evoked in us by these objects under all conceivable conditions.

I shall not touch on the subject of training taste and smell, since to do so would be to repeat what I have already said with regard to other senses. I shall merely point out that sensations from all spheres of the senses can be diversely combined, but always by means of consecutive reflexes. These combinations give rise to countless notions that arise in childhood, notions *providing,* so to speak, material for the entire subsequent psychical life. The value of this material can be summarised thus: *the child is aware, and positively so, of all the external influences surrounding its childhood; it knows them concretely, in their simplest and most ordinary forms; in other words, it knows the phenomena, as they are supplied by nature.* Finally, to show that this material already contains rudiments of higher psychical acts, I shall demonstrate that all the real substrata of the famous concept of space are already present in the child. As is known, the sole property of space is the mathematical concept of its measurability in three dimensions—length, breadth, and thickness. Everyone knows that the human eye is capable of measuring in this way. If, for example, we see before us a cube in perspective, the muscular sensations which are caused by the horizontal movement of the optical axes* crossing on the object, will correspond to the breadth of the cube; a similar movement of the optical axes up and down produces the sensation of height. Finally, the constantly changing angle of convergence of the optical axes, when we look consecutively at different points of the object lying along its depth, that is, receding from us, likewise produces muscular sensations, because the act of convergence of the optical axes is generally a muscular act. This complex process is endlessly repeated in childhood, since all objects of the external world have three dimensions. Consequently, the elements essential to the concept of space really exist at this early age.

Let me now summarise what has been said concerning the development of the child.

*By means of absolutely involuntary learning of consecutive reflexes in all spheres of the senses the child acquires a multitude of more or less complete ideas of objects, i.e., elementary concrete knowledge. The latter occupies in the integral reflex exactly the same place as the sensation of fright in the involuntary movement; hence it corresponds to the activity of the central element of the reflex apparatus.*

Analysis of concrete impressions of space and time is the next step in the development of the child. We shall now pass

* Optical axes are lines and, therefore, can cross at one point only; hence, to see a line it is necessary that the point of intersection of the optical axes should be led along the entire length of the line.

to consideration of the conditions necessary for this analysis, conditions determined by the material organisation of man; we shall then see whether psychical acts of this kind with their external manifestations can be included in the category of reflexes.

But first let us answer the following important question which we owe to the reader: Does the new-born child react passively to external influences on its senses, or is it actively striving towards the external environment? In the latter case it will be necessary to disclose the nature of this striving because being added to the environmental action on the child it is bound to influence the results of this action.

Physiology has at its disposal facts which can help to elucidate this matter. From observations of adults, children and animals it is known that the first condition for maintaining the material integrity of all nerves and muscles without exception, and consequently of their functioning, is adequate exercise of these organs; for example, the optic nerve must be under the action of light, the motor nerve must be subjected to stimulation, its muscle must contract, etc. On the other hand, it is known that when the exercise of any of these organs is forcibly discontinued, a painful feeling arises in the individual, impelling him to seek for the missing exercise. It is obvious, therefore, that the child does not react passively to external influences. It is equally clear that the child's striving towards the outer world is an instinctive, involuntary phenomenon; when this striving is satisfied, i.e., when it causes a certain movement in the child, it is a reflex in the full sense of the term. There is no doubt that complete dependence on this instinctive striving is responsible for the extreme mobility of the child which constantly passes from the exercise of one nerve to that of another. And it is this that ensures the all-round development of the sense organs and of movement. There is, however, another property, common to all nerves, one which prevents the child from concentrating too long on a single impression; this is fatigableness of the nerve, i.e., its property to become dulled as a result of protracted activity in one direction. These are, of course, well-known facts.

Thus, the nature of the phenomena ensuing from the action of the external environment on the child is not changed one iota by the additional influence upon them of the child's active striving. A new reflex is merely added to the series of others.

We shall pass now to the conditions necessary for the analysis of concrete impressions.

They include phenomena relating to the decomposition of the concrete impressions connected with one sensory sphere, as well as of complex impressions, for example, the visual-tactile-aural one.[15]

Let us suppose that a mosaic representing a man is placed before a child. First, the child sees the figure of the man—this is a concrete impression. Then it notices that this figure consists of head, neck, trunk, arms and legs. Later it begins to discern each little stone constituting perhaps a thousandth part of the entire picture. How does this ability to analyse and synthesise develop in the child?

An indispensable condition is, of course, the faculty of the eye simultaneously to perceive each point of the visible object separately and all the points together. This condition is ensured by the specific structure of the optical membrane and lies, therefore, in the material organisation of the eye.

The optical membrane on which the images of the observed objects are impressed and where all the nerve fibres of the optic nerve terminate can be compared with the surface of the photographic plate used for taking portraits. Just as the surface of this plate consists of a multitude of points situated close to one another but independent of one another with regard to the reception of light impressions, so the surface of the retina is a mosaic of separate areas. A ray of light cannot pass from one area into the adjacent ones. If to this we add that each area is to a degree the terminal of a separate nerve fibre, the reader will easily appreciate that since the image of an object on the retina covers a thousand areas, the eye sees this object as consisting of a thousand separate points. Moreover, the eye is able to see separately one definite point of the entire image of an object. This is attained by the uneven distribution of visual areas on the surface of the retina: near the point of intersection of the retina and of the optical axis these areas are situated close to one another; the farther from the point of intersection, the larger is the space between the areas. It is obvious, therefore, that the points of the object impressed on the retina where it is intersected by the optical axis are perceived more clearly than all the other points. As the reader is aware, this is an indispensable condition for visual attention.

A mosaic of a man is placed before the child. The latter can see the entire picture at once, but when the optical axes of its eyes are directed to one particular point, for example to the man's nose, the latter is seen best of all, the mouth and eyes less so, and the feet—the farthest removed from the nose—least of all.

Thus, it is possible to see simultaneously the whole and the part.

It is hardly necessary to dwell here on the way in which this ability, i.e., the habit of analysing concrete visual sensations, is developed; the reader undoubtedly understands that it is similar to that described by us for the development of concrete visual impressions, i.e., of a reflex acquired by frequent repetition.*

I shall but mention the importance of the analytical faculty of the eye for man's psychical life. It produces the impressions on which the concepts of the complexity of the external bodies of nature, of their divisibility and dimensions are based. Our concept of motion is also partly due to this analytical power of the eye. Motion is comprised of the displacement of the body in space as well as of the time spent on this displacement; but it is precisely this latter element that is missing in the purely visual impression produced by moving objects.

The tactile surface of the human body, like the retina of the eye, is divided into areas, each of which senses the touch of only one point of the external object. Like in the case of the retina, not all parts of the surface of the skin are equally sensitive to tactile stimulation. Sensitivity is higher on those parts of the skin where the surface of the afore-mentioned tactile areas is smaller—for example, the lips, finger-tips—and vice versa. At the given moment I have in my hand a cigarette with

* It is likewise clear that the laws of association between the components of a visual sensation and the impressions from the spheres of other senses are the same as those described for concrete sensations.

a cardboard mouth-piece. I press it to my lips and obtain the sensation of a ring. I then press it to the skin of my neck or back; I feel the contact of the object with my body, but cannot discern its form. It is obvious that in the first case the concrete sensation of a ring is due to the fact that I feel separately, so to speak, many points lying on the circumference of the ring, while in the second case the mouth-piece of the cigarette covers, perhaps, only one or two areas on the neck, and not even one on the back; hence, of all the points of the ring I am conscious of only one or two, which is not sufficient to receive the sensation of a ring.

Let us now imagine a body of a more complex form, say a star-shaped body; the lips and finger-tips will feel this shape too, i.e., all the corners of the star. It is also clear that the parts of an object which come into contact with the more sensitive points of the skin surface will be sensed more distinctly than the other parts. Hence, it is possible to distinguish separate components of a concrete sensation. If the surface of the object is rough, its projecting points exert greater pressure on the skin than the other points; here, too, we observe the inequality of separate elements of the sensation, or its decomposition.

The conditions for the analysis of concrete tactile sensations and the development of this capacity are manifestly similar to those described for visual sensations. The results are also the same, namely, concepts of the complexity, divisibility and dimensions of bodies. The sole difference is that man's visual analysis of the properties of external objects is immeasurably finer than his tactile analysis; because of this, persons with normal sight are guided by the former to a considerably greater degree than by the latter. Consequently, the results of visual analysis, too, are much finer and richer.*[16]

As is known, the analytical power of the ear** consists in its ability to distinguish separately each tone in the given com-

* The modifications of the sense of touch which produce sensations of hardness, softness, elasticity and temperature of bodies are not of a complex character and, therefore, cannot be decomposed.

** For the description of the analytical power of the ear from the physiological point of view I have used Helmholtz's famous work *The Sensations of Sound*.

bination of musical tones. In other words, the ear perceives combinations of sounds in a concrete way and decomposes these combinations into separate musical tones. It is also known that this analytical power develops as a result of exercise; that is why it is most developed in musicians. The physical conditions which ensure the analytical power of the ear can be described as follows:

In the part of the ear known as the cochlea the auditory nerve divides into separate nerve fibres; each fibre is connected with an elastic body—a resonating "key" (the nature of this connection has not yet been fully disclosed). It is believed that these keys, like the strings of a musical instrument, are tuned in a correct musical order and that a definite musical tone conforms to the vibration of each key. Man is supposed to have about 3,000 of these keys. Assuming that the ear is capable of discerning about 200 tones besides those used in music, we find that for the seven scales there are 2,800 separate keys, i.e., 400 per scale, or 33 $^1/_3$ per semitone. Clearly the ear is capable of distinguishing very minute parts of a semitone. It is also clear that the analytical capacity of the ear can go even farther than one thirtieth of a semitone. Indeed, if the pitch of the given tone falls between the tones of two neighbouring keys, both begin to vibrate; however, the vibration of the key closer to the given tone is stronger. Hence, the extreme limits of the differentiation lie between $^1/_{33}$ and $^1/_{66}$ of a semitone.

The concrete impression of a musical chord is explained, then, by the fact that all the keys which correspond to the different tones entering the chord begin to vibrate simultaneously. This also explains the concrete impression of *vowels* which are simply combinations of tones of different pitches. As to mixed sounds, noises, and consonants, the conditions for their differentiation have not yet been ascertained; it is supposed that noises, i.e., non-periodical vibrations of the air, are perceived by another part of the auditory nerve located in the extensions of the semicircular canals.

In any case aural analysis is due to the difference of the nerve fibres which receive separate elements of the acoustic impressions. Actually the mechanism here is the same as in the eye.

In one respect, however, aural sensations differ entirely from visual ones.

The following example will illustrate the point. If a certain sound, say, a musical tone, is perceived by a person, the latter quite easily determines its duration and distinguishes the sound by means of its attributes—abrupt, prolonged, very long, etc. In general, the sensation of sound is of a protracted character; this means that our hearing perceives a sound concretely, and at the same time is conscious, so to speak, of each separate moment of this sound. Hearing is an analyser of time, while the organ of sight—in the narrow sense lacks this capacity: no matter how long rays of light act on the optic nerve, the sensation of light itself is by no means protracted. For example, we cannot say in any language: "the sensation of red, white or blue was durable". If we say that a glance, like a sound, can be abrupt, protracted, very long, etc., this does not apply to the visual sensation itself, but to the muscular apparatus of the eye controlling the glance, i.e., to the convergence of the optical axes on the given object and to the adaptation of the eye which is also a muscular act.

The ability of the ear to sense the duration of a sound is an indispensable condition for the analysis of sounds in time. Actually, this analysis consists in the ability to concentrate on separate phases of the sound, which now increases and decreases in volume, now changes the periods or forms of vibrations. Singers have this ability to the highest degree. The same ability underlies, of course, our manner of speaking: we drawl one syllable to a greater, another to a lesser degree, while a third is pronounced abruptly. Even very young children can do this. Obviously, it is acquired in the same way as the capacity of articulating words in general, i.e., as a result of frequent repetition of a reflex in one and the same direction.

Taste and olfactory sensations are decomposable only to a very limited degree (various tastes and smells). As to muscular sensations, their analysis differs greatly, in the nature of the process, from the decomposition of concrete visual and aural sensations. I shall illustrate this idea by examples. *First example:* As is known, a singer knows beforehand, i.e., prior to the formation of the sound, how to arrange the voice controlling muscles in a way that produces the desired tone; he can even sing silently to himself, so to speak, any song he knows, simply by moving the corresponding muscles. Clearly this ability is based on the same analysis of muscular movements in time as in the case of sound analysis. *Another example*: When we bend the arm at the elbow, we are conscious of doing so without the help of the eyes; moreover, we are conscious of the different phases of this process, i.e., we know when the bending is slow and when it is quick; finally, we can even know—again without the help of the eyes—at what phase of the act of bending the arm has stopped moving. It is clear that man can analyse his muscular sensations not only in time, but also in space. From these examples one might conclude that in analysis of the sensations muscular sense combines the properties of eye and ear. Everyone will appreciate, however, that muscular sense itself can analyse its sensations only in time and, as we shall see shortly, even this capacity develops subject to the participation of audition and vision, as well as to frequent muscular exercise; it follows, therefore, that this is an acquired capacity. This is partly due to the fact that muscular sense as such, i.e., the sensation produced by a contracting muscle, is in itself extremely vague and weak; it is much less pronounced than any olfactory or taste sensation. Consequently, additional factors must participate in developing its specific properties, which (judging by the external nature of muscular movements), are present already in childhood. The following well-known facts show that muscular sense cannot analyse its sensations in space. Many anatomically separated muscles participate in the act of respiration, i.e., in expansion and contraction of the thoracic cavity; the concrete sensation produced by contraction of the respiratory muscles reaches our consciousness, but we are unable to single out from this combined sensation that which corresponds to each contracting muscle taken separately.

The same is true for all the movements produced not by a single muscle, but by groups of muscles. It is a different matter when the activity of one muscle separates from the activity of a number of muscles which up to the given moment had been functioning simultaneously, i.e., jointly, and when this single muscle is exercised frequently in one and the same direction;

in this case the sensation induced by contraction of this muscle must of necessity become increasingly definite in man's consciousness (let the reader imagine the act of bending one finger as separated from the act of clenching the fist). Thus, the muscular act of converging the optical axes of the eyes—one of the most frequently repeated acts—imparts to our consciousness almost the clearest of all muscular sensations. From what has been said it will not be difficult to understand the nature of the process by which an elementary muscular sensation is separated from a concrete muscular sensation, or—what is actually the same—the process of separating the activity of a single muscle from the combined activity of many; *instinctive imitation by the child of what it sees and hears gives rise to* this process, while exercise of the sensation due to frequent repetition is the means by which it is developed.

The examples of silent singing and of bending the arm at the elbow can be fully explained from this point of view. The first is based on a musculo-aural association, the second on a *musculo-visual association. It is probably because of this that* in the latter case the muscle is capable of determining spatial relationships.

Thus, thanks to the faculty of instinctive aural and visual imitation, the child, through frequent repetition of the same *reflex, develops the activities of different groups of muscles.* This makes its speech articulate; at the same time its external body movements become intelligent. Such, in general outline, are the results of the analysis of muscular sensations.

In conclusion, I should like to repeat that parts of concrete notions from all sensory spheres can be associated with each other or with the sum of concrete notions in exactly the same way as the latter are associated with each other (i.e., by means of habitual reflexes). The reader will appreciate that the number of psychical acts is, therefore, increased many thousand times.[17]

Having *considered the conditions, process and consequences* of the decomposition of visual, aural and other notions, I shall now proceed to the analysis of complex concrete notions, i.e., with their decomposition into pure components (the process of disassociation). A few examples will elucidate this question.

In the act of seeing purely visual sensations are usually associated with muscular sensations evoked by contraction of the muscles which move the eyeballs and adjust the eyes. These two sensations differ greatly. Purely visual sensations are of an absolutely objective character: although the external objects acting on the eye cause changes in the optic nerve and in the brain, i.e., in certain parts of the human organism, they are, nevertheless, always conceived by man as being outside his body. Muscular sensations, on the contrary, are of a purely subjective character—they reach man's consciousness in the shape of some kind of effort. To disunite the two sensations means to be conscious of each separately. This necessitates what is usually called attention to both. It is known, further, that attention can be concentrated easiest on the stronger sensation. Hence, for the development of disassociation it is necessary that in the complex act of seeing either the visual or the muscular sensation should be stronger. These conditions actually exist. In the daytime when we look at objects situated not too far and not too near, the visual sensation is in general incomparably stronger than the muscular one. But when the light is weak and the contours of the objects indistinct, when the object is too near to the eye, or too far from it, the reverse is observed. Thus the process of disassociation of a complex sensation also arises from the frequent repetition of the act of seeing under different conditions, this act being of a reflex nature.

The concept of the roughness of an object is of a visual and tactile character. Here, too, the process of disassociation of sensations is attained by strengthening one component at the expense of the other. Our hands encounter objects with rough surfaces both in the daytime and in darkness, and often independent of our vision. In this last case it is the vividness of the sensation that makes many people instinctively close their eyes when they want better to feel an object.

The decomposition of visual-aural associations is, of course, subordinated to the same laws. It should be pointed out that in most people, owing to the conditions under which their senses develop, aural sensations are much stronger than visual ones. The talks between mother and child, the tales which the child hears, and generally the fact that within a definite space of time it is possible to hear the names of considerably more external objects than can be actually seen, strengthen aural sensations compared with the visual. Because of this, most people in most cases think not in images, but in words, and many objects are known to man only by hearsay, i.e., partly.

When analysing associated sensations man for the first time meets his own self. Separation of all that is subjective in the sensations gives rise to self-consciousness. It is not my purpose here to trace the development of self-consciousness step by step. I shall indicate only the main factors responsible for its formation, and try to convince the reader that self-consciousness is also based on a more or less complex reflex.

The question is: How does the child learn to distinguish between the visual, aural and tactile sensations which it receives from its body, and the visual, aural and tactile sensations which it receives from the outer world, predominantly from other people?

Let us begin with vision. The child sees its hand, say, ten times a day and the hand of its mother an equal number of times.

To be able to see its hand distinctly it holds it at a definite distance from the eyes. This is accomplished by means of an acquired reflex. Thus, the child associates the visual sensation of the hand with the sensation of its movement. But to see the hand of the mother the child must perform another movement: it must, for example, come closer to the mother. As long as the different associations are few, the child, of course, cannot distinguish its own hand from its mother's. But as the number of associations increases under diverse conditions their distinguishing features become more pronounced and the mind begins to differentiate between two similar objects. This process goes still further: the child sees a toy in the hands of its mother and no less often in its own hands: the first of these sensations is simple, while the other is joined by tactile and muscular sensations. This is repeated thousands of times. The two acts begin to separate from each other, with the result that the child becomes conscious of its own hand (this phenomenon acquires a tinge of self-consciousness).

The conditions for distinguishing one's own voice from the voices of others are strongly pronounced, though both sensations are purely subjective. One's own voice is invariably accompanied by sensation in the vocal muscles, the voices of other people are not. Besides, an external sound reaches the auditory nerve mainly because of the vibration in the eardrum; faint sounds, for example, are transmitted to the auditory nerve exclusively in this way; on the other hand, transmission to the auditory nerve of the faint sound of one's own voice is largely accomplished through vibration of the bones of the skull which imparts a peculiar character to the sound. So here, too, the principal and final condition for distinguishing one's own voice from the voices of others consists in analysis of the musculo-aural association. And since the process of disassociation develops by way of repeated reflexes, the main elements of self-consciousness are the consequences of the same acts.

Add to the above the multitude of muscular sensations, always of a subjective character, which must fill the mind of the child, and you will appreciate that the psychical act of separating man's own self from the surrounding world takes place already at an early age.

The phenomena of self-consciousness include also the indistinct, obscure sensations which accompany the processes going on in the organs of the thoracic and abdominal cavities. Who, for example, has not experienced the sensations of hunger, satiety and repletion? Even insignificant disorders of the cardiac activity cause changes in man's temper; in nine cases out of ten the nervousness and irritability of women are caused by morbid states of the womb. These facts, common in human pathology, clearly point to the association of these obscure sensations with those induced by the sense organs. Unfortunately, this problem is extremely difficult to elaborate, and a satisfactory solution of it is still awaited. Its solution would be of vital importance, because the sensations we are now discussing are inherent in man, are repeated more frequently than all others, and are numbered among the most powerful factors of man's psychical development.

This capacity of the sense organs to perceive external influences in the shape of sensations, to analyse the latter in time and in space, and to combine them fully or partially into diverse groups is the sum total of the means which govern man's psychical development. But the reader acquainted with psychological literature will ask: What about the process of generalising concepts? What about the transition from lower to more generalised concepts, the combination of concepts into series, and finally, what about the products of the so-called commensuration (or comparison) of psychical acts in consciousness? The answer is that all these processes are covered by what has been said above. This can be proved by a few examples.

1) As is known, "animal" is a very general concept. Different people have different notions of the animal. Some people say that animal is what breathes; others connect this concept with freedom of movement; still others add sensitivity to movement; and finally, naturalists not so long ago believed that the simplest, and consequently typical, form of animal (*Protozoa*) is a cell —the tiny particle which constitutes the basis of all tissues of the animal body. It is obvious that although these notions are different, they have a common feature: all are notions of certain parts of the animal organism, i.e., all are products of analysis.

2) "Time" is usually regarded as a very general concept, because it implies very little reality. But it is precisely this circumstance that shows that it is based only on one part of a concrete idea. Actually, sound and muscular sensation alone give man the idea of time—and not by their entire content, but by one element only, namely, the duration of the sound and the muscular sensation. A certain object is moving before my eyes; following this object I gradually move either head or eyes, or both; in each case the visual sensation is associated with a protracted sensation of the contracting muscles; I say: "the movement is durable like a sound". In daytime man either moves himself, and thus obtains protracted sensations, or he sees the movement of other objects, which leads to the same results; finally, he hears lasting sounds (olfactory and taste sensation are also protracted). Hence, the day lasts like a sound, the year lasts like a sound, etc. If we separate the feature of durability from the concrete notions of movement of the day and of the year, we shall obtain the concept of time. Thus, here again we have the process of decomposition of the whole into its component parts.

3) The concept of "size" is usually regarded as the product of commensuration of two notions in our consciousness; this process is believed to be based on the specific faculty of comparing and drawing conclusions. The real explanation, however, is much simpler. Analysing concrete visual impressions millions of times, the eye becomes accustomed to the difference of sensations between the whole and the part in all respects and, consequently, also in respect of size. The child associates these acts with the aural sensations which identify these relations, and learns thereby to distinguish the dimensions of objects and to say which object is bigger and which is smaller. The concept of the size of the whole and of the part is subsequently cleared up by the difference in the tactile sensations which are combined with the visual. Finally, the moment comes when the difference is absolutely clear. Physiologically this moment may be described thus: The child has learned to distinguish between the number of optical areas on the retina covered by the image of an entire object and by part of it. Then, it distinguishes also the size of two separate objects impressed on the retina: the object whose image occupies a greater space on the retina is larger in size, and vice versa. The child knows two objects of the same size, and observes—once, twice, ten times, millions of times—that one of the equal objects, the one farther from the eye, always seems smaller. If the concept of the real equality of the objects is firmly embedded in the child's mind, the apparent inequality will not deceive it (for example, a four-year-old child will never confuse a playmate standing nearby with its mother who from a distance gives the impression of being the same height as the girl); in the opposite case, the child, of course, will make an error.

An adult judges the size of objects in a similar way: he feels consecutively and most distinctly (owing to frequent repetition of the process) the number of optical areas on the retina which are covered by two images. It is obvious that in this case the attention is, so to speak, focused on only one aspect of the concrete visual sensation; this, too, is analysis.

As to the combination of concepts, there is no need now to explain it with the help of examples: they combine as fragments of concrete notions.

So that the reader should be fully convinced that the aforementioned means of psychical development, despite their seeming scantiness, are themselves an inexhaustible source of this development, I shall draw his attention to the limits of human associations; every day they begin at the moment of awakening and end at the moment of falling asleep. If we suppose that the duration of this part of the day is 12 hours and that each successive phase of visual sensation lasts on the average five seconds, we shall find that every day more than 8,000 *sensations* enter the eye, as many enter the ear, while an immeasurably greater number are caused by muscular contraction. And every day this mass of psychical acts forms ever new combinations, the previous ones being repeated only in certain particulars.

It would be opportune now to pass on to the question of the relationship between an association, taken as a whole, and each of the external sensory stimuli of which it is composed. This, however, would be incomprehensible to the reader not yet acquainted with the *so-called acts of reproduction* of various sensations in human consciousness, i.e., images, sounds, tastes, etc. We shall, therefore, dwell for a while on this question. Its essence is this. Man, as is known, possesses the faculty of *thinking in images, in words and in other sensations* not directly connected with the factors that influence his sense organs at the given moment. Consequently, images and sounds are formed *in his consciousness without the participation of corresponding* real images and sounds from the external world. But since these images and sounds have already been seen and heard by him, the capacity to think in these images and sounds without the corresponding external substrata is known as the *capacity of reproducing sensations.*

To elucidate this phenomena, we must, apparently, deter *mine the conditions whereby sounds, images and all other kinds* of sensations are preserved in the nervous apparatus in a latent state during the interval between the emergence of the actual sensation and the moment of its reproduction; the conditions of the reproduction, too, must be determined.

The idea that sounds and images are preserved in the nervous apparatus in a latent state is no fancy: this preservation is, so *to speak, the beginning of reproduction. Should the actual sen-*

sation end with the removal of the external substratum, there would be nothing to reproduce. The reader has probably guessed that what we have in mind here is memory, i.e., the force—still obscure to psychologists—on which all psychical development is based. Indeed, if this force were non-existent, every real sensation would not leave any trace, and we would experience its millionth repetition in exactly the same way as we did the first time, the analysis of concrete sensations with its consequences and psychical development in general would be impossible. This force, therefore, participates in every second, third and all subsequent elementary sensations right from the first minutes of man's life. That is why it should have been mentioned long ago; however, for the sake of greater coherence I deemed it advisable to present the entire subject at once. For this purpose I had first to acquaint the reader with the relationship between sensation, notion and concept from the point of view of their content. The study of memory to which we now pass will show how a pure concrete sensation is differentiated when entering into connection with similar preceding sensations; how it becomes connected subsequently with pure sensations from other spheres; and finally, how fragments of concrete sensations are interconnected. The study of the basic conditions of memory is a study of the force which links the preceding with the subsequent. Thus, memory covers all the psychical reflexes, beginning with the simplest and ending with those associated during the whole day.

What, then, is memory in its simplest, primary form?

I shall answer by citing an example. Suppose, a new-born child sees a table; this lasts for a moment, and then the infant does not see it for ten minutes; it reappears afterwards before the child's eyes, and again a more or less considerable interval follows. The child then falls asleep for the night. The next day the same thing is repeated. It would seem that every day and even every time the child should sense the same object just as it did for the first time; but the experience of centuries (with adult people who see the same objects over and over again) shows the opposite: the sensation becomes clearer and clearer. It is obvious that the nervous apparatus undergoes an increasingly profound change with each new influence encountered; between two successive influences these changes are retained by the nervous apparatus for a more or less considerable time. The capacity of retention must be inborn and, consequently, has its source in its material organisation. Are there any indications of this capacity in the physiology of the nerves?

Yes, there are. This capacity has been studied predominantly on the optic nerve, as well as on the motor nerves. Its essence can be described as follows (I speak of the optic nerve only): any stimulation of the optic nerve by light, no matter how brief, always leaves a pronounced trace which persists in the form of a real sensation for a more or less considerable time depending on the duration and strength of the actual stimulation.* Given ordinary stimulations, i.e., stimulations of average intensity and duration, the visual traces *(Nachbilder)* last for a few minutes only; in the child many hours of visual rest intervene between the last visual impression of one day and the first visual impression of the next. It would seem, therefore, that the visual traces are of no importance for the explanation of the matter. However, this conclusion, despite seeming infallibility, would be too hasty. To make the reader revise it, I shall first of all remind him that ever since the appearance of man all the way to the first half of this century, i.e., to the time when *Purkinje*[18] first published his works on visual traces, these traces, though for thousands of years they remained unnoticed, have always existed in human eyes. Hence, the absence of a clear sensation (in our case of a visual trace) by no means proves that excitation of a nerve ends when this sensation disappears. Theoretically it should persist for long, gradually and steadily diminishing. There is a belief—an essentially wrong one—that one or two drops of water cause no injury to a rock; we know that one drop of water after another can in the end wear away any rock. But, to return to the sphere of the eye, I shall give a striking example showing how defects of the eye can be corrected by influences which when considered separately are insignificant, but which produce a powerful effect when infrequently repeat-

* The reader interested in this subject can find the necessary particulars in any German textbook on physiology, in the chapter dealing with vision. The best exposition was given by Helmholtz, the greatest physiologist of this century, in his famous work on physiological optics.

ed. As is known, short-sightedness can be corrected to a degree by making the individual concentrate on objects situated at gradually increasing distances. On the other hand, it is common knowledge that when a person constantly works with small objects he becomes short-sighted. It is obvious that despite the fact that at night the eyes are at a state of rest and that during the day more or less long intervals intervene between separate acts of seeing, each act effects a change in the eyes which remains until the subsequent act begins. But who can determine the magnitude of each change?

Thus, the idea that the visual traces persist for a long time after the disappearance of the clear subjective sensation is perfectly justified.

The fact that visual sensations gradually become clearer as a result of frequent repetition in one and the same direction has been proved by direct experiments, although the nature of this perfecting of our vision still remains an enigma. It has been established, for example, that the capacity of the eye to distinguish two closely situated points or lines greatly increases (of course, to a definite limit) as a result of exercise; it is *this capacity that forms the basis of our clear vision of flat images.* It is noteworthy that the adult eye can be perfected by exercise incomparably quicker than it loses what it has acquired after the exercise is discontinued. It takes hours to learn but days to forget. These facts testify also to the capacity of the optic apparatus to preserve sensations in a latent state.

If it is possible to explain the preservation of sensations in a latent form for the duration of one night, then it should likewise be possible to explain their preservation for a number of years. Indeed, what objects does the child remember? It remembers only those which are often before its eyes; the infant soon forgets even its mother should she die. The reader may ask: How can you explain that an adult who having seen another person only once in his life, and then only briefly, recognises this person ten years later at a second meeting? It might seem that preservation of traces is out of the question here, but actually preservation takes place in this case as well. An adult, upon meeting another person even for a short time, receives from him a multitude of diverse sensations; the facial expression of the person, his features, pose, gait, manner of speaking, sound of voice, the subject of conversation, etc.—all remain in the memory for a more or less considerable time, depending on the strength of the impression; in the end, however, the traces of the impression begin to weaken. But one day another person is met, who along with other sensations induces one closely resembling the sensation produced by the first person. The latter sensation is revived in the memory, and becomes refreshed to a degree that it seems to be experienced anew. If these conditions are repeated from time to time, the traces remain. In the child, however, these conditions, even if they are present, are incomparably less pronounced.

Thus, frequent repetition of an actual sensation or of a reflex makes the sensation clearer, and because of this, it is more firmly preserved in a latent state by the nervous apparatus. The latent trace is preserved longer and longer, and the sensation is not so easily forgotten.

The perfecting of the optic apparatus derives precisely from these conditions. Indeed, if a given sensation is firmly preserved in a latent state, a very insignificant external hint is sufficient to reproduce it in the consciousness. This is proved by everyday experience and leads to the conclusion that if the optic apparatus has been exercised in one direction for a long time it can be brought into the customary state of excitation even by the most insignificant stimulus.

What has been said of concrete visual sensations is undoubtedly true of their parts, i.e., of separate sensations obtained by means of analysis. The reader will recall that fractional sensations are in their nature identical with concrete sensations.[19]

There are two other features of memory resulting from this main property of preserving sensations in a latent state: the memory of a vivid sensation is stronger than that of a weak one, and the more recent the sensation (the fresher the impression) the stronger the memory of it. These two features are easily explained from the point of view of the capacity of the optic nerve to preserve visual traces. If we examine only those phenomena which are connected with the onset of a visual trace, i.e., with the period when the trace still bears the character of an actual sensation, we shall easily see that it becomes stronger with the intensification of the external influence; the same is observed when the actual stimulation is more protracted, though its strength remains invariable. It is likewise easy to note that the trace is strongest immediately after discontinuance of the visual stimulation and that subsequently it steadily diminishes. The similarity of these phenomena is further proof that memory, being a property of the sensory apparatuses, is really due to the afore-mentioned consecutive changeability of the nerve under the influence of external stimuli.[20]

But the reader may ask: Why is a visual sensation preserved in our memory in its real form, i.e., why does the green colour remain green, a circle round, a triangle triangular, etc.? The question is easily answered. The reader already knows that the sensation of a circle, or of a triangle, emerges because different points of the circle or triangle simultaneously excite separate nerve fibres. Consequently, it suffices for the excitation to be preserved only in these fibres. And that is what actually takes place, since, according to physical laws, excitation cannot pass from an active nerve fibre to a neighbouring inactive one. As to the preservation in our memory of colours in the form of traces, no matter what physiological viewpoint is held by the reader with regard to perception of colours[21] (i.e., no matter whether he assumes the existence of different nerve fibres for the perception of different colours, or believes that the very process of nervous excitation varies according to the physical difference of the coloured rays of light), the traces are simply a prolongation of the actual optical excitation, though in a considerably weakened form.

But another question arises. As mentioned above, every day thousands of optical images fall upon the most sensitive part of the retina of the child's eye. Since all the images are preserved in the memory in a latent state, an incredible confusion may arise. How is this confusion averted? Only a general answer can be given to this question. Let us suppose that today I have seen the colour green 3,000 times, blue 500 times, and yellow 25 times. There is no doubt that till tomorrow the trace of the green colour will be strongest in my memory. However, tomorrow another colour may leave a deeper trace; at the same time the trace of the green will not remain unchanged. And although at sound, retains this change for a more or less considerable time, just like any other body; consequently, here, too, we have conditions for the summation of repeated acoustic effects. On the other hand, aural sensations have an important advantage over all other sensations: in early childhood they are closely associated with muscular sensations arising in the chest, larynx, tongue and lips whenever we speak. Because of this, aural memory is reinforced by tactile memory. When a child thinks, it at the same time inevitably speaks. In children of five thought is expressed by speech, whisper, or at least by movement of the tongue and lips. The same thing happens very often (perhaps even always, though in varying degree) with adults. I know this at least from my own experience: my thought is often accompanied by mute speech (my mouth remaining closed and immovable), i.e., by contraction of the muscles of the tongue in the oral cavity. But whenever I want to separate a definite thought from others and fix it, I invariably whisper it. I even have the feeling that I never think in words, but always in muscular sensations which accompany my thought in the form of speech. In any case, I am unable to sing a song mentally, I always sing it with my muscles, and only then the sounds are reproduced in my memory.

Even the parrot possesses aural memory; so there is nothing extraordinary about it. Besides, it is inconceivable that the auditory nerve should not preserve acoustic traces.

The role of traces here is essentially the same as in the case of visual sensations. They connect similar preceding sensations with similar subsequent sensations; they also unite the part with the whole in time, inasmuch as the two phases of one and the same act, which underlie the analysis of a concrete aural sensation, are repeated in a definite order. It is precisely this that gives rise to the memory for words, syllables and their combinations.

*Visual and purely tactile memory can be described as memory of space, while aural and muscular memory*[23] *can be described as memory of time.*

The reader will recall that the concepts of space and time, insofar as they are based on real impressions, are fractions of concrete visual-tactile and muscular-aural sensations.

series. An adult can distinguish between cases when external sensory excitation produces in him one corresponding sensation or notion and cases when it evokes an associated series of sensations or notions. The first occurs when an object appears before the eyes of a person absorbed in thought, bearing no relation whatever to the train of thought; although the person actually does not see the object he is vaguely conscious of its presence; this is a sensation. Given similar conditions the sensation is often so distinct that the person sees the form of the object. Finally, when an external object, so to speak, induces thought, there is an obvious reproduction of an association.

In the sphere of visual sensations there are facts which strikingly prove this law of reproduction of combined sensations. At the same time the facts clearly show the great psychological significance of the combination of sensations. These two circumstances compel me to dwell in detail on one example.

As is known, the image of an object on the retina is the smaller the farther the object is from the eye, and vice versa. It often happens that the retinal image of a small but very close object is greater than that of a large and distant object. If, for instance, we hold a finger close to the eye, it seems larger than a church in the distance. The adult, of course, is never deceived by this phenomenon: he knows from experience that the church is taller by far than he himself; so he draws *correct conclusions* concerning the dimensions of the objects which he compares. It might seem that the concept of the size of objects situated at varying distances from the eye is the result of thinking; however, the following simple experiment proves the opposite: in a dark room lit by one candle we close both eyes for a few moments; then we open one of them, look attentively at the candle for two or three seconds and close it again. The image of the candle will remain for some time in the dark field of vision; this is a visual trace. Now, while this trace still persists let us try to imagine—without opening our eyes—that we are looking right in front of us; in this case the after-image becomes smaller. If we imagine that we are looking into the distance, the image becomes enlarged. The explanation is this. The concept of the dimensions of an object seen with one eye is based on the actual size of its image on the retina and on the degree of tension of the muscles which adjust the eye for distant vision. If the second factor changes, while the first remains invariable (as in our example), the impression which results from the combination of both sensations (the visual-muscular association) also changes. In life the visual-muscular association mentioned in our example always follows the following pattern: when two objects situated at different distances from the eyes produce on the retina images of the same size, the eyes must be adjusted to distant vision to see the farther and larger object, and to near vision to see the closer and smaller object. That is why the association (concept of size) in the above example is reproduced in the form of a larger object when we accommodate our eyes to distant vision and in the form of a smaller object when we accommodate them to near vision.

Here is another interesting example from the sphere of cutaneous sensations.

It is common knowledge that cold often causes "goose-flesh" contraction of special small muscles in the skin. This phenomenon, obviously, is a reflex complicated by the conscious sensation of cold and, in this sense, it is absolutely involuntary; however, I know a gentleman who can get goose-flesh even in a warm room, merely by imagining that he feels cold. In this remarkable case imagination produces the same effect as the actual sensory stimulation.

What, then, is the act of reproducing psychical formations? Essentially it is a process of excitation of the central nervous mechanisms as real as in the case of any acute psychical formation caused by the action of an external agent on the sense organs. And I maintain that from the point of view of the processes taking place in the nervous mechanisms it is not important whether I see a real man before me or simply recall him. The only difference is that among the numerous sensations evoked in me directly by the man, the visual sensation is particularly clear and sharp, because it is constantly supported by real visual stimulation (but if the man relates extremely curious things my aural sensation is stronger than the visual; the reasons for this will be discussed in the section devoted to emotions). When I recall the man, the first stimulus for his appearance in my memory comes usually from the influence exerted on me at the given moment by a certain external agent which, among many others, was acting on me the moment I saw the man. This stimulus evokes the whole complex of sensations produced in me by the man and preserved in the form of traces; his figure, words, expression of his face, movements of his hands, etc., begin to flash in my consciousness one after another. It is often difficult to determine which of the images is strongest, because my attention does not remain fixed on any one of them for long. However, everyone knows that a man with an arresting countenance and an ordinary voice is better remembered in images than in words, and vice versa. This is due to the fact that the intensity of latent traces wholly depends on the strength of the actual impressions.

I repeat: *from the standpoint of the process, there is not the slightest difference between an actual impression with its consequences and the memory of this impression.* Essentially, this is one and the same psychical reflex with an identical psychical content, but evoked by different stimuli. *I see a man* because his image is actually focused on the retina of my eye, and *I remember him* because impressed on my mind is the image of the door at which he stood.

By now the reader will have an idea of the importance of frequent repetition of one and the same act for psychical development. Repetition is the mother of learning, i.e., of a better differentiation of all psychical formations.

The laws of latent traces, applied to the process of acquiring muscular movements by learning, easily explain one of the phenomena of the act of learning which we call the instinctive "aping" of the child under the control of audition and sight. For the sake of clarity I shall use an example showing the process by which the child learns the name of a certain object. The reader knows that in the child there are among other reflexes also reflexes from eye and ear to the voice: the child screams at the sight of an object or when it hears something. In the first case the latent traces retain a visual-muscular-aural association, and in the second case an aural-muscular-aural sensation. According to the law of differentation of sensations, the acoustic components in the second case become differentiated most rapidly when they are similar. And that is what actually takes place since such similarity is present. The child hears the mooing of cows and screams. But in this scream, for all that is seems absolutely meaningless, and consequently in the latent traces left by it, there are acoustic elements, similar to the mooing of the cow. As a result of repetition, the aural-muscular-aural association changes so that the identical acoustic elements become increasingly clearer; at the same time the position of the vocal apparatus, which is necessary to reproduce the similar acoustic elements, *becomes more and more fixed. Hence, the differentiation* of an association is *most rapid* when its acoustic elements are similar.

It is natural that at the sight of a cow the child reproduces mooing sounds, i.e., imitates what it hears and at the same time learns the names of objects. The names of inanimate soundless objects are learned by the child in the same way. The mother or the nurse associate in the child's mind the given visual image with a sound, and this association is renewed in the child hundreds and thousands of times, until the acoustic components become fully differentiated, i.e., until the child is able to pronounce the name of the given object.

No examples are needed to illustrate the child's visual imitation, or its *consequence—the process of learning muscular* movements. I shall merely say here that this is wholly a matter of differentiation of the visual components of the child's *visual-muscular-visual association.*

Thus the theory of latent traces has, presumably, clarified those aspects of psychical development which previously remained obscure to the reader, namely, *the differentiation of sensations, notions*, etc., as a result of repetition, and the process of learning muscular movements.

Lastly, I would ask the reader to pay attention to the following aspect of reproduction of impressions.

As already stated, any complete psychical reflex ends in a *muscular movement which is invariably accompanied by sensations* (muscular); consequently, the trace of a complete reflex, which is a latent sensation, includes the beginning, continuation and the end of the act. *It follows from this that the act becomes* differentiated in man's consciousness as a whole. At the same time, due to the analysis of the associated sensations, notions, on me at the given moment by a certain external agent which, among many others, was acting on me the moment I saw the man. This stimulus evokes the whole complex of sensations produced in me by the man and preserved in the form of traces; his figure, words, expression of his face, movements of his hands, etc., begin to flash in my consciousness one after another. It is often difficult to determine which of the images is strongest, because my attention does not remain fixed on any one of them for long. However, everyone knows that a man with an arresting countenance and an ordinary voice is better remembered in images than in words, and vice versa. This is due to the fact that the intensity of latent traces wholly depends on the strength of the actual impressions.

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And now let me summarise what has been said in the following general formula:

*All psychical acts without exception, if they are not complicated by elements of emotion* (we shall dwell on these elements later) *develop by way of reflex. Hence, all conscious movements resulting from these acts and usually described as voluntary, are reflex movements in the strict sense of the term.*

Thus, the question whether voluntary movements are based on stimulation of sensory nerves has been answered in the affirmative. It is also clear why in voluntary movements this sensory stimulation often remains unnoticed, or at least cannot be determined

Although the reasons for this are many, they can be reduced to the following.

1) Often, if not always, a distinct association, for example, a visual-aural one, is supplemented by a vague muscular, olfactory, or some other association. In this case, because of the vividness of the first association, the second is hardly noticeable, or it remains unnoticed altogether. But it exists, and as soon as it flashes in our consciousness even for a moment, it evokes the visual-aural association. Here is an example. In the daytime I am busy with physiology, but at night when I go to bed I think of politics and it happens, of course, that sometimes my thoughts roam to the Emperor of China. So an acoustic trace becomes associated with the various sensations evoked in me by the state of lying in bed, i.e., with muscular, tactile, thermal and other sensations Sometimes, being tired or having nothing to do, I lie down in the daytime and all of a sudden the thought of the Emperor of China comes into my mind. It is usually said that thoughts like this have no particular cause; actually, however, the thought of the Emperor of China was engendered by the sensation of lying down. And now that I have cited this example,

it will come to mind even more frequently, because it has become associated with more vivid notions.[24]

2) A series of logically interconnected notions can become associated with another notion which bears no relation whatever to them. In this case, it seems strange to deduce a series of thoughts from this notion; actually, however, it is this notion that engenders such a series.

3) Sometimes a chain of associated notions persists for long in our consciousness. As already stated, its maximum duration is from the moment we wake up in the morning till the moment we fall asleep at night. In such cases, it is extremely difficult to recall precisely what induced the series.

However, in most cases, if we attentively observe ourselves, *it is possible to establish the external influence which engendered the given series.*

§ 12. Now I shall pass to the second question: Does the mechanism of inhibition, already known to us from the study of reflexes, play any role in originating voluntary movements? This is a natural question, seeing that we have identified the process of voluntary movements with the development of reflexes.

*Are there any phenomena in man's conscious life which show* that movements are inhibited? These phenomena are so numerous and so pronounced that it is because of them that all movements effected with full consciousness are called voluntary movements. On what is the usual concept of these movements based? It is based on the fact that man, influenced by one and the same external and moral conditions, can perform a definite series of movements, exhibit no movement at all, or, finally, can perform movements of an altogether reverse nature. As is known, people of strong will can suppress the most irresistible, seemingly involuntary movements; for example, one man screams and struggles when suffering acute physical pain, another endures it silently without making the slightest movement, while a third performs movements which are utterly incompatible with pain, for example, he jokes and laughs.

Consequently in conscious life there are cases of inhibition both of movements generally regarded as involuntary, and of those known as voluntary. Since, however, voluntary movements develop in accordance with the basic laws of reflexes, we may, naturally, assume that the mechanism of inhibition in both cases is the same.

In chapter one of this book we considered involuntary movements arising when sensory excitation is anticipated, and pointed out that such phenomena can best be explained by the intervention of a new element which inhibits the activity of the reflex apparatus. We also referred to experiments which show that there is no doubt whatever about the existence of these mechanisms in the brain of the frog, and that their presence in the human brain is highly probable.

Now we must establish whether this hypothesis is also true for voluntary movements.

Let us accept this hypothesis and assume that there are mechanisms in the human brain which inhibit muscular movements. But the reader may ask: Why is the activity of these mechanisms manifested so unevenly in different individuals? If inhibition of movements had an organic origin one would think that it should not vary in different people to the degree that it does (a weak nervous woman and an extreme stoic); moreover, inhibition would be present also in the child. As a matter of fact it exists in all cases, but man must learn to control the inhibition of movements just as he learns to perform the movements themselves. Nobody, for example, doubts that a new-born child already possesses all the nervous centres which subsequently control the acts of walking, speech, etc.; nevertheless the child must learn to perform these acts.

Let us now see how the child's ability to inhibit movements, or, strictly speaking, to eliminate the last member of a reflex, is acquired by learning.

Childhood is generally characterised by extremely extensive reflex movements arising in response to relatively weak (from the adult point of view) external sensory stimulations. For example, reflexes from ear and eye spread to almost all the muscles of the body. The time comes, however, when the movements, so to speak, become grouped. One or two entire groups of muscles separate from the mass of other muscles which have functioned in a disorderly manner; having become more limited, the movements acquire a definite character. It is in this limiting process that the inhibitory mechanisms take part. For the sake of simplicity, let us examine the transition from the simultaneous flexion of all the fingers of the hand to the separate flexion of one finger. Assuming that the simultaneous flexion of all fingers is due to certain inborn properties of the child's make-up (which is really so), it is obvious that one finger can be moved separately only if the movement of the other fingers is inhibited. There is no other explanation. But what causes this inhibition? It can be supposed that the flexion of the fingers is prevented by the functioning of the muscles which act in opposition to the flexors, i.e., contraction of the extensors; at first sight this supposition seems highly probable. To keep the other four fingers in a state of immobility, it suffices during the flexion of one finger for contraction of the extensors of the other four to prevail—even very slightly—over that of their flexors. True, this preponderance should be accompanied by certain muscular sensations, because the state of immobility is still the result of the antagonism between two sets of muscles; but the sensation should be very weak and for this reason may remain unnoticed in the presence of a distinct muscular sensation obtained from bending the finger. The matter can be explained, apparently, without the participation of special mechanisms inhibiting movements, and boils down to the functioning of antagonistic muscles. But this explanation cannot be fully accepted. Imagine that the simultaneous flexion of all fingers is engendered by a very powerful cause. In this case, the flexion of one finger must be accompanied by a very strong desire to bend the other four; hence, the latter can remain in a state of immobility only when the activity of the antagonistic muscles is most pronounced. In this case the flexion of one finger would be accompanied by an extremely acute muscular sensation in all the others. But in reality this does not occur. A person of ideally strong will can endure pain with composure, i.e., without muscular contraction.

So, while not denying in the least that inhibition of movements can be caused by the contraction of antagonistic muscles, and even granting that this frequently takes place in the process of preventing conscious movements, we must, however, admit the functioning, in some cases, of a mechanism acting on the reflex movement in the same way as the vagus nerve acts on the heart, i.e., an activity which paralyses the muscles.

From this it follows that if a conscious psychical act is not accompanied by any external manifestation, it still remains a reflex. And if we admit that in all these cases the prevention of movements is due to the activity of antagonistic muscles, then the end of the act must be a purely muscular movement; but if we accept the other explanation, the end of the reflex must be an act fully equivalent to the excitation of the muscular apparatus, i.e., the motor nerve and its muscle.

As to the development of capacity to inhibit the end of reflexes, the first case fully accords in this respect with the development of grouped muscular movements in general, and the vast difference in the external manifestation of both phenomena (performance of a movement and its inhibition) is explained by participation of different muscles in the movement. Hence the instinctive imitation of the child is the beginning of capacity to prevent movements; muscular sensation and its analysis are the guiding factors, and frequent repetition is the means by which capacity is acquired. When the child learnt to control its muscles, i.e., when it is able to walk and talk (and, consequently, to understand speech) the capacity to inhibit movements is further perfected through the development in the child's mind of associated concepts of the following kind: "Don't do this, don't do that, if you do, this or that may happen!" For the sake of greater edification these admonitions are often associated with painful physical sensations, which greatly affect the future of the child, with this system of education the morality of the motive by which the child is guided becomes overshadowed by the stronger sensation of fear, and the grievous morale of frightened people develops in the world.

The development of the capacity to paralyse movements (the reader should not forget that with regard to man this capacity is merely a hypothesis) is extremely obscure, because the only guiding factor is the sensation which accompanies the inactive state of the muscles. The reader will get a better idea of this by performing the following experiment on himself: after an exhaling movement delay for some time the subsequent involuntary movement of inhaling. During the first few seconds there will be no distinct feeling (one will be but indirectly conscious of the fact that the muscles are in a state of immobility); afterwards a certain feeling will set in—but not in the muscles—which will impel inhalation.

This example undoubtedly is one of those in which the inhibition of movements takes place without any active contraction of the muscles; it can be explained, therefore, only by the activity of a mechanism which paralyses the involuntary inhaling movements. From this example the reader will gather that the muscular sensations accompanying the inhibition of movements are really weak. The fact that teachers cannot develop in their pupils the capacity to paralyse the external manifestations of their psychical activity must be attributed precisely to this circumstance. This also explains why this capacity is rarely encountered in man and why persons possessing it are, to a degree, regarded as freaks of nature. As to other means of developing this capacity, here, as in the case of learning any kind of muscular movement, frequent repetition is of decisive significance. It is said that the present Emperor of France is able to conceal his internal emotions to the point of external impassivity; it is also said that he has achieved this by a tireless study of his own face in the mirror. I have obtained even more convincing proof of what has been said above by observing dogs. But to make it clear to the reader, I consider it necessary first to say a few words about the way in which the cerebral mechanisms that inhibit reflexes are excited and aroused to activity. In frogs, where the presence of these mechanisms in the brain has been proved beyond all question, they become excited, i.e., they inhibit reflexes, every time the sensory nerves are subjected to strong stimulation. Probably the same occurs when stimulation of the sensory nerves is weak, but in this case the effect is so insignificant that it cannot be detected by our crude methods. In the frog, then, the mechanisms that inhibit movements become excited in a reflex way.

Granting the presence of similar mechanisms in man as logical necessity, we are bound to admit that they are excited by means of reflexes. From this it follows in general that if in the course of life a man or an animal is subjected frequently to sharp external influences acting upon the sense organs, there is the likelihood that the man or the animal will greatly develop the capacity to resist these influences.

It has been said that people living a grim life of toil endure acute pain with absolute composure, without complicating the process by emotion. From the point of view of what has been said above, this "crudeness" of the nerves is quite explainable. It is also clear that the conditions in which the children of the so-called cultured classes are brought up preclude this "crudeness" of nerves in adults too.

The following example will prove this to the hilt. Being a physiologist, I am, unfortunately, compelled to experiment with animals; in the course of these experiments I have seen real heroes among plebeian dogs, i.e., dogs that live anywhere and eat anything; even the most terrible pain is endured with barely a moan. Nothing of the kind is observed in pet dogs, especially in lapdogs. And since dogs cannot, of course, manifest any emotion, this speaks for itself.

Thus, *man not only learns to group his movements through the frequent repetition of associated reflexes, he, at the same time, acquires (also by means of reflexes) capacity to inhibit them.* That is why psychical activity in the multitude of phenomena remains, so to speak, without external manifestation, i.e., in the form of thoughts, intentions, wishes, etc.

I shall now show the reader the first and most important result of man's capacity to inhibit the last member of a reflex. This can be summarised as *the ability to think, meditate, and reason.* What, actually, is the process of thinking? It is the series of interconnected notions and concepts which exists in man's consciousness at a given time and which is not expressed in external manifestations resulting from these psychical acts. But a psychical act, as the reader knows, cannot appear in consciousness without an external sensory stimulation. Consequently, thought is also subordinated to this law. It manifests, therefore, the beginning of a reflex and its continuation; only the end of the reflex, i.e., movement, is apparently absent.

*A thought is the first two-thirds of a psychical reflex.* This can be best explained by means of an example.

At the present moment I am thinking silently, without performing the slightest movement: "The bell which is before me on the table has the shape of a bottle; it is hard and cold to the touch and if I shake it, it will ring." This is a thought, just like any other thought. Let us examine the main phases in the development of this thought from childhood.

When I was about a year old I used to react as follows to this bell: looking at it or simultaneously looking and taking hold of it, or simply taking it without looking, I moved my hands and feet, and when it rang I was so pleased that I began to move my hands and feet even more vigorously. The psychical aspect of the phenomenon as a whole consisted of an associated notion in which the visual, aural, tactile, muscular and, lastly, thermal sensations merged.

Two years later I stood on my feet, held the bell in my hand, shook it, smiled and said: "ding-ding". In this case, not all the muscles of my body, but only the muscles of speech were involved in the reflex. At this stage the psychical side of the act is greatly advanced: the child is able to recognise the bell by shape, sound, or touch; it even knows the sensation of cold. All this is the result of analysis.

The child's development continues: its capacity to inhibit reflexes becomes more pronounced, but its interest in the bell steadily declines (we have already said that a nerve becomes fatigued and dulled when too frequently exercised in one and the same direction). Finally, the time comes when the child rings the bell even without a smile. At this stage it is able to express in words the thought mentioned by me at the beginning.

Since the thought is expressed in words, the reflex is confined to the muscles of speech only.

Already at this age the child can, by means of muscular-aural disassociation, separate in its consciousness the aural sensations of words which constitute a thought from the muscular speech movements expressing this thought. Moreover, it is already capable of inhibiting speech. It is obvious that even a child can think quietly about a bell.

So when it is said that a thought is the reproduction of reality, i.e., of real past impressions, this is true not only for the development of thinking from childhood, but also for every thought which is repeated in one and the same form even for the millionth time, because the reader already knows that from the point of view of the nature of the process, the acts of a real impression and of its reproduction are identical.

I shall now dwell briefly on the properties of thought, so that the reader will have no difficulty in understanding me later on, when we discuss the illusions of self-consciousness.

*Thought, by its nature, is highly subjective* The reason for this will be easily appreciated if we recall the history of its development. Thought is based on sensations from all spheres of senses which are themselves half subjective; even the visual and tactile sensations, which are of a purely objective character, at the moment of their emergence, can become completely subjective in thought, for most people think of tactile and visual images in words, i.e., by means of purely subjective aural sensations. Lastly, irrespective of the fact that in thought objective sensations become subjective (by means of visual-tactile-aural disassociation), our visual and tactile sensations, even when we think in images, as a rule have no real vividness in thought, i.e., the images are never as vivid in thought as they are in reality. This, of course, is due to the fact that the visual and tactile sensations are associated with others; consequently, there is no reason why in thought our attention should be concentrated on the visual and not on the aural sensation. But when our eyes or hands encounter a real external object, there is cause for concentrating attention precisely in this direction. It follows therefore, that thinking in images does not interfere with the subjective nature of our thoughts.

Now the reader, being aware of the properties of thought, will understand how man learns to separate thoughts from the external acts which follow them. Indeed, in any man affected by sensory stimulation thought is sometimes directly followed by action, at other times movement is inhibited and the act seems to end with the thought; at still other times thought again leads to action, but the latter is different from that in the first case. It is clear that thought, as something concrete, must separate from action which also appears in a concrete form. Since the succession of two acts is usually regarded as an indication of their causal relationship (*post hoc ergo propter hoc*), *thought is generally accepted as the cause of action.*[25] When the external influence, i.e., the sensory stimulus, remains unnoticed—

which occurs very often—*thought is even accepted as the initial cause of action.* Add to this the strongly pronounced subjective nature of thought, and you will realise how firmly man must believe in the voice of self-consciousness when it tells him such things. But actually this is the greatest of falsehoods: *the initial cause of any action always lies in external sensory stimulation,* because without this thought is inconceivable.

The seeming ability of one and the same person to express a definite thought by different external actions leads self-consciousness into a new sphere of errors. Influenced by a certain thought a person, as we are used to say, often deliberates on the mode of his action, and finally chooses one of its many possible forms. This means that influenced by definite external and internal conditions, he manifests the intermediate member of a psychical reflex (for the sake of brevity I shall use this term for any integral act of conscious life); and to this intermediate member is added—also in the form of thought—the image of a certain end of the reflex. If this intermediate member had several ends (seeing that the reflex developed in different external conditions) it would only be natural for them to appear in imagination one after another. Later we shall discuss the inevitable motives that determine the so-called choice of one or another end of the reflex.

Thus, we have replied in the affirmative also to our second question. *There are many psychical reflexes whose last member, i.e., movement, is inhibited.*

§ 13. I now pass to the third and last part of our investigation of the acts of conscious life, namely, to those psychical reflexes which have an intensified end. The phenomena belonging to these reflexes embrace the entire sphere of emotion.

Our task will be merely to show that emotions are, in origin, intensified reflexes.

As pointed out in the chapter on involuntary movements, emotion originates in the elementary sensual pleasures of the child. The sight of a brightly coloured object, the sound of a bell, etc., produce excessively irradiated reflex movements. But the state of excitement evoked by a definite object is not durable; at the age of three or four the child is no longer amused by objects, say, of a red colour; but it likes brightly coloured pictures and gaily dressed dolls, it listens with keen interest to stories concerning every kind of brilliance. It is obvious that, with the development of concrete notions, the pleasure obtained by the child from their separate properties merges, so to say, with the notion as a whole, and the child begins to enjoy complete images, shapes, and sounds. Thus, the whole impression acquires a highly emotional character. The attachment of the child to mother or nurse is of the same origin: the images of mother and nurse are always associated in the child with pleasure in all spheres of the senses, predominantly, of course, with the pleasure of eating. So it is not without reason that children are called egoists.

Desires arise in the child along with the development of emotional psychical formations. For example, the child likes the image of a burning candle, and has often seen how a candle is lighted with a match. A series of images and sounds preceding the lighting of the candle become associated in the child's mind. Now let us suppose that the child is absolutely quiet; suddenly it hears somebody strike a match, and its immediate reaction is extreme delight, it cries out and tries to reach the candle, etc. It is clear that the sound of the match inevitably evokes in the child's mind a pleasant sensation; hence its joy. But should the candle not be lighted, the child becomes restless and begins to cry. It is said, that this is the result of unsatisfied desire.

Here is another example. Suppose that tonight, when the child was being put to bed it was told a story that delighted it; this means that emotional aural sensations were associated in its mind with the sensations of lying in bed. There is no doubt that tomorrow at bedtime it will ask for another story, and will whimper until the story is told.

Obviously the recollection of pleasure, being of an emotional character, differs from actual pleasure just as hunger, thirst, and sensuality in the shape of desire differ from the pleasure of eating, drinking, etc. Generally speaking, desire can be compared with the feeling of hunger both from the psychological and physiological points of view. The only difference between visual desire and hunger, thirst, or sensuality, is that in the case of visual desire the oppressive sensation common to all desires is associated with an image; in the case of an aural desire it is associated with the notion of sounds, etc. The oppressive sensation itself derives from the specific and so far unexplained organisation of the nervous mechanisms, under which the insufficient exercise of these mechanisms always produces a feeling of depression.

The reader will now have an idea of the mechanism of caprice as well. Any desire is as oppressive as hunger and thirst and, if not satisfied for a long time, evokes a similar reaction. When the child is hungry or thirsty it is usually restless and cries; consequently, the same thing is bound to occur in the case of unsatisfied desire.

In the organisation of the nervous mechanisms there is another condition for the development of emotion: the more frequently these mechanisms function, the greater and more urgent becomes the necessity for them to act (there are, however, limits to the frequency and intensity of repetition). Three-quarters of all Europeans are immoderate in food and drink, they thereby intensify their feeling of hunger and thirst and make its emergence more frequent; the same is true of people who are immoderate in sexual pleasures. This law, when applied to pleasures in the sphere of higher senses, i.e., vision and audition, is easily explained. The more frequently an emotional psychical reflex is repeated, the greater the number of extraneous images and notions with which it is associated and, consequently, the easier the reproduction of the emotional reflex in the form of thought, i.e., of desire.

From this it follows that the development of emotion is subject to the same laws as, for example, the development of images from sensations. It originates in the instinctive craving for sensual pleasure, while frequent repetition of the pleasure or of the psychical reflex, which is the same, is the means by which it is developed.

But there is a difference between these two acts. When a reflex is frequently repeated in one and the same direction, its psychical element (sensation, notion, etc.), apart from the emotional element by which it is accompanied, becomes clearer (through association and analysis); emotion, on the contrary, often disappears. The child becomes tired of its toy. Things that delighted it at the age of two, leave it indifferent at five; as to the adult, he is indifferent to the amusements and joys of children altogether. The following conclusion is usually drawn from these facts: Man is so constructed that a frequently repeated impression, no matter how pleasant, begins to pall him; many people even go farther and say that our nerves are so constructed that they are fatigued by a pleasant impression, if it is frequently repeated.

Here are the only physiological facts, which confirm this. If light of a certain colour, for example red light, acts on the eye for long, the sensation of red becomes dulled: what previously seemed very bright gradually begins to seem paler. A musical tone irritates the ear if it sounds too long. On the contrary, the ear can listen with pleasure for a long time to modulations. The same is true of the eye: we can look at varying colours longer and with greater pleasure than at one particular colour. In what way do these facts come within the phenomena that we are now considering? Every invariable external influence acting on the child must in its consciousness pass through all phases of gradual fading. When this influence is repeated frequently, the difference between vividness of its beginning and paleness of its ending (i.e., between emotion and impassivity) becomes more and more distinct in consciousness. The beginning remains emotional in the positive sense, while the end acquires a more and more negative-emotional character. These two sensations, always accompanying each other, must of necessity be balanced. Numerous facts speak in favour of this explanation. It is possible, for example, to like a certain dish—say, roast grouse—and to eat it with pleasure; but everyone knows that the first grouse, eaten after a long period of abstention from this dish, tastes incomparably better than the tenth; if you treat yourself to grouse every day for months, the time will come when you will look at it with aversion. Clearly this feeling is of a negative-emotional character compared with the feeling that accompanies the eating of grouse for the first time; in the foregoing example this steadily increasing negative feeling first counterbalances the positive-emotional feeling and then overpowers it.

Another very important factor plays a definite rôle in the disappearance of emotion from many psychical reflexes. When a reflex of an emotional character is repeated many times, a decomposition of the concrete impression finally takes place. After the first transports of delight evoked by the appearance of a new doll the child begins to analyse it. This process is repeated, and the products of analysis become ever clearer in the child's consciousness; in other words, they are reproduced with increasing ease whenever opportunity is present. Thus, the delight of the concrete impression gives way to the clarity of placid consideration. By this I do not mean that analysis inevitably kills pleasure: parts are often no less pleasant than the whole, and the analyst does not lose the capacity of feeling concretely.

Replacement of an old image by a similar new one facilitates the disappearance of emotion from a psychical reflex. Let us suppose that a child has only one rather poor toy and has never seen a better one. This toy gives pleasure for quite a long time—of course, with intervals. Now let us suppose that this child catches a glimpse of another toy—one that is possibly no better than its own. The image of the new toy will be firmly associated in the child's mind with the impression of the old one, and the latter will no longer yield full satisfaction. Everything new, like everything unexpected, affects the child strongly, just as it does the adult. Surprise is related to fear. Pleasure, aversion, and even fear often begin with surprise. The infant just beginning to see, hear and feel is naturally surprised at everything.

Lastly, no matter how strong it may be, the emotion of a psychical reflex is gradually extinguished with the disappearance of the external influence which induced it. This is the reverse of the law according to which frequent repetition of an emotional psychical reflex both in reality and in thought strengthens emotion to a degree. The nature of this process is also quite clear. Just as any image, when reproduced in thought, is paler than it is in reality, i.e., when the respective object is actually encountered, actual emotion is much stronger than that which is imagined. For this reason alone emotion is bound to diminish with the removal of the real substratum. Moreover, with the weakening of emotion the reproduction of an emotional image in thought inevitably becomes less and less frequent, this being the second factor which accelerates the disappearance of emotion. And an emotional image reproduced in thought is associated with oppressive sensations of longing which impart to the entire psychical act a specific, though still emotional, character, but in the opposite direction.

Such, then, is the beginning and such are the conditions for the development, as well as for the disappearance, of emotion in the child. I should like now to summarise what I have said.

At the beginning of human life all psychical reflexes without exception are of an emotional character, i.e., they have intensified ends. However, little by little the sphere of emotion narrows, and pale and monotonous images gradually give way to brighter and more mobile ones. This process is based on the analysis of similar concrete sensations which, however, may be more or less vivid and more or less mobile. Frequent repetition of an emotional impression will, to a degree, strengthen the emotion, because reproduction of the emotional notion and of its result, i.e., of desire, becomes more and more frequent. In social life emotion is measured by its strength or depth and vividness. The strength or depth of emotion just like the clarity of a notion derives from frequent repetition of the reflex. As to the vividness of emotion, it is supported by the mobility of the impression, or by the sum of pleasures possible at the given time. In an emotional psychical act desire is of the same importance as thought in an ordinary psychical act—being the first two-thirds of the reflex. The oppressive side of desire is in its turn a source of emotion, though differently expressed compared with pleasure. Negative emotion is subject to the same laws as positive emotion: here, too, the strength is determined by frequency of repetition, while the vividness depends on acuity of the oppressive desire. Fortunately for mankind, human nature does not favour a steady intensification of negative emotions; being the mental reproduction of an emotional act, desire cannot be as vivid as the latter; at the second reproduction it becomes less vivid, at the third still less, etc. Consequently, pronounced development of negative emotion can be maintained for a long time only by a constant actual deficiency of sensual pleasures, or, as it is often said, by constant failures in life. Indeed, one can get accustomed to cold, hunger and even to the dark, silent prison.

It follows, then, that emotion in children is generally characterised *by high mobility*.

With the development of the child, its concepts, or to be more precise, the images connected with them, become emotional. This can be best illustrated by the following example. Under the present-day method of education the child's emotion switches from toys to heroes, strength, courage and similar qualities. It is obvious that this emotion is induced mainly by the images of swords, spears, armour, plumed helmets, and horses; in short, the child's mind is again full of glowing pictures, but they are now much clearer and more varied. This change in the child is inevitable, due to its natural striving for light, brilliance and noise, and also to the present-day methods of education. We shall see later that the change is, in some respects, a positive factor. But owing to superfluous impregnation of the sense organs with images of knights the emotion of very many people is forever concentrated mainly on outward brilliance. This might have been the ideal thing in the Middle Ages, but in our life, with its toil and lack of brilliance, such people are out of place.

And yet the child's attraction to strength, courage and valour is in one respect a positive factor. By this time the child has already separated its personality from the external world and, unconsciously, of course, loves itself very much, or to be more correct, loves itself in pleasure. (Imagine an adult person who always experiences only unpleasant sensations and never pleasant ones; obviously he will be, so to speak, a burden to himself, i.e., will never love himself.) It is no wonder, therefore, that the child girds itself with a sabre, puts on a helmet and rides a stick. It associates its personality with the heroes who pass through its mind and, of course, with all their qualities—at first purely external ones. With the passage of time, due to repeated aural reflexes (stories), the child's concept of the knight assumes more and more knightly properties. If into the composition of the knight an aversion to vice is introduced, the child, while associating itself with the knight, will despise vice, in its own way, of course, i.e., according to its concept of vice. If the knight helps the weak against the strong, the child becomes a Don Quixote: it will tremble at the thought of the defenceless weak.

Associating itself with an image, the child begins by loving all the properties of this image; subsequently, as a result of analysis it loves only these properties. This is what determines the moral side of man.

Love of truth, generosity, compassion, unselfishness, as well as hatred of all the opposite features, develop, of course, in the same way, i.e., by means of frequent repetition in man's consciousness of emotional images (no matter whether visual or aural), in which the above-mentioned properties are vividly manifested. It is no wonder, therefore, that a youth of eighteen, who ardently loves truth and is not impelled in the opposite direction by motives that develop in most people only at a mature age, is ready to endure torments for this truth. He knows that his ideal knights also suffered for truth, and he cannot but be a knight, since he has been one from the age of five to eighteen.

If the reader has attentively followed this example, he will easily see that our emotional worship of virtues and our aversion to vice are based on nothing else but an extremely extensive series of psychical reflexes: emotion is first directed to the bright colour of a certain object, then it switches to the bright mantle of a knight as shown in a picture, then to oneself mentally arrayed in knightly garments; emotion turns from concrete impressions to particular notions, i.e., to the virtues of the knight, or to concrete images in new forms and, finally, leaving the covering of a knight, turns to similar properties in the peasant, soldier, official, or general. It should now be clear to the reader that one may remain a knight even at a mature age. Naturally, by this time emotion has diminished, but it is replaced by what is usually called deep conviction. People of this type, given favourable conditions, develop into the noble characters mentioned at the beginning of this chapter. In their activity they are guided exclusively by lofty moral motives—by truth, love of man, and tolerance for his frailties; they remain true to their convictions despite all natural instincts, because the latter fade before the brightness of the pleasure which the knight derives from truth and love of man. These people cannot, of course, change: their activity is the inevitable result of their development.[26] And there is much consolation in this thought:

without it belief in the durability of virtue would be impossible.

In summing up this survey devoted to emotions, I shall cite one more example—the love of man for woman; this is especially important in view of the extremely widespread perverted concepts of this problem.

There is an instinctive side to the love of man for woman—sexual attraction. This is the beginning of love, because it arises in the boy only when his sex organs become mature. I shall not attempt to answer the question whether the boy involuntarily associates his first sexual sensations with the image of a woman, or whether this association is prepared by knowledge already acquired. But it is common knowledge that with the present system of education the latter happens with nine boys out of ten. In any case, this association exists already at an early age, and no matter how it may be acquired, there is nothing voluntary in it. It is likewise difficult to explain why early sexual sensations are associated with the image of one particular woman and not with the image of another, or of woman in general. But one thing is clear: sexual sensations can hardly be associated with the images of those women who constantly surround the boy. Since the boy has known these women for a long time he associates them with other sensations, which are also of an emotional nature, but which greatly differ from sexual sensations; they are of a very pronounced character due to the frequent repetition of reflexes in which these women act as stimulators on the boy's sense organs. It is obvious that the image of these women evokes strong sensations in his mind, and even if they are associated with sexual sensations, these latter cannot be noticed because they are relatively weak. (For example, we are unaware of the thoughts associated in each of us with reflexes from the stomach, though such associations undoubtedly exist.) That is why boys first fall in love with dim, uncertain images—their ideals. To the boy this image is of the same importance as the image of a knight, though accompanied by different sensations. It is obvious that in the course of the boy's experience various properties, in the shape of images and sounds, may be bestowed to this elastic form. Despite its seemingly poetic character, this process is still nothing but a frequent repetition, influenced by real encounters with women, of a reflex with an ideal feminine image. When this ideal firmly grips the boy's imagination he begins to attribute to it all the properties which he loves not only in women, but even in knights. When, finally, the ideal has assumed a more or less definite shape, and the boy encounters a woman who resembles this ideal, he, so to speak, transfers his dream to her and begins to love her as the embodiment of his dream. In our terminology, he has associated his emotional ideal with a real image. This is the so-called platonic love. The sex element here is only slightly pronounced, because compared to vivid and, consequently, emotional, visual and aural sensations, sexual desires are as yet unsettled and vague. For the same reason, love, notwithstanding its highly subjective character as a sum of emotional sensations, is more objective than any other emotion. This is the source of the noble side of man's love for woman: he learns not to be an egoist, because he loves someone as much as himself, and sometimes even more. A word of explanation is needed here. When a man loves a woman, he, properly speaking, loves in her his own pleasures, but he objectifies the latter and regards the woman as the source of all his pleasure; thus the radiant image of the female possessing all the virtues appears in his consciousness along with the image of himself. He loves the woman more than himself because he will never attribute to his ideal those of his emotional feelings which are unpleasant. Man attributes to the beloved only the best side of his pleasure. After what has been said there is no need to prove that such emotion inevitably leads to so-called self-sacrifice, i.e., may contradict man's natural instincts, even the voice of self-preservation.

Then the time comes when the man begins to possess his ideal. Now his emotion is intensified, because instead of vague, indistinct sexual desire there arise the vivid, palpitating sensations of love, and the female appears in all her splendour. However, months pass, or a year, or two at most, and the emotion burns out even in those fortunate cases when reality fully conforms to the ideals on both sides. What is the reason? The reason is that the vividness of emotion is maintained only by the changeability of the emotional image. After a year or two of joint intimate life, all possible changes become completely exhausted on both sides, and the vividness of emotion disappears. Love, however, does not disappear: owing to the frequent repetition of reflexes, where the image of the beloved with some or all of her qualities constitute the psychical content, her image is associated, so to say, with all the movements of the lover's soul, and she really becomes his other half. This is love by habit—friendship.

He who has once experienced these natural stages of complete love rarely loves passionately a second time. Repeated emotions usually indicate dissatisfaction with the previous emotions.

This concludes my examination of the development of emotions. The foregoing examples show that these phenomena, too, are essentially reflexes, but complicated by the addition of emotional elements and because of this expressed outwardly in movements which are more intense than the usual ones. It is due to this factor, making emotion perceptible, that I have named such reflexes *psychical reflexes with an intensified ending*. Fear, which we discussed in the chapter on involuntary movements, undoubtedly also belongs to the sphere of emotions, both from the point of view of psychical content and of its external manifestation. Hence, the hypothetical scheme of fright, with which the reader is already acquainted, is, at the same time, the anatomical model of the mechanism of emotion.

Now a word about the external manifestations of the highest degrees of emotion—enthusiasm and ecstasy—which seem to differ from the general rule being distinguished by immobility. Actually this state, despite its external manifestations commonly known as numbness, torpor, etc., is not absence of movement. On the contrary, it is connected with movement, otherwise enthusiasm would not be expressed outwardly; what is more, in this state movement is even considerably intensified, the contraction of the muscles being here in the nature of a more or less protracted petrifaction. This explains the immobility, the petrified forms of the outward manifestations of enthusiasm. The process is exactly the same as in the highest degrees of terror. Consequently, in this instance the mechanism of inhibition of movements plays no role whatever.

§ 14. After examining the process of inhibition of reflex movements and after showing that the chief result of these acts is a psychical reflex minus its last component, i.e., thought, I directed the reader's attention to those properties of thought which enable man to separate in his consciousness thought from action, even when the action is performed mentally. It was pointed out that the knowledge of their relationships would be of importance subsequently, when studying the illusions of self-consciousness. Now I shall try to do the same with regard to desire and action:

The reader is already aware of the place occupied by desire in an emotional reflex. It invariably appears when the emotional reflex remains uncompleted, i.e., unsatisfied. From this point of view desire and thought are identical. However, since in most cases desire in an adult is caused by a certain notion, or a series of notions, i.e., thought, the desire is, of course, merely the emotional side of thought. It follows, then, that the conditions for distinguishing desire from the action induced by it, i.e., from the act of satisfying the desire, even when the act takes place only in thought, are the same as those described above. In this case, the above-mentioned conditions are even more distinct, because desire as a sensation is always of a more or less oppressive, negative nature; conversely, the sensation which accompanies action, i.e., the satisfaction of emotional desire, is always of a vivid and positive character. Hence it is clear that mentally I can desire something more or less passionately, i.e., long for satisfaction of my desire. Outwardly this act is expressed in the words: "The man is thoughtful." If you ask him what he is doing he will answer: "I am thinking." "What are you thinking about?" "I intend, I desire, I wish, I long to do this and that." Choice of words will depend on the more or less emotional nature of the thought. Thus, the words "desire" and "wish" are practically identical; yet they are frequently used to denote different things. It is usually said that desire is capricious, and like everything emotional, contradicts will to a greater or lesser degree, whereas wish is often regarded as an act of will. "*I do not wish to fulfil my desire, and I shall not do so. Being tired, I am sitting; I should like to lie down, but I remain sitting.*" The wish to remain sitting, despite the desire to lie down, is regarded as an absolutely unemotional act. *It is believed that man can act against his desire, if he so wishes* *(unemotionally)*. I am tired and am sitting. I should like to stretch out, but I get up and begin to work. Here the unemotional wish to get up is, of course, stronger than in the first case. In general, in the languages of different peoples and in their consciousness unemotional wishing, or will, appears as a limitless power. Even the French, who are one of the most volatile and emotional peoples in Europe, say: "*vouloir c'est pouvoir*", meaning that the power of will, or of unemotional wishing, knows no limits.

The reader will see therefore that there is a certain confusion either in the usage of words which expresses sensations, or in the sensations themselves and in the concepts and words associated with them.

Let us try to clear up this confusion.

First, we must agree on terminology. Given an almost unemotional psychical reflex in consciousness, i.e., in the form of thought, we shall call "*wish*" the element of emotional striving for completion of the reflex, i.e., for satisfaction of the emotion—"*I wish to do this or that.*"

If the reflex is of a strongly pronounced emotional character, we shall call the same side of the reflex "*desire*".

So, having agreed on terminology, we shall now consider cases when an unemotional wish, so to say, overpowers desire.

I am tired and am sitting. The feeling of fatigue inevitably impels me to lie down (I desire). Is it possible to remain sitting if at the given moment there is no reason whatever for doing so? No, it is impossible. Obviously, there must be a reason for the unemotional wish to remain sitting; the presence of this reason is determined by the fact that wish, in our definition, is the element of striving in a thought. Even when a person remains sitting in a completely voluntary way, i.e., *merely out of caprice*, there is always a reason for it; everyone will say that this gentleman is not very tired and that his caprice is stronger than his fatigue.

The same applies when a person wishes to do something against his desire, and actually does it. The result, i.e., the action, is the inevitable consequence of the person's wish which is stronger than his desire.

But the reader may ask: How can a less emotional thought overpower a more emotional one? The point is that in many cases the first is only seemingly unemotional. When I am tired, the feeling of fatigue is, of course, more distinct than all other feelings; however, I do not go to bed, being, for example, afraid that if I fall asleep I may be bitten by a snake. Given different conditions I would tremble at the thought, but now I remain sitting quietly; and it is fatigue alone which I clearly feel in addition to this thought. The matter will be different when, being tired and fearing snakes, I suddenly see one nearby; in this case the sensation of fear will manifestly overbalance the feeling of fatigue, and I shall take to my heels. Here is another case when an absolutely unemotional wish overcomes emotional thought. Being strictly punctual, I do not go to bed—though I am tired—because I am afraid that I shall fall asleep and be late for my appointment; I do so although I realise that there would be no great misfortune in my being late. Here, the power of the thought which keeps me from going to bed is determined by the habit of punctuality, i.e., by the frequent repetition of the reflex in this direction. What has been done a thousand times is easily done for the thousand and first time.

The reader will appreciate that in all cases of this kind there is a certain reason for every *wish*, and if the wish is stronger than the *desire*, the former always takes the upper hand. The reflex does not thereby lose its reflex nature. Definite external influences evoke a consecutive series of associated thoughts, and the end of the reflex is the logical result of the strongest thought. In many cases, however, the cause of a wish cannot be established, and then it seems that the wish arises causelessly. Here is what, in my opinion, is a striking example.

To prove that my argument concerning unemotional wishing is nonsense, my opponent demands from me an explanation of the following fact. He says: "*I think that I wish to bend my finger in a minute; I actually do* so (and he bends his finger within the minute); *I am absolutely conscious of the fact that the beginning of this act originates within myself, and that every moment of it is under my control.*" To prove that the act really originates in himself, my opponent asserts that he can repeat it at any time of the year, in the daytime as well as in the night, on the summit of Mont Blanc or on the Pacific coast, standing, sitting or lying—in short, under any conceivable external conditions, provided, of course, he is conscious. From this he draws the conclusion that wish does not depend on external conditions. His conviction that he has power over every moment of the act is based on the fact that he can bend his finger at will not only in one minute, but also in two, three, four or five minutes, and bend it slowly, quickly, and still quicker.

I shall try, as far as possible, to show the reader that my opponent, despite the arguments which speak in favour of his judgement, bends his finger mechanically.

First, the very conversation between my opponent and myself concerning unemotional wishing cannot begin without a cause, in Lapland or in Petersburg, during the day or at night, standing or lying—in short, in any place or at any time. There is always a reason for the conversation. However, one can put forward the following objection: the conversation is fully under the control of my opponent, since it is his will to speak or not to speak. The answer to this is quite easy: there must be special causes for both cases. If one of them is stronger, it will predominate. My opponent has begun to speak and this means that he could not help speaking.

But once he has begun to speak on the subject under our consideration, he will do so without any further external influence: he may close his eyes, stop his ears, etc. It is immaterial whether he is in Europe or in Asia, on the top of a mountain, or in bed—in short, everywhere he will speak in the same way. What is the reason? It is very simple: throughout his life he has performed millions of voluntary movements with his arms, legs, tongue; in millions of cases he has refrained from making such movements at will; thousands of times he has named these movements, or has thought of them as of acts of will; consequently, the notion of the entire act with its name is associated in my opponent with practically all possible objective external influences, so that this psychical formation cannot be influenced by the view of surrounding nature, by cold, or by posture of the body, i.e., by any external factor. Thus, the thought has come into my opponent's head in the given form inevitably. But the reader may ask: Why did your opponent express his idea precisely by bending the finger and not by some other movement?

To that I can only give a general answer. Man performs most of his movements with his eyes, tongue, arms and legs. However, the expression "man's movements" is much more frequently associated with the movements of the arms and legs than with those of the tongue and eyes; naturally, this is because the tongue is not visible during speech and the movements of the eyes are too rapid and short to be noticed, while the movements of the arms and legs are clearly manifest. In any case, when we speak of voluntary movements, it is incomparably easier to illustrate them by a movement of the arm or leg, than by any other movement. Further, the arms are more suitable for this purpose than the legs, being much more mobile and less occupied. Persons who get excited when speaking, always move their arms and only in extreme cases move their legs. It is natural, therefore, that the arms should be used more readily than the legs to illustrate one's thought. But in the upper limb as a whole it is the hand which is more mobile and used more than all other parts. Indeed, in most movements of the upper limb the fingers move at least ten times when the arm bends at the elbow or turns on its longitudinal axis only once. Hence, it is quite natural to illustrate a thought, similar to that now being considered by us, by the movement of a finger, namely, by bending it, which is the most frequent act. But what does the word "natural" imply? It implies that the movement of the finger follows the above-mentioned thought of its own volition, i.e., involuntarily. Thus, my opponent, without having noticed it, or to be more precise, being sure that he had noticed the opposite, first thought, then spoke and, finally, moved his finger quite inevitably and involuntarily. But why did he think first, and move his finger a minute later? Because thought usually precedes movement. The reason for the definite interval between the thought and the movement lies in the very nature of my opponent's act. He wants to show that he can choose the time of the movement at will (he himself says so). But why did he choose precisely one minute, and not two, three, or five? The answer in this case is the same as to the question why my opponent chose the movement of a finger and not of some other limb to illustrate his thought: a minute is longer than a second and at the same time not too long. My opponent knows that any interval is suitable, but the shorter it is, the better.

We see, therefore, that my opponent is really under the delusion of his self-consciousness: his entire act is nothing but a psychical reflex, a series of associated thoughts evoked by the first impulse to conversation and expressed in a movement which logically follows from the most powerful thought.

Hence, an unemotional wish, no matter how independent of external influences it may seem, actually depends on these influences as much as any sensation. Whenever the cause of the wish cannot be determined, as in the example just considered, the result of this wish is not strong. Conversely, if an unemotional wish triumphs in the struggle with a powerful emotional desire, the former is based either on a thought with a very emotional substratum, or on a thought which has become strong as a result of frequent repetition, i.e., habit. The man of high moral principles, mentioned at the beginning of the chapter on voluntary movements, acts as he does solely because he is guided by the high principles acquired by him in the course of his life. Prompted by these principles he cannot act otherwise: his activity is the inevitable result of these principles.

After what has been said it is hardly necessary to analyse in detail the typically voluntary activity of man, described in the beginning of the chapter on voluntary movements. Readers who appreciate and accept my point of view do not need this analysis; those who do not, will not be persuaded by any further reasoning.

And so, the question of whether the most voluntary of all voluntary actions of man depend on external and internal conditions has been answered in the affirmative. From this it inevitably follows that *given the same internal and external conditions the activity of man will be similar*. Choice of one of the many possible ends of the same psychical reflex is absolutely impossible; its apparent possibility is merely a delusion of self-consciousness. The essence of this complex act is that apparently one and the same reflex with the same psychical content is reproduced in man's consciousness in the form of thought; however, this reflex takes place in more or less different conditions and is, therefore, expressed in different ways. If one of its ends is of a more emotional nature, you will want to act accordingly; if a less emotional but stronger image emerges in your mind and draws you in the opposite direction, the reflex will have another end in your thought. Ultimately conditions arise for the reflex to manifest itself, and we see that in half the cases the plans vanish and we do not act as intended. Even those who firmly believe in the voice of self-consciousness say in these cases that we have lost control of the external conditions. But in our opinion, this clearly shows that the *initial cause of any human activity lies outside man.*

My task is nearing its end. Thought in the broadest sense and the external activity induced by it exhaust the whole range of the highly diverse conscious life of man. I have answered all the questions posed as clearly as possible.

Now it remains for me to point out the very great deficiencies of the present work and thus show the insignificance of what I have done compared with what will be done in the future.

1) The present work analyses only the external side of psychical reflxees, or, so to say, the paths which they follow; there is no mention whatever of the nature of the process itself. Everyone knows, for example, the sensation of the colour red, but nobody in the world can explain the nature of this sensation. Nor do we know what takes place in the sensory or motor nerve when excited It is all the more impossible, then, to comprehend the nature of more complex psychical acts. The reader may ask: How then can one speak of the paths of reflexes? But this is quite possible: although we do not know what takes place in the nerves, muscles and brain centres during excitation, we cannot but see the laws of pure reflexes and regard them as true. He who accepts this, is obviously entitled to look for similarity between any phenomenon, for example any conscious act of man, and a reflex. Whenever we find this similarity (and I am sure it can be found, but my conviction is not an absolute truth for everybody), we say that the conscious act and the reflex are similar in their nature. This is what I have done in this work.

2) Proceeding in my investigation from the phenomena of pure reflexes, I must thereby accept the typothetical side of the teaching on reflexes. For example, the idea that the nerve centre connecting the sensory and motor nerves is a nerve cell is a

highly probable hypothesis, but, a hypothesis, and nothing more. Further, *assuming the existence in man of centres inhibiting* and intensifying reflexes, I thereby admit another hypothesis, because I carry over phenomena which have been observed in *the frog directly to man.* The existence of such centres in man is highly probable, but it has not yet been definitely proved. "But what, then, is your teaching in essence?", the reader may ask. To this I reply: My teaching is pure hypothesis to the extent that it concerns the existence in man of three separate mechanisms controlling the phenomena of conscious and unconscious psychical life (i.e., the mechanism of pure reflex and the mechanisms *which inhibit and intensify reflexes*). Those who regard this hypothesis as being doubtful and insufficiently substantiated, or who simply cannot accept it, can, of course, reject it; but *that will not affect my propositions in the least, because my* chief task was to show that all acts of conscious and unconscious life are reflexes by origin. As to the explanation why the ends *of these reflexes are extremely weakened in some cases and* intensified in others, that is a matter of secondary importance. I shall be the first to congratulate anyone who finds a better explanation.

3) In the present investigation nothing is said about the individual peculiarities of the nervous mechanisms in the newborn child. These peculiarities undoubtedly exist (ancestral and inherited from the nearest kindred), and they must, of course, influence man's entire subsequent development. However, it is absolutely impossible to detect these peculiarities, because in the overwhelming majority of cases $^{999}/_{1000}$ of the psychical content of man is determined by education in the broadest sense, and only $^{1}/_{1000}$ depends on individuality. By this I do not mean to say that a fool can be made intelligent; this would be the same as trying to develop hearing in a person born without the auditory nerve. What I have in mind is that a clever Negro, Lapp or Bashkir brought up in European society and in a European manner will differ very little intellectually from educated Europeans. But I could not enter into an examination of these highly interesting problems. In my opinion, there was no need to do so. When analysing the acts of conscious life from the point of view of their origin I had in mind a highly developed

psychical type. And if my basic propositions can be applied to the activity of this type, then they are all the more applicable to less developed types.

4) Our interpretation of memory and of the reproduction of psychical formations is also based on a hypothesis—the hypothesis of latent traces of nervous excitation. To naturalists there will be nothing unusual about this hypothesis, especially because the phenomena of memory, as shown by us, are in the main akin to the phenomena of perceptible traces of light which appear after every real optical stimulation. The following fact, in addition to what has been said earlier, will help prove this. It is known that the traces of light are the more distinct the less light acts upon the eyes after stimulation by an external object. For example, after looking at a burning candle we close the eyes and then cover them with the hand in order to make the trace of the candlelight clear. The same applies to reproduction of images in thought. They are particularly distinct in sleep, when very little light acts on the eyes and when the other senses are at rest. As is known, it is best to think in images in darkness and absolute silence. Only a mentally disordered person suffering from visual hallucinations, i.e., from disorders of the nervous system, can think in images in a noisy and brightly lit room.

In any case, the hypothesis of latent nervous excitation explains the most delicate sides of psychical acts without overstepping the limits of physical possibility.

5) Finally, I must confess that I have framed these hypotheses without any great acquaintance with psychological literature. I have only studied Beneke,[27] and in my student days at that. I have obtained from his works a general idea of the teaching of the French sensualists.[28] Experts in psychology, i.e., professional psychologists, will probably point out defects in this investigation. But my task was to show them the possibility of applying physiological knowledge to the phenomena of psychical life, and I hope that I have succeeded, even though partly, in attaining my aim. It is this circumstance that justifies my decision to write about psychical phenomena without having any preliminary knowledge of what has already been written on this subject, knowing only the physiological laws of nervous activity.

After reading this long list of hypotheses from which my views on the origin of psychical acts derive, the reader will probably ask once more: Why should I relinquish my belief in the *voice of self-consciousness which tells me many times a day* with absolute clearness that the impulses inducing my voluntary acts originate in myself and are not, therefore, the result of external stimulations, except, perhaps, those which support the life of the body?

If what I have said is not sufficient to prevent questions of this kind, I ask the reader to consider the following well-known phenomena. When a person, being physically very tired, falls into a *deep sleep*, his psychical activity sinks to zero, and in this state he does not dream; he becomes highly insensitive to external stimuli: neither light, noise nor pain can awaken him. This simultaneous loss of sensitivity to external stimuli and complete absence of psychical activity are also encountered in cases of alcoholic intoxication, chlorophorm narcosis and fainting. Everybody knows this, and no one doubts that the two acts are causally interrelated. The only difference in the views on this matter is that some people regard loss of consciousness as the cause of loss of sensitivity, while others assert the opposite. Actually, however, there can be but *one point of view*. If one, two, three or a hundred guns are fired near a man in deep sleep, he will awaken and his psychical activity will reappear at once; but should the man be deaf, theoretically even a volley of a million guns would not bring him back to consciousness. The same is true of optical stimuli of any strength in the case of a blind person; this is likewise true of the most terrible pain in the case of a person deprived of cutaneous sensitivity. In short, a man in deep sleep and having no sensory nerves would not awaken till his death.

Now let anyone try to contend that psychical activity and its expression—muscular movement—are possible, even for a single moment, without external sensory stimulation!

## OBSERVATIONS ON MR. KAVELIN'S BOOK "THE TASKS OF PSYCHOLOGY[29]"

Being, like Mr. Kavelin, one of those who regard psychology as a still unsettled science and like he being convinced that the time for its scientific elaboration has come, I accept with particular pleasure his kind invitation to discuss his book; I do so the more willingly, since it may enable me to dispel, even though to a small degree, the false ideas concerning the final aims of the modern physiologico-psychological school[30] which, unfortunately, exist among the public and to which, incidentally, Mr. Kavelin adheres. I make bold to express the hope that Mr. Kavelin, no matter how violent my attacks on his fundamental principles may seem to him (of course, not in form, but in essence), will ascribe them exclusively to my sincere and ardent desire to serve the truth. In any cause like ours the only possible driving motive is the desire to reveal the truth. And it is this motive which guides me in the present work.

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Among all the branches of human knowledge one can hardly find a science with a fate so peculiar as that of psychology. The materials it deals with, namely, the products of self-consciousness or introspection[31], which are verified by identical observations carried out on other individuals, or by our own actions, as well as by the actions of other people, have been available to man almost since he first appeared on earth. This is not the same as, for example, the tedious secular work of chemistry which had to create and still continues to create its own research materials (almost all the gases except the gases of the air and some others which are erupted from the earth, and almost all the metals with the exception of the precious ones which are found in a pure state, were discovered artificially). But one cannot say that the psychological material accumulated as a result of introspection and observations on other people remains unused ballast, a chaos of incoherent observations and deductions. Not at all. Way back in ancient times man began to study his spiritual life basing himself on the results of introspection. The masterpieces of ancient sculpture show us that man learned to observe the external manifestations of human mental movements. Moreover, it is knowledge of the human heart which lies at bedrock of the law-making and literary works of all times and of all nations; what a profound knowledge of the human heart was shown, for example, by such moralists as Confucius and such poets as Shakespeare! Everyone who read the works of the great writers undoubtedly felt the profound veracity of the characters created by them. These creations are by no means a photographic reproduction of reality; at first the writer conceives the given character in general outline; later, on the basis of his psychological knowledge, he attributes to the character certain feelings and ideas, making him act in a definite way. The writer, as it were, predicts future developments proceeding from knowledge of their causes; such prediction is the touchstone of true knowledge.

But this is not all. Some of the greatest minds, from Aristotle to Kant, tried to elaborate psychology as a science.

And yet it remains unsettled; this can be convincingly proved in a few words.

Take any expert psychologist, say, a professor of psychology, and ask him to tell you in all frankness whether he organises his own internal life in accordance with the data obtained by his science, or whether he is guided by the empirical psychological rules of everyday life, not verified by science; he will have to answer that it is the latter which determines his mode of life. Indeed, it cannot be otherwise. Had the psychologists lived in conformity with science, the experience of their mode of life would have long ago become widespread among the public, just in the same way as happened with hygienic and dietetic knowledge, although these sciences are also insufficiently advanced. Moreover, try to discuss one and the same subject with psychologists belonging to different schools and you will find that every school has its own ideas; but if for the sake of comparison you engage in conversation with a physicist from any country concerning, for example, sound, light, or electricity, you will obtain essentially similar replies.

What, then, is the explanation for the fact that so far psychology cannot be regarded as a science? Here is what Mr. Kavelin says on this subject in his book.

Man's consciousness abounds in facts leading to deductions which always contradict one another: man is conscious of himself as of a single and indivisible entity, but at the same time he distinguishes within himself two absolutely different principles —the spiritual and the corporeal; he is aware of his spiritual freedom and at the same time he is conscious of the tremendous influence which the body and the external environment in general exert on his spirit; the power of the spirit over the body appears to him with the utmost clarity, yet he is aware that the body obeys definite immutable laws and operates fatally (pp. 14 and 15).

These contradictions—Mr. Kavelin goes on—and the desire to explain them gave birth to the three principal philosophical theories—dualism, spiritualism and materialism. The two last-mentioned try to explain the phenomena of both the spiritual and material worlds by proceeding from a single principle: the idealists from the spiritual principle, and the materialists from the material principle (p. 15). Idealism, which misinterpreted and distorted the profound observations of Kant, made a rapid advance and as rapidly died away; in Hegel's theory it came to such absurdities and incongruities which, at last, revealed to everybody the falsity of the fundamental principle underlying the entire idealist world outlook (p 16).

Materialism, which in its turn erroneously interpreted the brilliant researches of Locke, proved more viable. At present it tries to side with positive knowledge and the natural sciences (p. 16); but a critical analysis of its basic arguments (pp. 27-35) shows that the days of this doctrine, too, are numbered, because the positive sciences have, little by little, undermined the foundations on which it rested; this fragile and delusive union with the natural sciences will but hasten its demise.

Since, according to Mr. Kavelin, we live on the ruins of these conflicting but equally erroneous views (p. 16), psychology as a science does not exist.

Later, I shall try to show that many other highly essential points should be added to this explanation. Meanwhile I shall pass on to a description of the means proposed by Mr. Kavelin for raising psychology to the level of a positive science.

The corner-stone of his scientific edifice is formed of the numerous facts amassed by worldly wisdom, facts which, on the one hand, make possible the realisation by our consciousness of the essential difference between material and psychical phenomena and, on the other hand, reveal the close relationship between the spirit and the body. His book abounds in facts of this kind which, by the way, are known to every educated person. But Mr. Kavelin does not content himself with the testimony of the voice of consciousness. While criticising the fundamental arguments of materialism directed against *the spirit as an independent autonomous and free principle differing from the body* (pp. 27-35), *he logically deduces the spirit with its afore-mentioned* attributes *from* the untenability of the arguments which deny it. He reasons as follows:

"Although the *spirit* and the *body* differ essentially, they cannot be *opposed to each other owing to the numerous facts* which *testify* to their *close relationship* and *profound interaction*; they should be regarded as *modifications of one and the same principle* (p. 55). (In this way Mr. Kavelin, apparently, hopes to eliminate the long-standing cause of controversy on the question of principles which, in his opinion, still divides the psychologists into two hostile camps—idealists and materialists.)

Mr. Kavelin then examines the question of how psychology must be elaborated in order to become a positive science.

On the one hand, acknowledging the usefulness of physiology in the study of the material substrata underlying psychical phenomena and, on the other hand, finding that man's body and spirit are *directly and organically* interconnected, he believes that psychology must be created by the joint efforts of psychologists studying the facts pertaining to the mind, and by physiologists investigating their material basis (p. 53). According to Mr. Kavelin, this division of labour is explained by the fact that psychical phenomena, being inaccessible to concrete investigation, can be studied only through introspection (p. 50).

Naturally, Mr. Kavelin does not touch upon the problem of elaborating the material substrata of psychical phenomena; but the following considerations concerning the study of psychical phenomena through introspection can be found in his book.

Inasmuch as we know the surrounding world exclusively by the impressions which it produces on us, and which are none other than psychical phenomena (p. 22), the supposed distinction between the material and the psychical world is actually reduced to a distinction between essentially similar psychical facts, though of different orders (p. 52).

On the other hand, since the external manifestations of the human spirit in science, history, the arts, industry, etc., have long been subjected to scientific study, in the same way as the material objects of natural science, i.e., since these manifestations are established in their objective reality and purged of extraneous admixtures, arbitrary interpretations, etc. (p. 23), the psychical phenomena are by no means so vague and inaccessible to positive study as it seems to many people; thus, the so-called positive exact sciences have no advantages over those which study man's mental life. Both base their deductions on impressions that have been subjected to a critical analysis (p. 24). This alone clearly shows that Mr. Kavelin regards the manifestations of the human spirit in science, the arts, industry, etc., as the basic material to be used in the study of psychical phenomena, as to the method of elaboration, it is the so-called critical method which must be applied.

From the foregoing passages concerning the nature of this study it follows that psychology as a science treating of the spirit, its attributes and manifestations (p. 11) is bound to become a *positive* science.

Let us stop here for the present and examine the elements of Mr. Kavelin's psychological system one after another, i.e., the points from which he departs when distinguishing the two principles in man, as well as his views on the method of elaborating psychical phenomena.

Now I shall try to prove that 1) the criteria from which Mr. Kavelin proceeds when distinguishing the two principles in man (consequently, the criteria used by the obsolete idealists and obsolescent materialists) are not axioms and call for strict scientific verification; 2) by passing from concrete facts direct to general principles Mr. Kavelin commits the same gross error which has ruined philosophy as a whole. Thus, parallel with the analysis of the criteria, underlying Mr. Kavelin's system, I shall explain here why the philosophical doctrines, on the ruins of which we now live, have collapsed and have left psychology an untouched science.

Mr. Kavelin advances the following three basic criteria for distinguishing two principles in man (other arguments will be examined later): 1) the distinction which our consciousness makes between purely psychical acts, such as thought, and proprioceptive impressions which are similar to exteroceptive impressions; 2) man's realisation of his spiritual freedom in relation to his thoughts and feelings, and 3) to his actions.

The two last-mentioned categories lead to the above conclusion, because it is recognised that the body also obeys the immutable laws of the material world.

Mr. Kavelin will, of course, agree that if we have in mind only those distinctions between purely psychical facts and so-called exteroceptive impressions of which man is conscious, such distinctions must in any case be the *products of man's own self-consciousness solely*. As to his confidence that all people perceive these distinctions alike, it derives from two facts: a) from the verbal testimony of people to the effect that everything seen, heard or touched in reality manifests itself in their consciousness more distinctly than the notions (in the form of thought) of the same objects seen or heard; b) from the fact that people generally react differently to real impressions and their reproduction in the form of thought. If a person is attracted by a stone lying on the ground, he picks it up, but when he recollects the same stone, he does not perform any movement. It is true that there is a third criterion by means of which man distinguishes an idea from a real impression: this is the comparison of the conditions in which the two acts originated; this comparison leads to the conclusion that a real impression invariably presupposes a real object as the cause of its origin, while it is possible to think of an object previously seen without having this object before the eyes. But if we go deeper into the matter we shall easily see that this criterion does not increase, but on the contrary, diminishes the distinction and enables our consciousness, as it were, to explain it.*

It is the voice of self-consciousness and the foregoing verifications effected on other people that lead us to the *conviction* that there is a *vast* difference between the purely psychical facts of thought and real impressions.

But let us see whether we can have absolute confidence in facts obtained from such verifications.

If a person tells you that in one case his sensation is vivid, while in another it is feeble, the matter ends at that; we do not know to what degree the sensation is stronger in one case than in the other. We only know from experience that some people vividly reproduce in their imagination the things they have seen or heard, whereas others are less imaginative. Consequently, in *vividness*, which is the sole *knowable* distinction between an actual impression and its reproduction, there are extreme gradations—from an obtuse imagination to morbid hallucinations. Where, then, is the gulf which, according to Mr. Kavelin, separates physical sensations from their reproduction in the form of ideas?

May be the criterion for their distinction lies in the difference between man's reactions to actual impressions and to their reproduction?

But in this respect people differ just in the same way as they differ in the vividness of reproduction. In a living person the

* Here I deem it necessary to make the following reservation. If it is our wish that the distinction between psychical facts and real impressions should not become a mere trifle, we should compare only those things which are of the same order, for example, objects really seen with their imaginary representations, or that which has been really heard in the form of words with an idea expressed verbally, etc. But if we compare objects which have been seen with the verbal representations of the same objects, and the more so with an abstract idea of an object, which has nothing to do with the object seen, for example, if we compare the impression produced on us by a tree with the idea of the Emperor of China, this would be comparing things which simply cannot be compared.

recollection of something of a disgusting nature may provoke nausea or at least a grimace of disgust; the recollection of something grisly evokes a shiver throughout the body; when a person describes a certain event he involuntarily repeats the movements of the eyes, arms and legs which actually took place.*

It will be seen, then, that the two verifications do not reveal the profound distinctions by which Mr. Kavelin, like all the outdated philosophical schools, is guided. If these distinctions seem to him strongly pronounced, this is due either to the peculiar character of his personal make-up, or to the fact that he tries to compare things which cannot be compared. The latter, of course, is ruled out; the conclusion is, therefore, that Mr. Kavelin obeys the voice of self-consciousness, of which he himself says the following (p. 21): *"Should consciousness alone establish and determine the psychical facts, their positive and exact investigation would be out of the question."*

*Consequently, his first criterion for distinguishing two principles in man is refuted.*

The second point relates to man's power over his thought and senses which is without analogy in the external world or in the body. Mr. Kavelin belongs to the philosophical school which admits the existence of this power, but on page 126 of his book he mentions that there is an opposite opinion which is quite widespread. It is clear, therefore, that Mr. Kavelin himself regards his second point as a shaky one.

It would take too much time to criticise here his third point, for this reason I refer the reader to the end of the present ar-

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* In this connection I recall the following. A physician whom I did not know visited me once and asked me to explain a phenomenon which he was ready to reproduce on himself in my presence. When I asked him to perform the experiment he rolled up one of his sleeves and held the bare arm before my eyes for about a minute. Little by little "goose-skin" began to appear on his arm as if it were cold in the room, though in reality it was quite warm. Knowing that the muscles of the skin which produce this phenomenon *do not obey our will, I told the physician that he was undoubtedly able to reproduce in his imagination a distinct sensation of cold.* He answered that he acted in this way when performing the experiment. I *explained to him that the real impression produced by cold and its distinct imaginary reproduction are similar as regards the process of their development; hence they produce similar external manifestations.*[32]

ticle where the question will be subjected to a detailed and systematic examination and where I shall try to show that in this case, too, it is dangerous to rely on the voice of self-consciousness.

Let us grant for the moment that not only the third point, but also the first two points are axioms. But in this case, too, Mr. Kavelin would ruin his entire system by his next step—by passing from the concrete facts straight to general principles, with the aim of explaining the former by the latter. All the preceding philosophical systems collapsed not only because they had tried to derive the universe from a definite single principle, but also because they considered it possible *to explain* something by a general principle.

I shall try to prove the erroneousness of this method by citing some examples taken from the natural sciences whose achievements are acknowledged by Mr. Kavelin himself.

As we know, physics and chemistry deal with material phenomena; consequently, to them matter is also a general principle. They recognise this principle, and attribute to matter all the general properties established as a result of the study of concrete material phenomena. Precisely in this sense it is affirmed that matter which invariably occupies space can be measured in three dimensions: it has weight, it is indestructible, and impenetrable, infinitely divisible and inert. But in affirming this, the naturalist does not forget that these properties are abstractions from the realities encountered at every step, whereas the general concept of "matter" implies, on the one hand, that it is a purely logical abstraction, and, on the other—that it is the result of contrasting any material object with a space devoid of a material substance, such as the vacuum of the barometer and the bell of an air-pump or the space beyond the limits of our atmosphere, etc. The first part of the foregoing will be easily understood if we apply the so-called general properties of matter to a particular material object, for example, a stone, or a certain volume of water or air. Here the aforesaid properties are, so to say, tangible, whereas when applied to a generic concept, i.e., to matter, they become its indispensable attributes only by virtue of logical thought. But should the naturalists suddenly discover a body whose properties are confined to extension in three dimensions, weight, indestructibility, and impenetrability, i.e., only to the general properties of matter, the latter would no longer be a purely logical form. That is why the natural sciences, whose achievements in addition to being the pride of man are widely used by him, do not contain any explanation, deduction or discovery based on the idea of matter as a general principle. On the contrary, the naturalist invariably proceeds in his researches from the so-called general properties of matter, since they rest on actual facts or relations.

The picture is altogether different when we deal with the intimate beliefs and aspirations of the naturalists; the chemist will tell you that many of the substances now regarded as elementary may eventually prove to be compound; the physicist will predict that all the physical manifestations of matter will, sooner or later, be probably reduced to purely mechanical movements. This tendency to simplify phenomena, which, naturally, leads from a greater to a lesser variety, is widespread both in physics and in chemistry, although in the latter this is achieved in a seemingly paradoxical way—through a continuous multiplication of facts. If it is permissible to judge of the further progress of the two sciences in this direction by the results already obtained, we can assume that the general concept of "matter" will become concrete to an ever-increasing degree. But this will happen only when all the deductions of physics and chemistry merge into a single law.

It is clear, therefore, that not a single naturalist encroaches upon "matter" as a general principle. This is the ideal point to which all the efforts of the naturalists are directed; but it is still shrouded in a dense fog, and the naturalists, when advancing towards it, are not guided by it, but by other nearer points on the new horizons opening up before science in its slow but steady advance.

Mr. Kavelin, however, follows the old-time philosophers and rushes headlong from the solid ground of facts into the dense cloud of general principles. In everyday life the spirit can be regarded as the noblest part of man; it can be accepted in science as a general principle, just as the naturalists accept matter; it can even be regarded as a guiding star in psychological research; but how is it possible to explain anything by something that is inexplicable? Surely this is to begin at the wrong end? The following conclusion can be drawn from what has been said: Mr. Kavelin bases his philosophical system on unreliable and unverified facts; moreover, he makes the same erroneous step which was predominantly responsible for the collapse of philosophy. Later we shall see that yet another cause contributed to this collapse.

I expect, however, that Mr. Kavelin will retort that so far I have examined only his basic criteria for distinguishing two principles in man. I shall, therefore, pass on to Mr. Kavelin's criticism of materialism from which it follows that the spirit is, *unlike the body, independent, autonomous and free* (pp. 17-40).

The theory which, in Mr. Kavelin's opinion, is common to the materialists of all times (of course, scientific materialists, since there can be no question here of materialists of the salon type) is the desire *to derive man's spiritual activity from matter.* I shall not argue here about the materialists of the past; as to the present-day materialists, among whom Mr. Kavelin, apparently, reckons all physiologists, I make bold to assure him that his allegation is profoundly erroneous. Any naturalist who is more or less acquainted with the natural sciences, especially with physics and chemistry, knows the meaning of the word "to explain" well enough to inscribe such an absurdity on his psychological banner This is all the more true of physiologists, since they know that the essence of the nervous, i.e., somatic activity, which is closest to psychical life, has not yet been elucidated thoroughly enough to disclose which of the known physical agents plays an essential part in the nervous act. The source of such gross errors as Mr. Kavelin's above-mentioned allegation lies precisely in the fact that the non-naturalists abuse the words "to explain". If, for example, the naturalist establishes a certain, purely external analogy between the origin of a manifestly psychical act and that of a somatic act, the non-naturalist immediately jumps to the conclusion that the *entire* given psychical phenomenon is reduced to its material conditions.

I can assure Mr. Kavelin that to the naturalist psychical phenomena are a much greater enigma than they are to the humanists; this will be clearly shown later on.

Mr. Kavelin begins his detailed criticism of the arguments of materialism (p. 27) by reasoning in a purely logical way; but he does not infer anything definite from his reasoning because all his conclusions are accompanied by the words "*we believe*", "*perhaps*", etc., or he appeals in advance to the "*impartial mind*".

The second point, however, is most important (pp. 27-28). According to Mr. Kavelin, the materialists deny the *independence* and *autonomy* of the spirit on the grounds that psychical activity is possible only when brain and nerves are intact. Mr. Kavelin's counter-argument consists in the following: plants and animals, too, are wholly dependent on the external environment, yet they possess a certain degree of *self-existence* and *autonomy*. I do not know what Mr. Kavelin implies by the term *self-existence*, but if it is used as an equivalent for the term "independence", he contradicts himself, since he at the same time asserts that organisms are *wholly dependent* on the surrounding medium. As to *autonomy*, it can but signify the ability to develop a certain activity independently of the external environment. If this is so, then Mr. Kavelin commits an error: science provides convincing proof that, unaided, animals cannot generate any force; activity, however, absolutely presupposes such force. The only seeming independence of the animal from the environment is manifest in the fact that the animal continues to live even when it is famished; but this is solely due to the fact that it has a reserve of matter in its body, and this reserve is extended on activity during the hungry period.

Mr. Kavelin expresses the same erroneous idea on page 31 of his book when he compares the spirit with animals and plants from the point of view of the penetration of foreign elements into them (why mineral substances and air are alien to the inherent substances of plants, or why vegetable and mineral food are alien to the substances of the animal organism, remains, however, a mystery).

The third argument in favour of autonomy (or to be more precise, originality?) of the spirit is formulated as follows: "if the psychical phenomena were directly dependent on the conditions and laws of the surrounding nature, the notions would be a mere photographic reflection of the impressions produced by the external world." The author, apparently, implies here the original character of the process of elaboration to which the raw material of the external impressions is subjected. Any naturalist could answer to this approximately in the following way. Let us take two different metals, for example, zinc and copper, immerse one of their ends into a certain acid, say, vinegar, and connect their free ends, i e., the ends which have not been immersed in the liquid, by a metallic wire; we shall then observe the emergence of certain phenomena in the wire which resemble neither the *properties of the given metals, nor the properties of vinegar:* if we cut the wire, a spark will appear at the intersection; if we fix a thin platinum wire between the two ends it will become heated to incandescence; if we wind the wire connecting the copper and the zinc round a piece of iron, the latter will become a magnet, etc. From this it follows that, generally speaking, the original character of the resulting phenomena and their distinction *from the phenomena* by which they are produced *in no* way indicate any *essential* difference between them. From this point of view there is no need to dwell on the imaginary creations referred to by Mr. Kavelin in his book, such as the head of the Medusa, the Minotaur, etc., especially since these images are, in Mr Kavelin's own words—with our small addition given in italics—"non-existent combinations of *existing* impressions". Should man be able to create combinations containing at least one *genuinely non-terrestrial* element, the independent creative activity of the spirit would undoubtedly be proved.

Moreover, I make bold to assure Mr. Kavelin that Wundt clearly indicates in his book the existence of a definite connection between the organisation, say, of the eye and ear, on the one hand, and certain properties of the visual and aural sensations, on the other.[33] For my part, I shall cite some other examples of this kind later on.

The fourth argument (p. 30) in favour of the autonomy of the spirit is formulated as follows: "The great variety of psychical phenomena and of the resulting external actions of man are free from any direct external influences and incentives, being caused solely by psychical motives."

It is evident that such unsubstantiated assertions cannot prove any scientific truths. Is not it merely the voice of self-consciousness that tells us of the absence of any external stimulus in these cases? Besides, it remains to be proved that a psychical motive can be originated without such an external stimulus

The fifth argument treats of the voluntariness of movements, i.e., again of the third basic criterion for distinguishing two principles in man; in view of this I refer the reader once more to the end of the present article. But I consider it necessary to give here a brief personal explanation in connection with the first part of Mr. Kavelin's fifth argument (p. 31). He states: "Materialism does not deny these facts, it interprets them in its own way. That which we regard as a psychical process is in the eyes of materialists a nervous or brain reflex which does not presuppose the existence of a psychical medium or the participation of will and which is accomplished mechanically." Mr. Kavelin, apparently, has me in mind when stating this; but he commits a gross error when he affirms that I identify psychical facts with reflexes. It is true that in my book *Reflexes of the Brain* I do advance a hypothesis according to which typical forms of the psychical processes of thought and emotion are of a reflex origin (and consequently bear a machine-like character), but nowhere in the book is it stated that the nature of the psychical processes is explained, for example, by the structure of the nervous centres. Apparently Mr. Kavelin has been led into error by the title of the book. But the story of its origin is as follows. When the article was submitted to the censor, it was headed "An Attempt Physiologically to Explain the Origin of Psychical Phenomena". The censor, however, found this heading inappropriate and insisted that it should be replaced by another one. I pondered over the matter for a long time and finally chose the one which is now well known to everybody; but at that time I could not foresee that these words, which seemed innocent to me, would give rise to so many misconceptions.

After that Mr. Kavelin turns to the argument advanced by the materialists to substantiate their denial of the psychical principle, according to which the psychical activity of animals contains rudiments of all the mental faculties of man. In his opinion, animals manifest embryonic elements of thought, or at least intelligence, embryonic speech, gregariousness, as well as the sense, and the faculty of adapting the surrounding nature to their needs and requirements. At the same time he declares that it is impossible to imagine an animal exhibiting even the slightest ability to make a statue, draw a picture, outline a scheme or sketch a façade, set sounds to music, write a letter, or a book.

Had a similar proposition been put to Darwin who investigated the relationships between animals and man more profoundly than any other scientist, probably his response would be to ask Mr. Kavelin first to decompose each of the faculties mentioned by him into their component elements and then to reduce each element a million times. Who knows, may be in this case some rudiments of the above-mentioned elementary faculties would really be detected. At any rate, there are signs that in some cases animals have a kind of aesthetic sense. For example, the Australian *chlamydophorus* decorates the place selected for its amorous rendezvous; the hen nightingale and hen-birds generally delight in the singing of their mates, etc. On the other hand, Mr. Kavelin himself does not deny a certain degree of intelligence in animals, and I believe that, from the psychical aspect, the acts of drawing, designing and writing hardly require anything except intelligence and an aesthetic sense developed to the human level.

So Mr. Kavelin's second method of distinguishing two principles in man and qualifying one of them also turns out to be a failure

Further, Mr. Kavelin tries, as he puts it, to make a deeper analysis of the structure of the spirit; as a result of his efforts he comes to the conclusion that everything psychical is of a *conscious* and *ideal nature* and that the spirit can divide itself into two parts But I deem it more convenient to examine these arguments later, when we examine the results obtained by Mr. Kavelin

For the present I should like to say a few words about the idea that *spirit and matter are modifications of one and the same principle*; afterwards I shall examine in detail the method of investigating psychical phenomena proposed by Mr. Kavelin.

As mentioned above, Mr. Kavelin, after examining a number of well-known facts concerning the close link between spirit and body, arrived in a purely logical way at the idea that because of this they cannot be opposed to each other and must be modifications of one and the same principle. This idea is of no great importance, because for Mr. Kavelin both the general principle which is modified to form the spirit and the body and the modifications are mere abstractions. Nor is this idea of any logical value, because to the best of my knowledge only homogeneous things can be opposed to each other. What is important, however, is that this idea is expressed by a man educated in the traditions of the idealistic school. From this point of view, it is a big concession to the new trends of our time, its importance would be all the greater if Mr. Kavelin were to acknowledge that among the reasons which prompted him to formulate this idea, a certain role was played by the frequent cases—the existence of which he admits himself—of the normally-free spirit suddenly becoming subordinated to laws of a physical nature, or of voluntary movements passing, in his terminology, into involuntary ones. When psychical facts are analysed in this way the serious mind cannot but regard them as an argument in favour of the existence of a number of successive gradations between freedom and non-freedom.

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Mr. Kavelin's system of investigating psychical phenomena is as follows: he uses introspection as an instrument of investigation; his materials are the manifestations of the human spirit in science, industry, and art, his method of investigation—critical speculation.

As far as introspection is concerned, Mr. Kavelin does not qualify it anywhere (though once, on page 101, he declares that the psychical is cognised *directly*; in his view the cognised and the cognising fuse); but since it has long been known to psychology it is not in need of qualification.

Introspection or psychical vision is based largely on man's ability, aided by the voice of self-consciousness, to analyse his ideas and actions (the latter, of course, in the form of thinking). Everybody knows this from personal experience; so there is no need to dwell on the phenomenon as such; the important thing is to explain it.

I shall advance three arguments to disprove the existence of a special psychical analyser; I have borrowed the first of these from the metaphysician Herbart,[34] the second is my own, while the third belongs to Mr. Kavelin.

*The first argument.* Let us suppose that a man analyses his actions by means of words (for the moment it is of no importance whether the actions belong to the past or the future). The analysis, even in the most complicated case, will, evidently, be something like this: I set out for a certain place—*what on earth made me go there?*—I arrived and I did so and so, *were it not for my absent-mindedness, I would, of course, have realised that I should have abstained from doing so and so*, etc., etc.

If we approach this discourse of self-consciousness directly, without any preconceived views, we shall find that the analysing subject is the whole *self*, not any special psychical organ. Let us grant this. In a minute's time I will be able to analyse my own analysis, as it follows from the idea I have just expressed, i.e., I can dissociate the analyser from the thing analysed,[35] and in this analysis of the second power the analysing *self* will be one degree higher than the *self* in the first case.

The same will occur if contrary to the voice of self-consciousness we interpose a special psychical organ between the *self* and the thing analysed, because in this case we shall have to admit that the organ is identical with *self* and, consequently, fuses with it.

If instead of analysing actions I had analysed thoughts, the degree of the latter *self* would be still higher. This would force us to admit that we have not one but three organs of introspection, despite the fact that the objects for the three organs are essentially the same

To this Herbart adds the following remark: the external sense organs serve us as long as they can, and when they cease to serve us we know the reason why; as to the inner sense, at times it reacts in a lively way to what is taking place in the innermost recesses of the heart (though adding much of its own), at other times, however, it is so dull and lazy that in some cases we just cannot recollect a certain idea although we are conscious of the fact that it existed in our mind.

*The second argument* Case I—analysing the past.

In this case the entire psychical act, which we designate as analysis, consists partly of an *immediate recollection* of what has happened, and partly of subsidiary ideas which are *new* in relation to the case analysed and, at the same time, *old* because they existed in the consciousness previously and, what is more, in combinations resembling those contained in the analysis. In the foregoing example the phrases in ordinary print express a simple recollection, while those in italics express auxiliary reasoning; everybody, I think, will agree that the emergence of both the former and the latter in our consciousness can be explained as *the reproduction of a series of associations.*

Case II—analysing the future.

The only difference between this case and the previous one is that instead of dealing with a past action we have in mind a forthcoming action, a forthcoming solution of a certain task, etc., while the other half remains as before. But it is clear that the concept of a future action emerges in the mind as a psychical fact in advance, i.e., prior to the act of reflection or analysis; hence in this case the act of reflection is again a reproduction of a psychical fact which already existed in the consciousness. This explanation can be applied in equal measure both to ordinary cases of analysis aimed at establishing the correctness, usefulness, etc., of certain ideas and actions, and to cases of scientific analysis of ideas and actions, for example, psychological analysis; in fact, even when we reflect on the nature of a thought or feeling for the first time, all the elements of analysis are given to us in advance.

This explanation is applicable likewise to a case when the analysis of notions gives rise to something absolutely new, for example, to the case of scientific discovery. Here, too, a discovery in the form of a certain scientific deduction never emerges as *deus ex machina*; all its elements had their existence in the consciousness, but were not properly grouped until the moment of the discovery.

Lastly, our explanation is applicable also to cases when the object under consideration and the knowledge at our disposal have nothing in common as far as content is concerned; for example, when a child imagines that he is a king or a general and thinks of the way in which he would lead the nation and the army, even in this case the king and the general are patterned in the concept of them in the child's consciousness.

*The third argument.* Mr. Kavelin repeatedly says in his book that we can know the external environment solely through the impressions it produces on us. At the same time he says (page 101) that we apprehend psychical facts *directly*, through introspection. Further, from the process of the bifurcation of the spirit (page 102 and others) he deduces that direct apprehension signifies cognition of psychical facts by means of the inner vision. Similar ideas may be found in the works of Beneke; but the latter, holding that everything psychical is cognised in a direct way and that as an experimental science psychology ranks with the natural sciences as to its methods, arrives at the absolutely logical conclusion that right now psychology in essentials is not lagging behind *any* of the natural sciences and that in future it may even surpass all of them (*Lehrb. d. Psychologie als Naturwissenschaft.* 3. Aufl. Berl. 1861, see introduction). How, then, can Mr. Kavelin claim that psychology is not a science? One of two things: either his entire treatise on inner vision is of no value whatever, or he is plainly inconsistent.

Thus, there is no special psychical vision as an instrument for analysing spiritual processes as distinct from material processes, but there "really" is an aspect of psychical activity which enables us to say that man has common sense. And as far as I know both naturalists and humanists make use of it in their spheres of research.

But perhaps the clue to comprehending the psychical processes should be sought in a broad historical study, from the psychological point of view, of all the products of the human spirit, the study of which Mr. Kavelin speaks in his book? And since the choice of research methods should be made with the utmost care, it is impossible to disregard this important question.

Unfortunately, my knowledge in this sphere is restricted, and for this reason I will confine myself to the conclusions drawn from the few facts known to me.

My task will consist exclusively in showing, by means of a few striking examples, the extremes to which we can go when we try to explain psychical facts by the historical method of studying the various manifestations of psychical activity.

It is obvious that the relics and monuments left by prehistoric man, as well as the products of mental activity of contemporary savages are of prime importance in this respect, since they bring us face to face with the rudiments of psychical life. We shall, therefore, begin with the facts established by geologists about the so-called fossil man; we shall elucidate them, whenever necessary, with the help of other data relating to the life of contemporary savages (for the data about fossil man and prehistoric man I am indebted to the book *L'homme fossile en Europe, son industrie, ses moeurs et ses oeuvres d'art* par H. Le Hon).[36]

The earliest era in Europe which has bequeathed to us human bones and relics of human activity is the one when Europe was inhabited by the so-called cave-bear, the mammoth, the hairy rhinoceros, etc. This era dates back at least 20,000 years. The following products of human activity relating to this first period of man's existence—a period which embraces thousands of years —are found in the earth together with human bones (I deliberately enumerate *all* of them).

1) Stone tools: axes, knives, darts, spear-heads; 2) tools made of bone and horn: arrow-heads; 3) pointed needles made of bone (probably for sewing purposes?); 4) various kinds of knives made of horn; 5) perforated teeth of bears (these finds, evidently used as objects of decoration, are still rare); 6) fragments of coarse earthenware (also extremely rare). Besides, from a number of other finds we can draw the conclusion that man 7) hunted even such big animals as the mammoth and the rhinoceros; 8) knew the use of fire, and, lastly 9) made offerings to the dead (hypothesis of Lartet[37] concerning the Aurignac grotto).

These relics indicate that already in this remote epoch man made weapons which could be used close at hand and at a distance and which were specially shaped for cutting and piercing, that he made tools for rough mechanical work (axes and knives), as well as earthenware; that he knew how to obtain fire, and, finally, that he thought in terms of a life beyond the grave. In the aggregate this evidence shows that man was an intelligent being, much superior, for example, to all the species of apes.

Let us see, however, what lay behind these primitive inventions. Observations carried out on monkeys show us that the making of weapons for near and distant use does not require a high degree of intelligence; it is common knowledge that monkeys use sticks when fighting, throw stones at their enemies or roll them downhill. We know, too, that they use stones to crack coconuts, hence, the idea of using stones for various purposes is an elementary one. Man, however, advanced much farther in this respect: he learned to shape his tools, imparting to them now the form of a piercing weapon, now the form of a blade.

Clearly, this idea could occur to man because in the course of thousands of years he had observed that sharp stones, thorns, etc., often wounded him and his fellows; in addition to using stones man learned to make use of the bones and horns of animals for the fabrication of tools and weapons; these raw materials were as available as stone.

As far as man's disposition to self-decoration is concerned, it is most likely of an instinctive nature, like the child's desire for brightly-coloured or glittering objects. Darwin in his history of the origin of man cites numerous examples of the coquetry displayed by animals in showing off their natural qualities. And from this, obviously, it is but a step to self-decoration (the tattoo of the savage, rings passed through the nostrils, feather ornaments on the head, etc.). As to the invention of earthenware, Le Hon has an ingenious and highly plausible explanation for its origin. Here is what he says on the subject: "From the very first period of man's existence clay was used as a means of accumulating supplies of water in the caves (where man lived) A hollow in a block of clay served as a basin; this hole was filled with water brought from the nearest river in the hides of animals. Subsequently, to render this device mobile, man began to remove from it the superfluous clay and to harden it by drying it in the sun. Still later, the crude forms of the device were subjected to the action of fire, as the latter made it more durable. Such was the origin of earthenware. . . ."

We do not know in what way the fossil man obtained fire; but he would know of its existence by observing volcanic phenomena, and from the emergence of sparks when processing flint. In any case, there can be no doubt that obtaining fire must have been a more or less faithful copying of the conditions or of the natural and fortuitous phenomena which accompanied the emergence of fire.

Lastly, the rite of offerings to the dead, a rite which was observed by primitive man and indicated a belief in the existence of life beyond the grave, can be explained only by analogy with similar beliefs of contemporary savages. Tylor's[38] famous *Primitive Culture*, equally remarkable for its wealth of factual material, sound reasoning and clear conclusions, provides a thorough explanation of this question. Tylor shows, firstly, that the idea of life in the hereafter is an elementary belief and, secondly, that it has its origin in dreams and in the comparisons made between the state of normal sleep, the state of coma of a sick person, and death. Whereas in the first two cases the soul temporarily departs from the body and meets in the course of its wanderings the souls of dead friends and relations, after death it retires into the domain of shadows or of the dead, but this time without returning to the body.

In sum, all this indicates that prehistoric fossil man, in addition to observing the conditions of phenomena, could explain them by way of analogy, establish their causal relationships, and co-ordinate them in the form of experience. In other words, fossil man was endowed with the basic mental elements of creation.

Five thousand years later, in the period of the reindeer in Europe, the European fossil man had registered the following essential advances: 1) he had perfected the fabrication of weapons; 2) had added the stone saw and the hammer to his domestic tools; 3) had learned to sew together hides of animals, using needles made of horn and tendon fibres as thread; 4) had begun to show a definite interest in self-decoration, making necklaces of shells, teeth of animals and little white discs carved out of sea-shells; and finally 5) had begun to cultivate the arts. Among the relics of the latter are: the crude sculpture of a woman made of ivory, the design of a mammoth engraved on an ivory plate, designs of an elk, horse, and auroch, and even the design of two fighting reindeer.

The appearance of the saw and of the hammer belongs, clearly, to the category of inventions associated with cutting and piercing weapons. The art of sewing is based on the ability to fasten objects or tie them together with the help of flexible materials, such as twigs, wisps of grass, etc. Nature offers a multitude of instructive examples for the development of this skill in the form of twining plants, the bird's nests, the spider's web, the caterpillar's cocoon, etc. These natural things provide certain elements not only for crude tailoring, but also for making ropes and fabrics, indeed, the first traces of this know-how is encountered in the era of pile-dwellings which dates back at least 5,000 years I have already mentioned the instinctive disposition to self-decoration; here I take the liberty of digressing for a moment to say a few words about the artificial discs which were perforated in the middle and used as ornaments. As we know, the wheel and the lever—in diverse modifications, of course—are the basic elements of all the machines in use today; yet the wheel and the lever were invented by prehistoric man; some travellers have affirmed that the use of the lever is known to the ape. It might seem that man could have no difficulty in conceiving of the wheel as a means of transport: all he had to do was to put a finger into the aperture of the toy disc and roll it over a certain surface. In reality, however, thousands of years had to pass before man cottoned onto this simple fact.

As far as primitive sculpture and painting are concerned, these arts are rooted in man's instinctive tendency to imitate everything seen and heard, a tendency which, while incomprehensible to us, is manifestly an innate human property. We are well aware that if, say, a child were brought up among cows, without knowing anything about other living beings, he would in all probability move on all fours and moo like a cow, though the reason for this phenomenon is unknown to us. We know, too, that savages skilfully imitate the voices and movements of animals, and this imitation already contains elements of painting and sculpture Add to this a developed human hand, equip it with a crude tool and the result in all probability would be a tracery of sculptural reproduction of an object which attracted the imagination This interpretation will be all the more comprehensible if we compare the physiological conditions which accompany the perception of the linear outline of the object with the reproduction of this outline by hand. As we know, definite groups of muscles act in both cases, the two organs—the eye and the hand—move parallel to one another, tracing, so to speak, all the outlines of the object. Thus, the main thing is that the hand should learn to follow the eye; similar cases are frequently encountered in elementary mechanical work.

Now let us turn from these rudimentary elements of industry and craftsmanship to the purely intellectual sphere of primitive peoples, for example, contemporary savages—to their philosophical approach both to themselves and their environment. Here, at the lowest levels of culture, we shall encounter, according to Tylor (*Primitive Culture*), the two basic facts: 1) man makes a distinction between his soul and his body, attaching to *the former the entire psychical content of his life, his entire* moral "self"; 2) *he extends this concept to all the objects of* the *surrounding world—from animals and plants to sticks and stones.* This *animation* of external objects is so universal that Tylor considers *animism* (his terminology) as the first primitive philosophical world outlook.

According to Tylor, the main reason why man began to distinguish between the soul and the body is that savages regard dreams as realities; the explanation is a highly plausible one, especially if we take into consideration the long, long way which man had to traverse before he realised that dreams, like recollections, do not rest on real foundations; even to us, with *our mundane view of the matter, the independence of the soul from the body seems to manifest itself* with the utmost clarity in dreams.

Having elaborated this concept of his nature, the savage logically extends it to all objects of the external environment, because this is his only yardstick for a philosophical knowledge of the world. Examining one level of culture after another—from the lowest to the highest—Tylor reaches the conclusion that all subsequent philosophical concepts stem from this common root.

Thus, *the essence of all philosophical theories concerning the body, the spirit and the objects of the external environment* is based (according to Tylor) on real, but *wrongly interpreted* facts. For our particular purpose we could add: "on the facts of life wrongly interpreted, because the savage is too ready to accept the voice of his self-consciousness."

Actually the philosophy of primitive man departs from the same basic psychical predispositions as the philosophy of the thinker of today who is guided solely by the voice of his self-consciousness.

In conclusion, we shall analyse from the psychological point of view the history of some natural-science problems, such as Darwinism, Galvanism, and also the matter of converting mechanical motion into heat.

Darwin, as we know, summarised his theory of the origin of species in the following proposition: species are formed by way of natural selection through the gradual deviation from type. Natural selection presupposes that between individuals of one and the same type living in a given locality there takes place a constant struggle for existence, a rivalry for the maximum satisfaction of the requirements of material existence; the victors in this struggle are the stronger, the quicker and the more agile, that is, those best adapted to the environment thanks to some slight distinctions in their make-up. By virtue of the law of heredity, the victors bring into the world another generation which on the whole is better adapted to the environment and, consequently, differs still more in make-up from the original type. The same thing is repeated with the new generation: again it is the fittest who survive. This goes on from generation to generation until the divergence from the original type is so pronounced that it is the equivalent of an obviously new variety.

Now let us see how this theory took shape. Darwin tells us that it is based on the generally known fact that species can be improved by artificial selection for purposes of reproduction. It may be that the second element of the theory—the struggle for existence—derived from Darwin's contemplation of human society As to the first part of his theory it rests on the most elementary observations of the following kind: tall parents have tall children, red-haired parents have red-haired children, etc. These facts, which in the aggregate constitute the law of hereditary transmission of characteristics are known even among ordinary people and have long been used by them. The theory of the struggle for existence belongs, it is true, to the category of conclusions of an immeasurably higher order, but few will disagree that it is based on everyday observations; for this reason it should be regarded as a product of life experience rather than a scientific abstraction. It follows, then, that one of the most fruitful and brilliant hypotheses of our time is based on elements drawn from everyday experience.

Galvanism, as we know, had its origin in the following experiment. Galvani,[39] desirous of investigating the effects of atmospherical electricity on muscle contraction (it should be pointed out that the phenomenon of muscular contraction under the action of electrical discharges, for example, discharges of the Leyden jar, was already known at that time), attached to the horizontal cross-beam of the iron grille of his balcony the hind legs of a frog deprived of their skin covering; the hook from which the frog's legs were suspended was made of copper and passed through a part of the spinal cord connected with the legs. Galvani noticed that each time the free extremities of the legs, swaying in the breeze, came into contact with the iron, the leg muscles moved spasmodically. Upon observing this, Galvani reproduced the phenomenon in a simplified form: he prepared a muscle containing a nerve, and with an arched metal bar began simultaneously to touch muscle and nerve with the ends of this bar. The muscle contraction was again in evidence; it was most pronounced when the ends of the bar consisted of two different metals. The application of the metal arc to the nerve and to the muscle described above resembles, in externals, the application of the metallic discharger to the Leyden jar; since it was known at the time that discharges of the Leyden jar, passed through a muscle or through a muscle containing a nerve, caused contraction, Galvani drew the logical and scientifically grounded conclusion that the muscle and its nerve constitute a kind of a Leyden jar—the muscle corresponding to the outer coating, the nerve to the inner coating. Volta,[40] who repeated this experiment, discovered that Galvani, in explaining this phenomenon, had disregarded the fact that the success of the experiment depended on the metallic heterogeneity of the ends of the arc, which in the case of the Leyden jar discharger was of no importance at all. Shortly after this Volta's keen eye established that three factors were involved in the phenomenon: two different kinds of metal in contact with a body impregnated with a fluid; as we know, this brilliant idea led to the discovery of the voltaic pile.

The history of this discovery is of special interest in the sense that it gave rise to a series of absolutely new facts, at least so far as the causal side is concerned; one could, therefore, expect to find here some convincing data pointing to the psychological aspect of creation. But what we really get is this: Volta's merit (psychologically speaking) is that, unlike Galvani, he was not satisfied with a ready-made explanation and approached the matter without any preconception; thanks to this he was able correctly to assess the conditions of the phenomenon. Volta's basic psychological work ended with this; all he had to do now was to reproduce the conditions of the phenomenon, i.e., combine the two metals and the liquid as they had been combined in Galvani's experiment; but this was now sheer imitation.

Now let us pass to the third example. Everybody knows that even savages are aware that friction generates heat—they use it to obtain fire. I cannot affirm with certainty that savages are conscious of the causal relationship between friction and the generation of heat but it can be assumed that they are, because to become aware of it all that is needed is to rub, just once in a lifetime, one hand against the other. In any case, the idea that friction is the cause and heat the effect has been known to men from time immemorial, at least for several millenniums. But throughout this long period man, until our century, had disregarded one simple circumstance: since friction is unthinkable without motion, i.e., some kind of motive power, the phenomenon as a whole consists not of two factors, as claimed in the foregoing explanation, but of three. When at last this error was rectified, when it was shown that the real cause of the generation of heat was mechanical power, friction was relegated to the role of a factor contributing to the conversion of mechanical power into heat.

This shows once more that the rudiments of scientific truths are sometimes prepared in their entirety by savages and that only a grouping together of the rudiments is needed in order to obtain a more or less important scientific discovery.

This reminds me of a thing I noticed in the Kensington Museum and which greatly impressed me. In the musical-instruments section of the museum there is, among other prototypes of our modern instruments, one which is used by a tribe of African Negroes; it is made of two suspended cords somewhat drawn apart at the bottom and of small wooden slats fixed between the cords like the rungs of a rope-ladder; the slats vary in length and are not unlike those used in the wooden or glass harmonicas. The main feature of the instrument is that at the back of each slat, on the same level but at some distance from it, are tiny pots made of clay also of varying dimensions; each of the pots, evidently, is a resonator attuned to that tone of the corresponding slat which comes out best when the slat is tapped. This shows that the African Negroes anticipated one of the most brilliant ideas of Helmholtz[41]—the idea of using hollow spherical resonators attuned to different tones.

These examples enable me to draw two conclusions:

1) If we subject even the most rudimentary manifestations of civilisation to psychical analysis, we shall see that even then man was endowed with the mental faculties of an observer, thinker, scientist and artist. Indeed, there is no reason to assume that the discovery of the method of obtaining fire or the method of extracting iron and copper from minerals required less intellectual energy than any modern technical or scientific discovery. What is more, we are bound to admit that the psychical factors are identical in both cases.

This conclusion, I believe, can be reinforced by the following consideration. if those prehistoric inventors of artificial fire and of bronze could have been switched from childhood straight into the nineteenth century, they would have become outstanding physicists, chemists and technicians.

2) While the historico-psychological method of studying the relics of human activity would not reveal to us the secrets of psychical processes, its importance, nevertheless, would be great—it would enable us to establish the successive development of man's psychical activity in accordance with his gradual accumulation of knowledge. Among other things such a study would reveal, for example, the successive chain of analogies by means of which the human mind was able gradually to advance from the cart to the locomotive and the railroad; it would show us how the dream to fly like a bird (probably cherished by

the children of prehistoric times) led to the developing and perfecting of aeronautics. This kind of research would be most helpful in investigating the languages and philosophical views of primitive peoples, because this is the only way in which an end can be put to the improper use of words and abstract concepts as psychical realities.

I must confess that, in view of the paucity of facts at my disposal, I would not have taken it upon myself to reject the method of studying psychical processes suggested by Mr. Kavelin were it not for the following general consideration.

Any psychologist upon encountering a relic of human mental activity and anxious to investigate it must of necessity attribute to its maker his own measure of observation, his own ideas of the ability to make use of analogies, to draw conclusions, etc. Without this, clearly, no analysis is conceivable. For this reason we regard the ancient inventor of fire as being the equal of Lavoisier in creative power. The matter would be different if the relics of the various epochs were such that we could say for certain that in this or that period man was still unable to observe things, to make use of analogies, etc.; but this, obviously, cannot be said; about the only thing we can affirm is that at one time man's powers of observation were poor, at another time they were better.

And so, while in no way denying the importance of the material recommended by Mr. Kavelin, we adhere to our view that it does not provide the means for throwing light on the darkness shrouding the psychical processes.

Before leaving the subject I should like to adduce a few hypothetical considerations concerning motives not mentioned by Mr. Kavelin, but which in all likelihood impelled him to offer such an abundance of material for establishing the science of psychology instead of observations drawn from everyday life as is usually done. Mr. Kavelin is aware, of course, that great minds such as Descartes, Leibnitz and Kant encountered the same everyday psychical facts as in our days; their instrument of research was the same—psychical vision; their analytical capacity was superlative ... and yet they failed to establish the science of psychology. This must have led Mr. Kavelin to conclude that the material with which they worked was either of no value at all, or it was not sufficiently elaborated. I am bound to say that only by reasoning in this way is it possible for me to understand why Mr. Kavelin so fiercely attacks the voice of self-consciousness when speaking about the material on which psychology should be based, and why he has such blind faith in this same voice when speaking, for example, about the *self*, of the division of the spirit into two, etc., in other parts of his book.

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Let us turn now to the third point, i.e., the method of research.

In view of the fact that the historical method of studying the relics and monuments of human activity involves the researcher in a study of everyday psychical life, this method has a shattering effect on Mr. Kavelin's entire edifice. He shies from openly following the research methods of the outmoded idealistic school, i.e., from basing all his research on deduction; centuries of experience show that, by using the method of speculative induction alone, it is simply impossible to derive anything from the raw psychical material of everyday life. In these conditions psychology will remain for ever an amalgam of correct observation and the deception of the voice of self-consciousness. But even if the study of the remains and monuments of human activity did not lead the researcher to results so deadly for Mr. Kavelin, his views on the method of research would still not justify his optimistic belief that the natural sciences would not have any advantage over psychology as far as elaborating the material goes and that psychology would be established as a positive science treating of the spirit, its attributes and manifestations.

Properly speaking, it is unimportant which method is used in the research—induction or deduction; what really matters is a method that would enable us not only to analyse the given phenomenon, but also to verify the result obtained. Pure and applied mathematics is, perhaps, the only exception because here truths, even absolute truths, can be obtained without verification, solely by way of mathematical speculation. The point is that mathematical speculation, since it is expressed in calculations and geometric constructions, is more constrained than any other kind of speculation; in searching for a new truth, the mathematician, in addition to beginning with axioms and other truths, relies on these throughout his research. It is clear, therefore, that speculation of this kind is bound to be foolproof and that conclusions drawn from it are not in need of verification. But when we go beyond the limits of simple spatial and quantitative relations, and find ourselves in the domain of complex phenomena not yet accessible to mathematical analysis, experience is the most reliable instrument of analysis and verification. As Mr. Kavelin correctly remarks on page 4 of his book, here, too, speculation plays a certain role; but in the experimental sciences it is restrained by the material of the experiment, this restraint being not so strong as in the case of mathematical truths, but at the same time preventing it from losing touch with reality. But when speculation with all of its attributes descends to the sphere of phenomena to which experience has no access, it becomes all powerful, but at the same time the reliability of the conclusions greatly diminishes, with the result that in our times we fall back on the statistical method. But it would be extremely difficult to use the statistical method in studying the psychical manifestations of the individual; if it could be done the results would be immeasurably more reliable than those obtained through introspective analysis alone. It would be good enough if speculation were to confine itself to conclusions drawn directly from a comparison of the facts; but true to ancient philosophical tradition, it tries to get to the root of things, to establish general principles, forgetful that all philosophical systems based on the method of deduction have discredited the very name of philosophy.

Surely these widely-known facts should be convincing enough for those who, lacking the means of verification and relying solely on critical ingenuity, venture to investigate such an unexplored area as psychology in which there are no axioms and any number of questions awaiting an answer. Clearly, the famous mathematicians who studied the problems of philosophy were also fertile enough in critical ingenuity; but what came of their endeavours? Their errors, however, in no way detract from their prestige, since they were determined by the conditions of the times. In those days there was no branch of knowledge that could furnish solid support to the initial analytical study of psychical phenomena.

Such branches were created only in our time, so it is understandable why psychology should still be virgin soil.

To sum up, 1) Mr. Kavelin's points of departure are not reliable; 2) his abrupt switching from concrete facts to general principles is a scientific error for which in our days there is no justification; 3) the special instrument which he recommends for psychological research is a fiction; 4) the material suggested by him for elaboration lacks the prerequisites for unfolding the secrets of the psychical processes; while without some special and completely unforeseen help afforded by this material, 5) his entire method boils down to pure speculation. These are the reasons why 6) psychology, on this basis, cannot become a positive science.

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The clearest proof of these conclusions can be found in Part 2 of Mr. Kavelin's book where he applies his general principles to the study of particular problems, such as: 1) phenomena which border between the psychical and material elements (pp. 59-69), 2) feeling (pp. 69-86), 3) acts of thinking (pp. 127-36 and 140-47), 4) voluntary spiritual activity (pp. 178-207). True, his system is not applied fully; he bases his conclusions not on the abundant historical material which he recommends in the general part of his book, but on an examination of the everyday psychical manifestations. However, as we have seen, the historical material would not essentially change the situation; what is more, if the founder of the system considers that attempts can be made regardless of the foregoing stipulation, this means that the attempts are feasible.

But before examining this part of Mr. Kavelin's book I consider it necessary to make the following reservation. I shall examine only his main conclusions and shall touch on his arguments only when this is unavoidable; otherwise, I would find myself repeating all the generally known views on thinking, feeling, etc., which, as stated above, underlie Mr. Kavelin's conclusions.

Although in Part 2 of his book Mr. Kavelin does not provide a clue to the general course of his reasoning, it is possible to single out his basic, guiding ideas which are:

1) Psychology is the science of the spirit, its attributes and manifestations.

2) The properties of the spirit are determined by the laws governing the psychical manifestations.

3) The principal forms of the psychical manifestations are: a) psychical facts bordering between psychical and material elements, b) feeling, c) acts of thinking, and d) will. These manifestations are critically examined, definite laws are deduced, and the spirit is accorded these or other attributes in keeping with these laws (consciousness, ideality, freedom, ability to break up into two, etc.).

Of these factors I shall dwell only on the following: the significance of hallucinations and dreams for psychology, freedom of thought and the ability of the spirit to divide into two.

As to the phenomena bordering between psychical and material elements, Mr. Kavelin examines them solely for the purpose of establishing the relationship between the psychical and the material and, at the same time, the conditions and the peculiarities of psychical life (pp. 58-59).

He first examines the phenomena of hallucination. He points to their basic symptoms (absence of external influences, distortion of impressions, all the way to the fantastic) and reaches the following general conclusion: "All the data relating to hallucinations reveal two tendencies in man, or two opposite currents; one takes into the spirit from the outside the actions and influences of the material world, while the other, as it were, ejects the same actions and influences from the soul into the external world, sometimes in a transformed state. If there were no other factors, this alone would suffice to prove the existence of a special psychical centre as the source of specific phenomena, *although it is possible and even likely that the hallucinations are provoked by certain abnormal states of the physical organism.*"

Hallucinations are *always* the result of a pathological state of the brain: visual hallucinations are caused by abnormal excitation of the optic centres, aural hallucinations by abnormal excitation of the auditory centres, and so on. There is nothing unusual about the outward projection of the excitations of the visual centres; on the contrary, it is perfectly normal, since the same thing happens in usual vision. Hence, hallucinations do not corroborate Mr. Kavelin's idea.

Further, he finds that in the state of hallucination ideas are not under control, whereas the normal mind forms the ideas *and has full control over them. The same proposition is found* in a modified form on page 68 where, in connection with dreams, Mr. Kavelin states that only the active side of the mind is expressed in the acts of thinking and will, while the passive side *is expressed in dreams. These are the only conclusions that* emerge from his work.

Mr. Kavelin's theory of man being free with regard to his ideas and thoughts is of an absolute character: in his view, both *one and the other are subordinated to our will and power* (p. 71). This theory occupies the entire second part of his book, and only once, on page 126, does he mention in passing the *rather widespread* view that actions alone can be voluntary in the strict *sense of the term, while feeling and thought do not depend on* man's will. Mr. Kavelin, who does not analyse this view, falls back on the indecisive phrase: "however, this is hardly correct", after which he leaves the *rather widespread* opinion without any *analysis whatever. But this, too, is hardly correct and, in view* of the importance of the matter, I shall have to go into it myself.

The question is, can man really evoke thoughts at will.

Mr. Kavelin will undoubtedly agree that an educated man is hardly ever baffled by a word even in a very large vocabulary. This means that his mind is stored with material for several thousand ideas at least. If Mr. Kavelin grants this, I invite him to try naming, say, 200 nouns in the space of an hour (naturally, we exclude associations of words learned by heart in childhood, such as exceptions to the rules of the Latin grammar, series of numbers, conjugation of verbs, etc.). I make bold to predict that *if just before the experiment Mr. Kavelin were to think, for* example, of psychology in general, his first words would go something like this: psychology, spirit, body, idealism, materialism, Kant, Hegel, etc., and it is quite possible that the experiment would be successful; but if he were asked to enumerate, Fortunately for man he has not even this semi-power over his thoughts, and precisely for this reason our thinking is a continuous chain the links of which follow one another in succession. Mr. Kavelin himself defines (pp. 108-09) states of day-dreaming as cases of involuntary thought; but then any idea which absorbs a person to the extent that he becomes oblivious to his surroundings, is, in every respect, similar to this dreaming. And it is these scientific dreams which often give birth to great discoveries; this does not necessarily imply that the dreams should be of an intermittent character, i.e., interrupted by the voluntary thinking up of new ideas; on the contrary, like any concentrated thinking, they usually proceed smoothly. Anyone who has ever experienced the birth of ideas which resulted in new scientific truths will confirm the correctness of my words.

All considerations enumerated here can be applied also to feeling which, in Mr. Kavelin's opinion, is also free, though to a lesser degree than thought.

But the crowning masterpiece of Mr. Kavelin's philosophical research is his conclusion on the ability of the spirit to divide off into two parts.

Here is what he says on the subject (pp. 103-04): "The inner vision and the faculty of the mind to receive and retain psychical impressions point to its being able to divide off into two parts and yet remain a single whole. Just as memory preserves and retains in the mind the facts which present themselves to the consciousness and self-consciousness, so the faculty of the soul to divide off into two, while simultaneously remaining a single whole, enables us to grasp these facts and to become aware that they are in our mind, to see ourselves and to be aware that we are seeing ourselves and not somebody else. If the mind lacked this faculty, man would not be able to look into his mind, to look into himself psychically; and if the mind did not remain a single entity when dividing off into two, man would not be able to know himself, would be unable to think of himself or to speak of himself as "I"; with such an inner division man would be psychically split into two halves—one alien to the other—and he would have the feeling of being some kind of foreign, external object; but, since he is conscious that this external and foreign object is none other than he himself, this shows that despite its division the mind remains a single entity, an integral whole.

"Nothing like this is encountered in the physical world.... If we tried to explain this psychical division and its consequences by means of *examples from the material world*, we would have to assume that an object can be separated from itself and that the separated *part can be equal to the whole and be a whole in its own right, or that the whole may remain a whole even after the separation of one of its parts*; but in application to the material world all concepts of this kind are absolutely impossible, whereas in the psychical world these concepts correspond to the *ordinary* and *indisputable* facts, facts which are so *simple and obvious* that everybody can observe them in himself and in others.... The psychical organism is of a specific nature; it bears no resemblance to any physical organism, *just as organic objects bear no resemblance to the inorganic, or as animals do not resemble plants*."

I shall examine the whole of this theory only in its logical aspect.

When Mr. Kavelin *claims that the splitting of the mind cannot* be explained by examples from the material world, he falls back on such abstractions which everywhere are regarded as axioms, i.e., as truths which do not need to be demonstrated (a part cannot equal the whole, or the whole is bound to diminish when one of its parts is separated). These truths are obligatory not only for the mathematician, but for *any logical thinking*. Hence, any deviation from these truths is generally considered as a *mystery*, i.e., a phenomenon which cannot be comprehended by the human mind. However, in the first part of the above-quoted passage Mr. Kavelin *deduces this mystery in a purely logical way* (!!!); in other words, *he comprehends the mystery*. But this is an obvious absurdity.

*Further, according to* Mr. Kavelin, *this deduction rests on simple* facts; hence, the facts which provide the data for the deduction are simple, while the deduction is incomprehensible. This is another absurdity.

Thirdly, physicists, chemists, botanists and zoologists all over *the world acknowledge that organic and inorganic objects, plants* and animals, are in essence governed by the same laws. Consequently, *the distinctions between them cannot be anything* as *great as those between the psychical organism which splits into two and still remains an entity and any physical organism.* Thus, the analogy is not only wrong, it is represented in an illogical manner: once it is said that the splitting of the mind into two cannot be explained by examples from the material world, how is it possible to reconcile the mind with this phenomenon by invoking the facts of the material world?

Here I conclude the examination of Mr. Kavelin's philosophical system. On my part, I shall try to outline a plan for the elaboration of psychical facts, since, I repeat, the time for this has come.

## WHO IS TO ELABORATE THE PROBLEMS OF PSYCHOLOGY, AND HOW?[44]

### I

Mental life is governed by definite immutable laws· in this *respect psychology can be a positive science.—But this will* happen only when the immutability of the laws is proved not only with regard to the whole, but also to its parts —Of all the phenomena encountered in the world there are but two categories which can be compared to the mental life of man; these are the mental life of animals and the nervous activity of man and animals, which are studied by physiology.—The two categories, being simpler in content, could be a clue to the understanding of the mental phenomena in man.—Comparison of concrete mental phenomena in animals with those in man is the subject of comparative psychology, while compari*son of mental phenomena with the nervous activity of* the human body is the groundwork of analytical psychology, be*cause the nervous processes taking place in the body have* already been subjected to at least partial analysis. Thus, it is *clear that only physiologists are qualified to investigate the* problems of analytical psychology.

He who says that psychology is not yet an established science is bound to admit that man has no special mental mechanism *for perceiving psychological facts, no special inner feeling* or psychical vision which, merging with the thing cognised, would enable him to cognise the products of consciousness immediately, *in their essence. Indeed, if psychology had this tre*mendous advantage over the sciences which study material life and which cognise the objects of their study mediately, it would have left natural science far behind, and would have long since established a reputation for itself for infallibility of its deductions and generalisations. In reality, however, we see that even-the very question of *who* should investigate the problems of psychology and *how* they should be studied still awaits solution.

Those who hold that psychology is not an established science are also bound to admit that the subject of its study, i.e., mental phenomena, is of an extremely complex nature. Otherwise, it would be impossible to explain the extreme backwardness of psychology in the scientific elaboration of its subject-matter, although this elaboration dates from ancient times, long before the appearance of physics and chemistry.

On the other hand, he who maintains that psychology is a science cannot but acknowledge that mental life as a whole, or at least part of it, is governed by laws every bit as immutable as those of material life, since this is indispensable for a *truly scientific* investigation of psychical facts.

Fortunately, this vitally important question is answered in the affirmative even by those schools of psychology which believe that there is an impassable gulf between spiritual and material life. And how could it be otherwise? The basic features of man's mind and of his sensory faculties have not changed in the course of historical development and do not depend on race, geography or cultural level. It is this that explains why we are conscious of the moral and intellectual kinship of all people inhabiting the globe, irrespective of race; and this alone makes it possible to understand the ideas, feelings and behaviour of our remote ancestors. The one fact which prevents us from admitting the concept of the immutability of the laws governing mental life is the so-called voluntariness of human actions. Statistics, however, have thrown unexpected light on this intricate sphere of mental phenomena by proving that some human actions belonging to the category of the most voluntary ones (such as marriage, suicide, etc) are subject to definite laws, if they are regarded not separately, but in the aggregate and over a fairly considerable period. But, these valuable statistical data apart, it is not difficult to see from a general point of view that even in individual cases voluntariness never violates the laws governing human behaviour. Take for example the attitude of public opinion towards the actions of individuals: some of the actions are attributed to environment, others to education, still others to the character of the given individual. Only in the actions of a madman is it difficult at times to discern rational motives. But even in this case there are, undoubtedly, definite motives, though the relationship between motives and the resultant acts are not the same as those found in the motives of normal people; hence, the actions are irrational. Subordination of human behaviour to definite laws is clearly manifested also in our ability to create literary images endowed with diverse traits—the characters strike us as being real and true just because their behaviour conforms strictly to their individualities, to environment, etc.

Thus, the basic condition for making psychology a positive science actually exists and has long been acknowledged by every thinking person.

But this merely signifies the possibility of it being a positive science; its actual existence begins when the laws of mental phenomena are not merely anticipated but can be proved both with regard to the whole and to its separate parts. Everybody knows, for example, of the association between the flame and the burning of the combustibles consumed by it. But this is not scientific knowledge—it is only raw material for science. The latter must decompose the phenomenon to the greatest possible degree and reduce the complex relationships to simpler ones; and only after this has been done does the anticipated laws become a scientific truth. The same course should be taken by psychology the first task of which is to elaborate the general principles on which the decomposition or analysis of mental phenomena is to be based.

Since we have admitted that psychology is not an established science, it would be best to tackle its first task, just as if mental phenomena had never been scientifically investigated. Having taken this stand the reader should keep in mind the fundamental principle of every science established by man—a principle followed even by mathematics—proceed from the simple to the complex, or, what is the same thing, explain the complex by the simple and not vice versa. It will then be clear that the next step in the research is to compare the complex phenomena with other simpler but similar phenomena. Let the reader call to mind the diverse phenomena which exist on earth—in the inorganic sphere, in the vegetable kingdom, in the animal world and in human society, and let him compare man's mental manifestations with each of the foregoing groups in turn. He will discover that only the mental manifestations of animals have something in common with those of man; moreover, he will realise that the phenomena of the social life of individuals are determined by the elements of their mental life. It goes without saying that the first group of phenomena (i.e., the mental manifestations of animals) is less complex than the mental life of man, while the second group is more complex.

*Hence, the simpler mental manifestations of animals, not those of man, should be used as the initial material for investigating mental phenomena.*

But is not the similarity between man's mental manifestations and those of animals purely superficial? Is not the divergence so great that they cannot be compared at all? This view has many supporters; it is reasonable enough as far as the quantitative side of the phenomena is concerned; for the quantitative difference is truly tremendous. But the claim that there is a qualitative difference between the mental organisation of man and that of animals cannot be regarded as being scientifically established; it is merely conjecture and not the product of scientific analysis, because the comparative psychology of animals and human psychology are not yet established as sciences.

Still, let us assume that the similarity of the mental organisation of man and animals is only of a limited nature, and that beyond these limits they differ essentially. In this case, too, the rational way to investigate mental phenomena in man would be to study first the similar aspects leaving the solution of all further problems to the future, if there are no grounds at the moment for their solution.

The development of physiology is instructive in this respect.

At one time the similarities and differences between the phenomena of the human organism and those of the material world held the attention of researchers in much the same way as the similarities and differences between the mental and somatic phenomena in man do at present; this gave rise to several schools of physiology which are as much at variance with one another as the idealists and materialists in psychology. Some researchers were chiefly attracted by the motor aspect of the life of the body and joined the school of iatromechanists who explained life in a purely mechanical way. Others, interested in the chemical aspect, joined the school of iatrochemists.[45] Then there were investigators who dealt predominantly with those aspects of life which, seemingly, made it different from the other visible phenomena of the material world; the latter formed a third group—the school of so-called vitalists who believed that the animal body has special "vital forces" that have no parallel in the material world. Although the original doctrines of the first two schools were often ridiculous in their details, they gave birth to the present experimental physico-chemical trend in physiology, while the third school no longer plays any role whatever in this branch of science. This is quite understandable if we bear in mind that the crude concepts of the iatromechanists and iatrochemists actually contained the rudiments of a scientific trend which sought to *explain the complex by the simple*; as to the views of the vitalists who separated the nature of the human body from the sphere of simpler phenomena, they could but lead to a feeling of surprise at the facts under investigation, and in no way to an analysis of their elements. To this day many physiological phenomena remain absolutely unexplained (for example, impregnation of the ovum, development of the embryo, hereditary transmission of specific and individual characteristics, etc.); but it has never occurred to any physiologist to *explain* them by claiming the existence of special forces; faced with such problems, the physiologist usually says: "I do not know."

Clearly we should follow the same course in tackling our problem. Unfortunately, at present it is still impossible to estimate, even approximately, the importance of the comparative study of psychical phenomena in man and animals. True, the raw material for this study is available (it includes, on the one hand, the results of observations on animals designated as "habits and customs of animals", and on the other hand, the facts accumulated by so-called practical psychology); however, serious attempts at a comparative study have only just begun. It is easy to see that this study would be of particular importance for classification of mental phenomena—it could reduce the numerous complex forms to less numerous and much simpler types and, in addition, determine the stages of transition from one form to another. It is quite possible, for example, that it would yield a more natural system of classification of the various feelings (feelings in the narrow sense of the word, affects, passions) and would bridge the gulf between reason and instinct, voluntary actions and involuntary ones, etc.

On the other hand, it will be appreciated that the method of comparing concrete facts of greater and lesser complexity can at best result in the complete reduction of a complex form to a simple one—in no way can it lead to analysis of the latter. Consequently, the researcher would be confronted with a new problem—to find the methods by means of which the concrete mental phenomena of animals could be analysed. Unfortunately, the methods used in physiology for analysing the phenomena of the animal organism cannot be used in our case, chiefly because one of the most important aspects of mental phenomena—consciousness—can be investigated only by one's self, i.e., by way of introspection.

Thus, the methods of comparative psychology cannot be used as the starting-point for *analytical* study of psychical phenomena and we must, therefore, turn to other sources for this purpose.

But with what are we to compare human psychical phenomena? To compare them with higher, more complex phenomena is impossible, just below them lies the psychical life of animals which cannot be analysed, and still lower begins the sphere of matter. Should we compare psychical life with the life of rocks, plants and even of the human body? It will be recalled that the great thinkers of the past used to compare man's corporeal and spiritual life and generally found no resemblance between them, but only profound differences. Indeed, in olden days the attitude of philosophers to psychical phenomena was, naturally, the same as that of the vitalists to the phenomena of the body; physiology did not exist at the time and the phenomena of the body had not been analysed to the degree that would make the similarity between some of them and psychical activities quite appreciable. Things are different now: *physiology provides a number of facts which establish the affinity of psychical phenomena to the so-called nervous processes in the body, i.e., to purely somatic acts.*

Here are the most important of these facts (it should be borne in mind that if a certain idea is supported by a number of arguments its conclusiveness is determined not by separate facts but by the sum of the arguments):

1) Every psychical act, even the simplest, takes a certain time; the more complex the act, the longer is its duration (see textbooks on physiology).

2) The anatomo-physiological integrity of the brain is a condition for any psychical activity (a well-known fact).*

3) The rudiments of psychical activity (at least the innate rudiments), develop clearly, from the purely material substrata of the ovum and the sperm (a well-known fact).

4) Numerous individual psychical peculiarities, among them those belonging to the category of higher manifestations, such as inherited talent, are transmitted by the same material substrata (a well-known fact).

5) There are no clear distinctions whatever between the obviously somatic, i.e., bodily, nervous acts and the definitely mental phenomena.

6) Remaining within its sphere, i.e., examining the phenomena of the body in connection with its structure, present-day physiology has proved the existence of a close relationship between the nature of perceptions and the structure of the corresponding sensory mechanisms, or sense organs (see textbooks on physiology).

Of the foregoing points only No. 5 requires a detailed explanation—the others have long since been known to science and even to the public. To prove that point No. 5 is true, it is sufficient to show the close relationship between the somatic nervous processes and the lower forms of activity of the higher sense organs, because since Locke's time this activity has been generally regarded as the chief, if not the sole, source of

* Points one and two show that psychical activity, like any other, takes place in time and space.

psychical development. Only those bodily nervous processes which develop in the same way as the so-called reflexes can be compared with the activity of the sense organs, because such nervous processes alone have a common basic property with the activity of the sense organs: they arise only as a result of the action of external stimuli upon the receptive surfaces of the sense organs. Fortunately, most of the bodily nervous processes are of the reflex type (there are some deviations but they belong to the least investigated phenomena); thus, an extensive analogy is possible here.

Physiology distinguishes the following three basic stages in the development of a reflex, according to the structure of the reflex mechanism: stimulation of the receptive surface, the activity of the centre, and manifestation of excitation in the effectors of the body—in the muscles and glands. For the sake of brevity, I shall designate the first stage as the beginning of the act, the second stage as its middle (intermediate stage), and the external manifestation as the end. The existence of the three stages makes it possible to compare the reflexes and the activity of the sense organs in the following way: 1) from the point of view of their general external character, 2) from the point of view of their general significance for the body (a general comparison), 3) from the point of view of the complication of the phenomenon by new elements, in addition to the three principal ones, and, finally, 4) from the point of view of the relationship between the beginning and the middle of the act, on the one hand, and between the middle and the end, on the other (partial comparisons which at the same time define the relative significance of each stage of the reflex taken separately).

The external nature of the reflexes is determined exclusively by their beginning and end, since the middle cannot be observed directly. The leg of a decapitated frog, if pinched, will be drawn back immediately, this is a reflex. A drop of vinegar poured into the mouth of a strongly narcotised dog, will cause it to salivate. A hand waved before the eyes of an animal will make it blink; if a finger is placed in the mouth of an infant the latter will begin to suck it, etc. In each case the action of an external stimulus on a sensory surface (in the above examples the sensory surfaces were: the skin, the mucous membrane of the oral cavity, the mucous membrane of the eye, and the mucous membrane of the lips) is *inevitably* followed by a certain manifesta*tion in the muscles or glands in the form of movement or secre*tion; and in all cases the external manifestation is an act of expediency which is of definite use to the body. For example, secretion of saliva evoked exclusively by stimulating the surface of the cavity which takes in the food is economically very useful —it prevents wastage of gastric juices; the blinking is a means of safeguarding the eyes; the sucking is the infant's way of taking food, etc. *This is true of all other known reflexes without* exception: for example, reflex sneezing and reflex coughing expel foreign substances from the nose and throat; vomiting clears an overloaded stomach; *constriction of the pupils dimin*ishes the intensity of the light reaching the eyes; the reflex contraction of the sphincter of the rectum retains the contents in the intestine, etc. Thus, in its typical form the reflex is an act of expediency (i.e., of benefit to the body); it is caused by the action of an external stimulus upon that part of the sensory apparatus known as the sensory surface.

Let us now turn to the lower and higher sense organs, and let us again consider quite objectively the effects of their functioning. What do we see? The animal uses its senses of smell, hear*ing, sight and touch as a protection against hunger, cold and* enemies. But the ears, eyes, nose and skin by themselves cannot ensure the attainment of these particular objects; the animal *is but guided by its senses, while objects are achieved by means* of highly diverse movements. Hunger impels it to hunt for food, but the direction of the hunt is determined by the sense organs. One has only to reflect on the vast sphere of phenomena designated as acts of self-preservation (they are well known and therefore there is no need to cite examples), to see that they consist of the same elements as the reflex: here, too, the beginning of the act is stimulation of a sensory apparatus (sensations of hunger, thirst, cold, stimulations of the eye, ear, and nose) and the end is a movement. Here, too, as in the case of reflexes, the movements are expedient and useful to the body, serving its needs and protecting it. The sole difference between these reflexes and the effects of the instinct of self-preservation is as follows: in the first case, i.e., in the case of reflexes, movements serve only separate needs of the organism—they close or clear a certain duct, constrict or dilate an orifice (such as the pupils or the glottis), keep clear or transparent those organs which must be kept in such a state (for example, the cornea is kept transparent by means of tear secretion and blinking); whereas in the second case, i.e., in the case of activities resulting from hunger, cold, visual, aural and olfactory sensations, it is the welfare and the overall security of the body as a whole that are ensured. Hence, the difference, obviously, is quantitative, and by no means of an essential character. But who will deny that the instinct of self-preservation may engender actions displaying all the essential features of psychical acts? Consider, for example, the case of a person who takes to his heels upon being frightened by a terrifying sight or sound. If we analyse this act, we shall see that it includes first a visual or aural impression, then awareness of danger and, finally, a movement of expediency, i.e., all the elements of reasoning, deduction and rational action; at the same time this is obviously a psychical act of a lower type, bearing all the hallmarks of a reflex.

Consequently, from the point of view of their external character and general significance for the body, reflexes and lower forms of activity of the sense organs can be regarded as identical.

But the phenomena which we are now comparing have not only a beginning and an end, they also have an intermediate stage, and it may be that it is this stage that makes the identification impossible. In point of fact, if we compare, for example, the blinking with the case of fright, mentioned above, the analogy may even seem ridiculous. In the blinking we observe, whether in ourselves or in others, only movement, whereas in the act of fright, if it is identified with a reflex, we observe in the intermediate stage a chain of psychical activities. The difference between the two—the two extremes of a series of acts—is really considerable; however, a simple experiment will show that the act of normal blinking contains all the essential elements of the act of fright, including even the intermediate element. Blow gently into the eye of a man or an animal, and the blinking will become more pronounced than is normally the case; the man will distinctly feel the puff on the surface of the eye. This sensation is the intermediate member of the blinking reflex. It is present in normal conditions, but is so weak that it does not reach our consciousness. Sensation, then, is the intermediate member even of the most elementary reflex. Observation gives grounds for assuming that in a normal, non-decapitated animal there are hardly any reflexes which, under certain conditions, would not be accompanied by sensation. It follows, therefore, that sensation, as the intermediate member of the reflex, is the rule, and in this sense comparison of the reflex with the activities of the higher sense organs is, from a general point of view, justified; in both cases the intermediate members of the acts are kindred sensations. The comparison seems still more justified if we consider the entire mass of reflexes and classify them into groups according to the role played by sensation in the process of the reflex and according to the complexity of sensation. In the first respect, all reflexes are divided into two large groups. In one group conscious sensation, apparently, does not play an important role in the act; this is proved by the fact that such reflexes are observed in man even in a state of unconsciousness, and in animals after decapitation. These are the simplest forms of nervous acts which serve the needs of the body perfectly even if the mechanism is so organised that it ensures only the inevitable emergence of the same movements of expediency. In other reflexes, on the contrary, conscious sensation is an indispensable factor which determines the beginning of the act, its course, and its end. Recall, for example, evacuation of the urinary bladder and the rectum movements induced by the desire to urinate and defecate; or the periodical supply of the body with food and drink caused by the sensation of hunger and thirst; or the limitation of the amount of food introduced into the body as a result of surfeit, etc. Without consciousness these acts would be impossible; hence, the element of consciousness is an indispensable factor here. From this to the intermediate member of the lower forms of activity of the sense organs is but a step, for it is here that the decisive significance of sensation for the movements is most pronounced. As already mentioned, the eyes, ears and nose are but movement regulators. Therefore, in this respect between the lower forms of the reflexes and the functions of the sense organs there are gradations but not complete contrasts.

The same gradation is observed also in the complexity of sensations, or, to be more precise, in their variability. They begin with almost unconscious manifestations (for example, sensations caused by blinking and normal tear secretion, muscular and normal gastric sensations, etc.), and develop into definitely conscious sensations, only differing quantitatively in form (for example, a rasping feeling in the throat during coughing, a tickling in the nose during sneezing, a desire to urinate or defecate, feelings of hunger, cold, thirst, etc.). In the sphere of the lower sense organs we already get variability of the sensation, expressed in the fact that changes in the impulses acting on the sensory mechanism entail not only quantitative, but also qualitative changes in the sensation. These changes influence even the nature of the motor reactions. We distinguish, for instance, different smells and tastes, and the effects of these vary, depending on their quality. For instance, the disgusting taste or smell causes vomiting, while the pleasant sensation evokes a smile of satisfaction. Everyone knows how we react to something sour. In the higher sense organs this qualitative variability of sensations, which depends on changes in the external impulses, is most pronounced. People rightly say that no two grains of sand are absolutely alike. This testifies to the remarkable perceptive capacity of the human eye. How is this capacity explained? Anatomy shows that the variations in capacity of the sense organs are due to the vast difference in their structure. In those organs which do not differentiate sensations, the sensory surface is relatively simple in structure; it is more complex in the nose and in the mouth, and as for the mechanisms of the eye and the ear, they are so complex that much in them still remains a mystery.

The reader will agree that so far my analogy has been perfectly reasonable. But will it be appropriate if in our study of the higher sense organs we overstep the borderline separating instinctive acts of self-preservation from acts of a higher order, acts involving the participation of the will? This latter agent explains why human activity is not of a mechanical nature, especially on the higher levels of psychical development; hence, it can be assumed that the will is found (or, at least, originates) only in the higher spheres of psychical life. To make the point clear we will take the act of blinking as an example. Suppose something has got into the eye. Can the resulting pronounced irritation of the mucous membrane of the eye, which normally induces the blinking, engender voluntary actions usually ascribed to the will? Yes, it can. It may lead, on the one hand, to conscious and rational actions aimed at removing the alien body from the eye; these actions are the products of the active side of the will. On the other hand, the man may suppress—also in a conscious and rational way—convulsion of the eyelids (i.e., intense blinking) in the belief that it is better not to interfere with the eye at all; these are products of the suppressing side of the will. Similar examples could be cited for coughing, sneezing, the desire to urinate, etc. It is obvious, therefore, that with regard to the will there is no difference between the reflexes and the products of the activity of the higher sense organs and that the will, too, can interfere with activities and sensations of a lower order, though in this case the forms in which it is manifested are not so varied.

Consequently, in the matter of interference by the sole extraneous agent, the will, there is no essential difference between the reflexes and the lower forms of activtiy of the sense organs; the only difference is a quantitative one.

On the basis of these facts it will not be difficult to establish three degrees of gradation corresponding to the three members of the reflex.

In the matter of the reflexes the natural stimuli inducing the phenomenon are extremely uniform, because the purposes of the reflex movements are fairly simple (for example, closing an inlet to prevent entry of foreign substances, retaining for a time the liquid contents in a sac, clearing a duct, etc.). In accordance with this, the sensory surfaces are often so constructed that they can be stimulated only by mechanical contact. True, even in this case, the stimuli can be extremely varied, because in addition to solids and liquid substances, gases, too, can come into contact with the sensory surfaces. But that is not the uniformity we have in mind; what we imply is that the sensation and its motor effect will always be the same, no matter what substance gets into the eye—be it a chip of stone, wood, glass, iron, or alkali, acid, ether, chlorine or other liquid or gaseous substances. As to the sphere of the sense organs, here with the ascent from taste to vision the natural stimuli become increasingly diverse. For example, the above-mentioned particles, while acting on the eye optically, differ greatly; the eye distinguishes not only between chips of iron and wood, but even between chips and particles of one and the same substance. Nevertheless, all external stimuli are similar in nature and in significance, irrespective of whether they induce a reflex or activity by one of the higher sense organs—the eye. All of them exert physical, chemical or combined influences on the sensory surfaces of our body, and all are actual causes of phenomena.

In the matter of the intermediate members of reflexes, we can now definitely say that they accrue from the structure of the corresponding sensory mechanisms; this conclusion follows from the data previously cited. But to assess their significance for the extreme members of the reflex an explanation is needed. *We know from experience that not every impression perceived* by the higher sense organs reaches the mind, that for this we need, as they say, a certain amount of attention. From this it might be concluded that the intermediate phase of the act does not necessarily follow the first stage; but such a conclusion would be absolutely wrong. Analysis of the reasons for inattention invariably shows that at the moment when the eye should see, or the ear hear, either we are diverted by another, stronger impression, or certain conditions prevent the eye and ear from looking and listening. This is proved also by the fact that absolutely similar phenomena exist in the sphere of the reflexes. A person who is busy doing something or who is absorbed in meditation, may be oblivious to the need to urinate, to eat, etc. But the moment his attention is drawn, so to speak, to these inner promptings, he becomes distinctly conscious of these sensations. There is, then, a direct linkage between the first and the second members. And the link between the second and third members is expressed in the following proposition: sensation is always the regulator of movement; in other words, the former induces the latter and modifies its intensity and direction. In cases when stimulation of a sense organ results in a movement, the link between the second and the third members is obvious from the data given above. In the lower forms of the reflexes, where the sensation is incapable of qualitative modification, this regulation can only be of a quantitative nature, but in the higher forms it can, in addition, be qualitative. But how are we to explain those cases when stimulation, while producing the intermediate member, is not manifested externally in movement? Is not this a distortion of the nature of the reflex which remains without its third member? Not at all! Here, too, the intermediate member retains its role as movement regulator, because in such cases the sensation stimulates not the motor organs of the body, but, on the contrary, their inhibitors. It is not difficult to understand that "*self-locomotion*", a power so highly developed in animals, would be absolutely impossible without inhibitors in the body, and without their being brought into action by stimulation of the sense organs (the sole possible regulators of movement). Physiology has shown that these inhibitors really exist; and the apparent absence of the third member in the reflex or in the lower form of activity of the sense organ is due precisely to the action of these inhibitors. Consciousness, as we know, ascribes control of these inhibitory mechanisms to the will.

As to the gradation in the nature of the three members, it can be described as follows. In the lower forms of the reflexes the motor mechanisms are innate (the new-born child is able to suck, sneeze, cough, etc.), while in the higher forms of the chain the third members are—at least in man—movements acquired by learning, for example, the movements of the eyes in the act of looking, the act of walking, the use of the hands as grasping instruments or levers, etc. True, these movements are acquired early, long before the age of reason; all the same, while in some animals even these movements are innate, in man the difference between the two forms is obvious. We shall see later how great this difference is; in the meantime we shall merely point out that among the reflexes there are those which can be inculcated. It is common knowledge, for example, that infants can be trained to suck and to urinate at definite times and under definite conditions; so that from the standpoint of training, the movements of the higher order cannot be said to be of a special kind.

Lastly, a few words should be said about the general significance of the third members of the reflex. We already know that they are all movements of expediency, always useful to the body; but whereas in the lower forms they serve particular body needs, in the higher forms they serve the body as a whole.

To sum up, *apart from a quantitative difference, there is not a single conceivable aspect which, in essentials, would distinguish the products of the lower forms of activity of the sense organs from the reflex processes in the body.* It follows, therefore, that *the somatic nervous processes and the lower forms of psychical phenomena resulting from the functioning of the higher sense organs are allied in their nature.*

If we accept Locke's view about the sources of psychical life, a view which is shared, though with certain reservations, by practically all schools of psychology, we shall have to admit that *the somatic nervous processes are, in general, allied to all the psychical phenomena stemming from the activities of the sense organs irrespective of their levels.* But before accepting this strictly logical and correct conclusion, it is necessary to remove a widespread prejudice. Should you ask an educated man what is a psychical act and how is it manifested, he would unhesitatingly answer that it is a spiritual phenomenon, the nature of which is unknown and which is reflected in consciousness in the shape of sensations, feelings, impressions and thoughts. Should you consult one of the older textbooks on psychology, you would find the same definition: psychology is the science which deals with sensations, feelings, impressions, thoughts, etc. The idea that only the *conscious* is *psychical*, in other words, that a psychical act begins from the moment it appears in our consciousness and ends when we pass into a state of unconsciousness is so deep-rooted that it is now widespread even in the everyday language of educated people. I myself, influenced by this habit, sometimes speak about the intermediate member of a reflex as a psychical element, and even as of a psychical complication of a reflex process; actually it never entered my mind to divorce the intermediate member of an integral act from its natural beginning and end. But perhaps in psychical life, beyond the boundaries of the lower sphere of sensation psychical acts really assume the shape of processes which take place exclusively in the mind? Does not man think with his eyes closed and his ears stopped, i.e., without using any of his sense organs? Does not the blind person who has lost his sight at a mature age preserve the capacity to think in images and to remember the things he has seen? It would seem that the earlier psychologists, *and all the educated people might be right when assuming that* the psychical acts of a higher order begin and end in our consciousness.

*In that event the conclusion we have drawn above would be* invalid, or at least premature. Fortunately, there is no difficulty in proving the erroneousness of the idea that mental acts begin *and end in the mind.** *Suppose we admit that this idea is right.* What, then, is the role of the spoken and written word—the outward expression of thought? What is the value of man's external activity in general, manifested in his movements and commonly called behaviour? In our view, these phenomena can definitely be regarded as the third members of psychical acts of the lower order, whereas from the point of view of the foregoing idea they are the result of the action of the mind on the body. But what about the multitude of cases in everyday life which impel even the layman to regard some conscious human acts as being the result of the material and moral environment, and others as being caused by the influence of the people with whom one mixes, or by sensual motives? In our opinion, since all these influences affect the human organism through the sense organs, they stimulate certain actions, and are equivalent to the first members of the lower forms of psychical activity. But from the standpoint of those who "isolate the psychical" they are cases *of the influence exerted by matter and body upon the spirit.*

What, then, should we do: extend our analogy beyond the sphere of sensation because psychical activity so often resembles *the reflexes, even though outwardly (and particularly since the* earlier psychologists were unable to make these analogies because of the paucity of physiological knowledge at the time), or confine ourselves to a definite aspect of psychical activity, as in the examples given above, and because of its appearance, break up that which nature has linked into a single whole (separate the element of consciousness from its source, i.e., from the external stimulus, and from its result, i.e., from the act), take away the middle from the whole and counterpose it to the

* For detailed arguments see section III of this article.

remainder as the "psychical" to the "material"?[46] It would not be bad if this unnatural operation were performed after exhausting all means of preserving the integral whole; actually, however, nothing of the kind was done: first the operation of dissection was performed, and only then were attempts made to link the separate pieces together. And what arguments were invoked in this connection! Some people asserted that spiritual and material processes coinciding in time are not allied causally, but are merely parallel and concomitant; others maintained that the nervous system is an organ solely for the material manifestations of the spirit; still others declared that although the material and the spiritual worlds are different, they are not opposed to each other, etc. It is clear that all such arguments are merely logical, or even dialectical, subterfuges which at best may satisfy the speculative mind, but simply cannot explain such manifestly real facts as the interaction of mind and body. On the other hand, the idea of a kinship between the nervous and mental processes fully explains these facts just as the whole explains one of its parts.

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Thus, even if one-half, or three-quarters, or nine-tenths of all the manifestations of the higher psychical activity had outwardly nothing in common with the reflex phenomena, then the remaining one-tenth would make it necessary to carry the analogy beyond the sphere of sensation; such is the requirement of reason and science. But we know that this is not so: as already mentioned, Locke's view that psychical development originates entirely from the activity of the sense organs is shared by all schools of psychology with very few reservations. So here, too, we have a vast field for analogy.

But what will psychology as a science gain from this analogy? It will gain what the human mind generally acquires through comparing *unknown and complex* phenomena with simpler and better known (i e., disintegrated) *similar* phenomena; it will gain what science in general gains from analogy. Indeed, the power of this method is well known. It is to the method of analogy that we owe, for example, the brilliant physical theories that identified heat with light, and both heat and light with the purely mechanical movement of particles. In our case, analogy is the sole means of decomposing the concrete psychical facts, of investigating them analytically. It is true that physiology has found a more direct approach to the study of these facts: it *examines the structure of the sense organs and compares the* various properties of the sensations produced by them with corresponding anatomical data. But it is clear that this is but one particular method in the general system of methods by means of which physiological data can be applied to the investigation of psychical phenomena. This method merely establishes the relationship between some properties of the second member of the reflex and the mechanism of the sense organ, whereas my system contains elements for an all-round study of integral acts, including their beginning, middle and end.

The thing is, as the reader will appreciate, to entrust the analytical study of psychical phenomena to physiology. The reasons for this have been sufficiently elucidated, and now it only remains for me to sum up.

All psychical acts of the reflex type can *in their entirety* be subjected to physiological study, because the investigation of *their beginning and end (i.e., the external sensory stimulation,* and the movements) directly concerns this branch of science; this applies also to the intermediate member of the psychical acts (i.e., to the psychical element in the narrow sense), because very often and perhaps always the latter is not an independent phenomenon, as believed previously, but an integral part of the entire process.

*In a more general way this idea can be expressed as follows:* the science studying the causes of psychical acts and their manifestations should also study the relationship between these acts and their determinants, on the one hand, and between the external manifestations and the psychic elements, on the other.

Accordingly, physiology should also study those psychical *acts in which the external manifestations deviate more or less* sharply from the reflex type, because the experience of all science (at least of the natural sciences) teaches that the cause of any deviation of a phenomenon from the basic type should be sought not in the interference of new factors but first of all in the form of relationship between the known factors, especially if this relationship is as complex, as in the case of the psychical processes. It may be, of course, that this method of investigation will lead to negative results, or even bring the investigator to conclusions that are the opposite of those anticipated; but it is the only rational method and is, therefore, obligatory.

No one doubts, of course, that psychology will thereby be in safe hands—modern physiology is guided by sound principles and by a sober view of things. As a science dealing with facts it will first of all separate the psychic realities from the psychological fiction which is all too abundant. Adhering to the principle of induction, it will not rush headlong into the sphere of higher psychical manifestations but will begin with diligent study of the simplest phenomena. Its advance may be slow, but it will be sound and reliable. As a science based on experiment, physiology will not affirm as an incontestable truth that which cannot be confirmed by precise experimentation; operating in this way it will definitely separate the hypothetical from the positive. It may be that psychology will shed some of its brilliant and universal theories; huge gaps may appear in its actual knowledge; instead of explanations we will get in most cases the laconic phrase: "We do not know"; the essence of the psychical phenomena, insofar as they are manifested in consciousness (like the essence of all other natural phenomena) will still be concealed from us. And yet psychology will have made a tremendous advance. It will no longer be based on erroneous reasoning prompted by the delusive voice of consciousness; it will rely instead on positive facts, on verifiable propositions. Its generalisations and deductions, strictly confined to real analogies, will no longer depend on the taste and whims of the investigator, which in the past brought psychology to transcendental absurdities, they will acquire the character of truly objective scientific hypotheses. The subjective, the arbitrary and the fantastic will give way to more or less reliable knowledge. In short, *psychology will become a positive science.*

*Only physiology can achieve this, because it alone holds the key to the truly scientific analysis of psychical phenomena.*[47]

## II

Criticism of the data on which psychology should be built up. —Determination of general criteria for distinguishing psychical realities from psychical fiction.—Classification of psychological *problems.*

Having exhausted the subject of who should elaborate the problems of psychology, I shall now pass to the second part of my work—elucidation of the methods of investigating psychical facts. First, I shall establish the data that should be used for the build-up of psychology.

Most of these data derive from psychological introspection and from observation of people in everyday life; in the aggregate they are widely known as practical or common psychology. Since the tasks of the physiologico-psychologist[48] are, as yet, rather modest, the data seem to be adequate; besides, they have two rare qualities—accessibility and handiness—which make them very useful for our purposes. In my opinion, it would be useless and even harmful to extend the sphere of investigation beyond the limits of these data; the experience of all positive sciences and, I would say, the experience of everyday life, shows that the soundness of any conclusions mainly depends (other conditions being equal) not so much on the abundance of material as on the degree to which the material has been elaborated, for this is what determines its usefulness. But as we shall see, the degree of elaboration of our psychological data is none too high.

When we examine the facts accumulated through introspection, with relatively little help on the part of science (or to be more exact, on the part of persons who have given more thought to psychical phenomena than others), we find that they bear all the marks of *self-observation.* Indeed, common or practical psychology establishes on the grounds of clearly perceptible distinctions not only the types but also the genera of psychical phenomena; in other words, it establishes the objects of cognition and classifies them. Moreover, practical psychology ascertains the basic conditions on which the beginning, course and end of psychical acts depend, i.e., *studies* psychical phenomena. Lastly, it offers a theory, or a number of theories, about their origin. Let us illustrate this by examples.

Even the layman can distinguish between a psychical act associated with looking at an object and the act of thinking about the same object; this is expressed in the words "*see*" and "*think*". One can easily understand that there is a definite kinship between seeing an object and recollecting it. One more effort of thought brings us to the third related form—the "concept", i.e., the idea that related objects have common features. Along with these elements of thought our consciousness distinguishes emotional processes of a different nature commonly known as *feelings* (for example, the feeling of pleasure, aversion, anticipation, fear, joy, anguish, sorrow, delight, etc.); at the same time consciousness divides these feelings into groups—corresponding to type and variety—in accordance with the degree of their intensity (emotion and passion), with their more or less pronounced character (calm feeling and affect), with the general nature of the body reactions induced by them (elation and depression), etc. This classification, naturally, suffers from shortcomings in detail, since direct observation is always of a superficial nature; still, it enables us to establish the generic features Everyone knows that feeling differs from notions or thinking by its impetuosity and subjectivity, by not being susceptible to decomposition; because of this, feeling cannot be described in actual words, although we are acutely conscious of it.

The entire area of the purely spiritual in man (excluding its external manifestations, i.e., behaviour), is covered by these two basic forms (mind and feeling) and it can be said that in performing this particular task, i.e., in determining the kinds and types of psychical processes, practical psychology proves to be quite a keen observer.

It has been no less successful in observing the conditions which cause psychical phenomena. It suffices to mention *memory*—a basic condition of psychical life, or *attention*—without which things would never reach the consciousness, or the analysis of the circumstances evoking recollection and determining the association of ideas, the intensity of the feeling. It will be in place to mention here also the observations conducted on the relationship between various psychical acts and behaviour, expressed chiefly in the fact that some actions are regarded as being instinctive and inevitable, others are held to be conscious and rational, some involuntary, others voluntary, and so on.

So far the research of the practical psychologist has been based exclusively on observation; and if he errs at times this is because of his undue confidence in the voice of self-consciousness and his forgetting the eternally-instructive example of the sun revolving around the earth. At this stage his consciousness begins to theorise, i.e., attempts to explain the origin of psychical acts. Any educated layman asked to explain his idea of the origin of thought and feeling would probably answer that thinking derives from the *mind*, that *feeling* derives from sensitivity. No doubt many would add that reason is seated in the head, while feeling is located in the heart. Then ask our layman what he knows about the relationship between thought and desire, on the one hand, and human behaviour, on the other; in all probability the answer would be that since man is free to act both in line with his thoughts and desires and against them, there must be some special *free force* separating thoughts and desires from behaviour and that this can only be "will". *Imagination*, which combines diverse concepts—sometimes in a most fanciful way—is for our layman also an *explanatory force*; *memory*, hitherto an undefined condition for retention of impressions, is likewise held to be a special force; the same goes for *attention*, and so on. In sum, it turns out that our educated layman *explains* the various aspects of psychical acts in much the same way as the savage explains the phenomena of physical nature which are incomprehensible to him; the only difference is that in the case of the educated man the original cause is an imaginary *force*, in the case of the savage it is a spirit.

This approach to psychological facts necessitates a strict delimitation between the concrete results of observation and all that bears the character of philosophising or tries to explain the essence of the matter. Unfortunately, however, it is not always possible to draw a line between the two categories: on the one hand, the theories of practical psychology are often based on fact, on the other, many, which at first glance give the impression of being sound and logical, are based on pure fiction. Errors of this kind arise mainly, if not exclusively, from the deplorable habit of forgetting about the figurative and symbolic character of language and taking dialectical images for psychical reality, i.e., *confusing the nominal with the real, the purely logical with the true.* A few examples will show how these errors can be eliminated.

The theory of the will, propounded by practical psychology, is a striking example of how facts can be misinterpreted. This theory is based on the following observations. When man experiences a certain desire, he, in one case, let us say, hearkens to it and satisfies it by means of a corresponding action; in a second case, influenced by other motives or because of some whim, he does not express the desire in any external manifestation, i.e., action; then, in a third case, the desire entails an action which not only disagrees with the desire but is its complete opposite. In the last case, the course of the action may greatly vary in different people (and in one and the same individual under different conditions). In normal people, however, the variability is always strictly limited and any action overstepping these limits acquires the character of irrational behaviour, the product of an upset mind, a manifestation of an uncontrolled will. The fact that the action can be the reverse of the desire is of decisive significance for the theory of the will. My point even can be strengthened by discarding the determining motives in the last two cases; as a result, the will acquires greater independence and remains the sole factor determining the behaviour. The example can be presented as follows: in the first case desire leads to action of expediency, in the second there is no reaction whatever, while in the third the action contradicts the motive.

If we approach these facts objectively (the only truly scientific method) we shall not observe anything new in them apart from the elements just mentioned; hence a comparison of our psychological example with a number of phenomena of the physical world will not be at all far-fetched. Fire, as everybody knows, not always heats objects (for example, thawing ice or snow); it can also cool an object when a rapidly evaporating liquid is interposed between the object and the fire. These facts are well known *from the point of view of the conditions of their origin;* so nobody will ascribe to fire the capacity to change the effect of its action either by itself or by means of some special free agent; but if we assume that these intermediate conditions are unknown and that only the fire and its effect are visible, the analogy will look anything but ridiculous. The point is that the conditions that determine the nature of our actions escape the ordinary mind in intricate phenomena where the will is involved; as a result, instead of an objective scientific approach to the facts, special forces are invoked which explain nothing at all. Would it not be more natural in these cases to seek explanations in the relationship which undoubtedly exists between the original cause of the phenomenon and its effect?

From this point of view, *all the theories of common psychology*[40], insofar as they are based on facts, *should be examined alongside the undefined conditions engendering the particular phenomenon.*

This approach does not predetermine anything nor does it hinder an explanation of the facts; by accepting this as a principle we shall at once eliminate a multitude of misconceptions in the practical appraisal of the facts of psychical life from the point of view of their reality.

To show how common psychology abuses language I shall cite a few of its propositions concerning human nature.

1) Man, as a single unit in the universe, as an integral whole, can be counterpoised to everything else in the universe, abstracted from all that is taking place in the external world. In this sense he is a special kind of unit, one and indivisible.

2) If we look at the sum total of the phenomena taking place in man, we shall see in him two principles operating according to dissimilar laws.

3) The corporeal man is subject to the laws of the material world, the spiritual man is not.

4) The corporeal man is the slave of matter, the spiritual man is its master.

5) Man has power not only over his body and behaviour, but also over his thoughts, desires, emotions, etc.

6) In this sense man, a free being, determines his actions himself.

At first sight these aphorisms look simple and intelligible, being based on well-known facts and having logical consistency, that is, if human nature can be defined by aphorisms at all. But when we examine the essence of these propositions, and verify how they conform with reality, we shall see that most of them are merely a string of absurdities. For the concept of man as one and indivisible, as an individual or an entity, in the strict meaning of these terms, cannot be anything else but an abstraction from the facts of his physical place in nature. Hence, whenever man is spoken of as one and indivisible, as an entity, the word "*man*" implies the physical nature of man and nothing else. From this point of view all the other aphorisms, in which the word "man" figures as the subject, would be downright absurdities. For example, the second of the propositions could be presented in the shape of the following impossible equation: the corporeal man=man himself+his spirit. The other propositions, too, would become utterly nonsensical. But let us suppose that the concept *man* implies the combination of spirit and body; then we should have to admit that man=spirit+body.

From this standpoint the first of our propositions would be impossible. Propositions three and four would be absurd, because one and the same thing cannot be subject simultaneously to certain laws and not subject to them, cannot be the slave of matter and its master. Proposition five is merely a figure of speech, since power always presupposes two subjects, namely, he who exercises power and he who obeys; hence, in our case it would be necessary to delete from the sum which consists of mind and body, not only the whole body, but even part of the mind as the subordinate element. Poor human nature, how often has this bold operation been performed on it. Fortunately, it has never gone beyond words.

Generally speaking, the errors associated with what are commonly called "quibbles" are due mainly to the fact that man performs mental operations with words—which are symbols of objects and their interrelations—just as he does with objects of the external world, and applies the results to reality.

In some cases, for example, the extreme results of abstraction or generalisation are introduced into psychology, with the result that a number of meaningless abstract terms, such as "being", "essence of things", etc., appear as scientific reality. In others the mind, influenced by the decomposability of language, unreservedly ascribes the same quality to the actual processes denoted by the words; hence the frequent confounding of the logical and psychological aspects of thought and, in general, confounding the purely logical (in words) with the true. Then there are the cases when man giving, so to speak, free rein to his imagination, attributes a psychical reality to a perfectly innocent grammatical form; take, for example, the naïve and widespread play with the concept "I". It is clear, however, that errors of this kind arise only because facts and inferences drawn from the nominal sphere are carelessly applied to the sphere of real objects, and this in turn is due to the fact that the ordinary mind lacks the general criteria for an assessment of the true psychical reality. The natural sciences, too, are developed through words which give definite shape to their inferences and generalisations; but quibbling is practically ruled out here because the features of the material realities are strictly established.

*It is obvious that in the case of psychology, too, words will cease to be a source of errors when science clearly and firmly establishes the general properties of the psychical realities.*

Thus, the problem of the general methods of critically assessing the facts of common psychology boils down to the following: What is implied by the term psychical reality which is the sole subject of psychological research?

I shall divide the question into two parts. My first task will be to show what *should be* studied as psychical reality and, the second, to show *what can* be studied as such.

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When drawing a parallel between nervous and psychical acts, I endeavoured to show their close relationship and thus prove the possibility of investigating the latter by analogy with the former. The analogy was confined almost exclusively to the external manifestations of the acts, the elements of both kinds of phenomena. But an analogy of this kind presupposes a more substantial similarity—similarity of original causes in both cases. In other words, if the sum of the material processes taking place in a certain part of the nervous system is the most substantial and the only real factor of a nervous act, then in a psychical act, too, only the material side can be real. In this sense, the psychical reality would be strictly definite and tangible, and could be as easily distinguished from psychological fiction as, say, ether is distinguished from air by the physicist. Unfortunately, our knowledge of the nervous processes,* even in the case of the most elementary reflexes, is negligible. All we know is the material form in which the particular phenomenon develops, some of the conditions of its normal variability, we can artificially reproduce a phenomenon possessing certain characteristics, and we know the role played by some of the parts in the phenomenon as a whole, etc. But the nature of the processes taking place in the nerve and nervous centres is still a mystery. Elaboration or at least elucidation of this aspect of the nervous and psychical phenomena belong to the distant future; we are compelled at the moment to confine our research to external manifestations. Nevertheless, *the concept of a psychical act as a process or motion having a definite beginning, course and end, must be retained as fundamental.* In the first place, this concept is actually the extreme limit of possible abstraction from the sum of manifestations of psychical activity, a limit within which reality still conforms to thought; in the second place, even in this general form, it is a convenient and simple criterion for testing the facts; lastly, it determines the general nature of the problems to be elaborated by psychology as the science dealing with psychical realities. In the first sense, i.e., as the fundamental principle of scientific psychology, the concept of psychical activity as a process or motion is merely the further develop-

* The term "nervous process" should henceforth be distinguished from the term "nervous phenomenon". I shall use the latter to denote the external manifestations of nervous activity, while the former will be used to indicate the partial molecular process taking place in the nerves and nervous centres and inaccessible to our senses

ment of the concept of the relationship between psychical and nervous acts and must be accepted as axiomatic, just as the idea of the indestructibility of matter is regarded as a fundamental principle of chemistry. Once this axiom is accepted as a criterion, psychology is obliged to approach every aspect of psychical activity from the point of view of a process or motion. *Should this method prove successful with regard to the* typical forms of psychical activity (beginning with the simplest), for example, with regard to the various aspects of sensation and with all their external manifestations, then the point of departure will be correct. In this case, anything too complicated, which does not fit the accepted principle must be resolutely left for future investigation.

As regards the general nature of the problems of psychology, our principle demands that psychology, like physiology, to which it is closely related, should confine its investigation to the questions of *how* a certain psychical process—expressed in feeling, sensation, notion, voluntary or involuntary movement—takes place, and how thought develops.

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With the basic means of investigation to hand, we can now proceed with our research. But how to begin? Which of the boundless and diverse facts of psychical life should be tackled first? Would it not be more expedient to take the psychical activity of an individual for a brief period, say, for one day, and minutely examine its external manifestations? The picture of this activity is well known. If we confine ourselves to the aspects reflected in man's consciousness, the entire psychical life will appear to us as a kind of magic lantern with continuously changing slides; each slide is retained in the field of vision only for a second at the most, or even a fraction of a second and sometimes sweeps past as a shadow, followed immediately by a new one. We get an *endless chain of sensations*, feelings, thoughts and images which assume aural, visual, or other form and are so closely linked that the mind distinguishes the fleeting intervals only with great difficulty and in exceptional cases. This chain lasts all day—from the moment we wake up till the moment we fall asleep, and not always does sleep interrupt it: the day-time images are replaced by dreams. If we examine the external agents which influence man during the day and compare them with the products of his consciousness, in some cases we find more or less easily a definite causal relationship (for example, when the man is thinking of something he had seen, heard, felt, etc.); but for most links of the chain the causal relationship cannot be established directly, since they seem to be original products of consciousness. No less complicated and intricate are the relationships between the products of the mind and the phenomena of the motor sphere: during the day the human body performs movements which succeed each other without any perceptible intervals; some of them seem aimless and automatic, although they are obviously associated with certain psychical processes (facial expressions and gestures). Others undoubtedly are acquired by learning, they are useful from the point of view of their determining motives, though they, too, are automatic to a greater or lesser degree (for example, the acquired movements of the handicraftsman). Still others directly express the processes taking place in man's consciousness (speech). Finally, some lack any motive whatever and bear no relation to consciousness (habitual movements). On the whole the picture is extremely variegated and confused; it has no beginning and no end and can hardly be regarded as the ideal starting-point for investigation.* At best the investigator would be faced with the issue whether psychical activity is to be regarded as a single and unceasing lifetime act, only briefly interrupted by sleep, or whether the whole picture is the result of the joining together of one-time separate acts of the body into a continuous chain.

Fortunately, this perplexity will not be of any duration. It can be easily proved that of the two viewpoints only the second is correct. To do so we should study the psychical activity of an individual not for one day, but for a longer period. In this case we shall see that the monotonous repetition of images

* Yet Herbart and some of his followers in Germany took this picture as the starting-point for their investigation and attempted to disentangle it.

day after day is suddenly broken by something new, by an image, sensation or thought expressed in words, etc. On closer examination we find that this intrusion is the result of something new experienced in the course of the day, for example, an impression produced by meeting a stranger, a new thought discovered in a book, etc. Even more instructive is the comparison of the psychical activity of an educated and an uneducated person; the activity of the first is rich in images and colours, while that of the second is almost wholly concentrated on everyday material life. Taking another step down we find ourselves before the mind of the child, which, as we know, is a kind of canvas on which the external world and education gradually embroider definite patterns. It follows, then, that the daily picture of adult psychical activity is a mosaic gradually formed by the separate acts taking place at different moments of his life.

This conclusion shows that the daily picture of man's psychical activity cannot be taken as the starting-point for our investigation. Still, it is useful to consider it, since it suggests the following classification of the problems of our science:

1) *psychology should study the development of the separate elements forming the picture*;

2) *it should investigate the manner in which the separate elements combine into a continuous whole and, lastly,*

3) *it should study the mechanisms which determine the resumption of psychical activity after each break.*

In the language of science this means:

1) *that psychology should study the development of sensations, thoughts, feelings, etc.*;

2) that it should investigate *the ways in which all types and kinds of psychical activity combine with each other, as well as the consequences of this combination* (it should be borne in mind, however, that the term "*combination*" is used in the purely figurative sense); and lastly,

3) *it should study the conditions which determine the reproduction of psychical activity.*

It is true that the three groups have long since been dealt with in all the works on psychology* but in the past the term "*psychical*" implied only that which is "*conscious*", i.e., from the entire natural process the psychologists abstracted both the beginning (which in its elementary psychical forms they assigned to physiology), and its end; thus, the objects of our investigation are altogether different, despite a certain similarity of classification. The study of the development of any psychical act should embrace both its beginning and its external manifestation, i.e., the motor reaction, including speech. When studying the combination of the separate elements, it is necessary to focus attention on the beginnings and ends of the acts. Finally, study of the conditions determining their reproduction should be concerned with the psychical act as a whole, not simply with its intermediate member.

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At this stage it is incumbent on me to give practical proof of the applicability of these general principles to the analytical study of *all* the chief forms of psychical activity; otherwise, I may be charged, and justifiably so, with shaking faith in the old ways of science and pointing to new ones, without adducing the proof that the latter can ensure real scientific progress. I shall, therefore, adduce the proof, but with this reservation.

In my *Reflexes of the Brain* I applied these principles to the study of all the chief forms of psychical activity; but since that work repeatedly states that all the phenomena were considered solely from the point of view of their origin, readers acquainted with it would be justified in saying that such a study can at best prove merely the applicability of physiological analogy to the purely external manifestations of the psychical processes. However, since we have established the reasons why psychology as a science can now deal only with this aspect of the phenomena, the approach to the subject, evidently, should be

* Actually our second group of problems includes the so-called association of psychical activity, while the third includes the process of its reproduction.

changed. *By its very subject-matter scientific psychology cannot be anything but a series of theories concerning the origin of the various forms of psychical activity.* From this point of view the conclusions which I have drawn in *Reflexes of the Brain* and to which I adhere, prove the applicability of the general principles I have just advanced. So I could answer the reader's legitimate question simply by referring him to my work. But I prefer another way.

The idea that the chief forms of psychical activity can be regarded as reflexes is developed in the *Reflexes of the Brain* on the basis of a series of examples of gradually increasing complexity. I based myself on the following considerations: many psychical phenomena are of a manifestly reflex character; consequently, it can be assumed that when a psychical act takes place without any outward manifestation (i.e., movement), or, conversely, when its motor effect is intensified, this is simply a reflex with a suppressed or intensified ending. In the first case, we have a thought, in the second, an emotional movement. Having settled this question all I had to do was to illustrate the concept of voluntary movement and, when I had done that, my aim had been achieved.

I shall now develop the same idea, but in a different way. I shall examine the history of the psychical development of man (individual, of course) from birth and try to establish the main phases of this development at different periods, showing that each consecutive phase derives from the preceding one. This approach, being of a more general character, will embrace the phenomena more fully and provide new arguments for the hypothetical conclusions contained in my previous work. I must, however, point out that here I shall touch neither upon the nature of the so-called association of impressions or, more appropriately of reflexes, nor upon their reproduction, since I have already elucidated these phenomena and cannot add anything essentially new in this respect. All I ask is that the reader should bear in mind that an association is the result of a frequent repetition of consecutive reflexes, while the reproduction of a psychical act is but a photographic repetition of one and the same process in the qualitatively changed conditions of stimulation of the sense organ.

III

In infancy and childhood all psychical phenomena are of a reflex character.—The only major changes which take place in the subsequent mental development are: a gradually increasing capacity for thinking and the voluntariness of actions.—Analysis of the process of thinking in connection with its real substrata shows, however, that the only elements which enter it are those which determine the transition of a concrete sensation from a state of oneness to a state of ever-increasing decomposition. Practice clearly shows that the process of decomposition of sensations begins in infancy and develops without any pronounced changes even in the case of abstract thinking; this proves that the process of thinking does not change essentially in the course of man's psychical development. Physiological analysis of voluntary movements and the application of its results to the sphere of psychology leads to the same conclusion with regard to the voluntariness of human actions.

*Generally speaking, the question of whether psychical activity is of a reflex character or not can be answered in the affirmative provided we can prove that the initial forms from which it originates are reflex acts, and that the nature of the processes remains unchanged during the subsequent stages of psychical development.*

While considering the first part of this proposition, the reader should pay special attention to the fundamental demand that science *should study only the realities*. Let us, then, from this standpoint see when psychical development of man begins and where its original cause is. The answer is obvious: it begins in infancy and its sole source lies in the various external stimulations of the sense organs. As a science dealing with realities psychology cannot deviate from this point of view, since besides motor reactions to sensory stimulation, the infant does not manifest anything but pure reflexes[50] (sucking, sneezing, coughing, closing the eyes, etc.). No one, naturally, will attempt to attribute the infant's crying or its quiet to its mood (to say nothing of the more complex mental formations); every nurse knows that the source of the child's behaviour is either in its intestines or in its tactile sensations. Moreover, the layman is aware of this from another aspect: he knows that the dependence of psychical activity on the environment is particularly pronounced in children, and that it lasts not for days but for years. Further, every educated person knows that *it is the child's contacts with the external world that provide the basis for its further psychical development.*

Hence, *with regard to the beginning of the acts (sensory stimulation), the initial forms of psychical activity must be similar to reflexes.*

In the infant the intermediate member of the act, i.e., the element of consciousness, is precluded altogether. But there are no grounds whatever for rejecting the assumption that stimulation of the sense organs is reflected in the child's mind in the shape of sensations with all their differentiated features peculiar to the given sense organ (qualitative differences of pain, light, sound, etc.); but these sensations are not differentiated because the infant is as yet unable to see, hear, touch, etc.

Now, what would be the result of the reflex act in an infant? In the adult, stimulation of any sense organ may induce a movement which often takes the form of such complex acts as walking, talking, etc.; it might seem, therefore, that a certain previously formed association between each sense organ and almost every motor (neuro-muscular) mechanism of the body lies at bedrock of these manifestations. The association may be inborn, but even in the adult it is not as direct and immediate as in the case of the mechanisms producing pure reflexes; under normal conditions, for example, it is not the sensation of light or the sound which makes the adult walk, but a visual or aural notion. Consequently, it is not surprising that *the infant, having no notions, does not move its arms and legs as a reaction to sound or light.* Only in animals that are able to walk immediately or very soon after birth is this indirect association inborn, while in man it only begins to show at this period. That is why stimulation of the sense organs of the infant does not induce any external motor reactions of the trunk or limbs. The child's body remains inert for a number of weeks; *the movements observed in it seem to bear a casual character and their origin cannot be ascertained.*

But even at this early period certain reflex movements of the eyes, caused by the action of light, begin to appear. These movements soon combine into a well-co-ordinated system, and the child learns to see, i.e., to focus the visual axes on a definite object and, by keeping them in this position, to follow the movements of the object, or to turn its eyes from one point of an immovable object to another. This is the external, visible side of the *art of seeing;* it is supplemented by the ability to adapt the eye to distant vision, which is not expressed in any outward signs, but which, like the first part of the movement is conditioned by muscular activity. Since the child *acquires* these movements independently, without any substantial help on the part of the mother or nurse, the process is of particular interest to us.

The child, as we know, can become squint-eyed in the direction of the source of light if it is constantly kept in a room where the light falls on the eyes from one side. The only explanation for this is that the source of the light impels the eyes to move in its direction.* This, obviously, is a *reflex* act, though we are inclined to regard it, even at this stage of development, as a manifestation of the infant's *instinctive striving* towards light. Should the action of light on any part of the retina evoke one and the same sensation nothing would cause the eyes to change the character of their movement under the continued influence of light. Actually, however, the central part of the retina, situated directly opposite the iris (the so-called "yellow spot"), is more sensitive to light than all other parts. Consequently, if light falls on this spot during movement of the eye the conditions arise for a definite change in this movement. This change is possible only in two directions: the eye movement is either intensified or diminished. Nature has chosen the latter—the eye remains without movement. *This is another reflex which ends in the inhibition of the movement.*

This phenomenon, however, can be carried further. If the light continues to act on the eye resumption of the movement

* I have often observed the following in frogs from which the cerebral hemispheres have been removed and which are incapable of any conscious voluntary acts if the frog is placed with its back to a window and left undisturbed for several hours, it will, sooner or later, turn towards the window and remain in this position indefinitely.

may follow the state of rest; actually all the reflexes thoroughly investigated by physiology show that, under the influence of continuous stimulation of the sensory nerves, these movements acquire a periodical character. The second, third and subsequent movements arising in this way may repeat the conditions of the first, i.e., the optical axes will again converge on the same or another point of the optical image; as a result, the act yields an intermittent series of consecutive movements aimed at focusing the optical axes on one or several points of the object.

But what determines the ending of the act? It follows from the fatigue experienced by the organ of vision, with the result that the movement is discontinued and the effects caused by stimulation of the other sense organs manifest themselves in the consciousness.

The accommodative movements of the eyes take place in the same way, because here, too, the clearest view of the object is in each case the result of a definite degree of muscle contraction. It is possible that the movement stops at the moment of contraction and is then resumed.

This interpretation of the act of vision, which conforms to the facts observed in the adult, is further corroborated by a striking analogy in the sphere of the spinal reflexes; if we subject a sensory nerve in the skin of a decapitated frog to a stimulus of moderate intensity, the immediate reaction will be a fairly strong and protracted movement; if, however, we apply a stronger stimulus the first reaction will be not movement but immobility: the frog preserves the posture which preceded the stimulation.

It is much more difficult to explain what makes the converged optical axes of the eyes follow a moving image. Here, for the first time, we have to assume that the child actively endeavours to retain the moving image within the field of vision. We do not know the nature of this endeavour, nor do we know the physiological factors on which it is based. But the common view is that it is related in some way to the above-mentioned reflex which the ordinary man regards as an instinctive striving towards light. The difference between them is the same as between the first feeling of hunger experienced by the newborn infant which has not yet been fed, and the similar feel-the eyes, caused by the action of light, begin to appear. These movements soon combine into a well-co-ordinated system, and the child learns to see, i.e., to focus the visual axes on a definite object and, by keeping them in this position, to follow the movements of the object, or to turn its eyes from one point of an immovable object to another. This is the external, visible side of the *art of seeing;* it is supplemented by the ability to adapt the eye to distant vision, which is not expressed in any outward signs, but which, like the first part of the movement is conditioned by muscular activity. Since the child *acquires* these movements independently, without any substantial help on the part of the mother or nurse, the process is of particular interest to us.

The child, as we know, can become squint-eyed in the direction of the source of light if it is constantly kept in a room where the light falls on the eyes from one side. The only explanation for this is that the source of the light impels the eyes to move in its direction.* This, obviously, is a *reflex* act, though we are inclined to regard it, even at this stage of development, as a manifestation of the infant's *instinctive striving* towards light. Should the action of light on any part of the retina evoke one and the same sensation nothing would cause the eyes to change the character of their movement under the continued influence of light. Actually, however, the central part of the retina, situated directly opposite the iris (the so-called "yellow spot"), is more sensitive to light than all other parts. Consequently, if light falls on this spot during movement of the eye the conditions arise for a definite change in this movement. This change is possible only in two directions: the eye movement is either intensified or diminished. Nature has chosen the latter—the eye remains without movement. *This is another reflex which ends in the inhibition of the movement.*

This phenomenon, however, can be carried further. If the light continues to act on the eye resumption of the movement

* I have often observed the following in frogs from which the cerebral hemispheres have been removed and which are incapable of any conscious voluntary acts if the frog is placed with its back to a window and left undisturbed for several hours, it will, sooner or later, turn towards the window and remain in this position indefinitely.

may follow the state of rest; actually all the reflexes thoroughly investigated by physiology show that, under the influence of continuous stimulation of the sensory nerves, these movements acquire a periodical character. The second, third and subsequent movements arising in this way may repeat the conditions of the first, i.e., the optical axes will again converge on the same or another point of the optical image; as a result, the act yields an intermittent series of consecutive movements aimed at focusing the optical axes on one or several points of the object.

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It is easy to see that this analysis does not provide a comprehensive explanation of the phenomenon as a whole (i.e., the faculty of seeing) in its perfect form. It characterises the main features only, but does not provide any explanation of the aspects associated with any *acquired movement*, namely, its ease, speed and machine-like exactitude (not only from the standpoint of the precision of movement but also from the standpoint of achieving an aim with the least possible expenditure of energy); the co-ordinated eye movements display these properties in the highest degree, certainly not less than the co-ordinated movements of walking or any other movements acquired by learning at a mature age (a more detailed description of this aspect of the act of seeing can be found in the textbooks on physiology). Suffice it to say that the ease with which even the unlettered person perceives the spatial attributes of visible objects, i.e., their outlines, magnitude, remoteness, etc., is determined by the ability to move the eyes, and this is an *acquired* skill.

Observations show that, with children, as with adults, the process of learning is based on frequent repetition of an act in one and the same way, and that this repetition leads to ease and machine-like precision; but the degree of the adaptation of many acquired movements to the requirements of a definite aim (skill and dexterity) is put down to reason (for example, in the case of handicrafts). In our case reason is, obviously, ruled out, hence physiology assumes that ability to move the eyes with the minimum expenditure of energy (henceforth designated as *skill*) is an innate quality of the motor apparatus of the eye. It follows, then, that completely co-ordinated eye movement is the result of the definite structure of the organ of vision and its motor apparatus; the capacity of the eye to move under the action of light makes this development possible, lastly, the movement is perfected through the repetition of the photo-motor act (optical reflex).

I have dwelt in detail on this minor phenomenon for the following reason: its development, although it takes place without any conscious guidance on the part of the grown-ups, is typical for all acquired movements and at the same time combines all the essentials of the development of any psychical activity. Actually we are dealing here with such factors as the relationship between the material structure of the organ and the products of its activity, the intervention of memory and the consequences of frequent reproduction of the acts; but the essential factor is the frequent repetition of the reflexes, in which movement is regulated by sensation.

Now let us observe the child at six months, i.e., when it has learnt to see, hear and use its hands as grasping instruments. At this age it has already acquired habits which affect its mood and temper (reflexes); the previously vague striving for light turns into a delight in vivid images and bright colours; the sight of a brilliant object evokes joy, impelling the child to move not only the eyes but the entire body; it turns towards the source of sound, tries to reach a ringing bell, jumps and cries with joy, grasps the objects within reach, and puts all kinds of things into its mouth. In brief, with the differentiation of the visual and aural sensations in the child's mind, new pathways leading from the organs of hearing and vision to all the motor apparatuses of the body, including the vocal mechanism, seem to have taken shape in the central nervous system. These acts, which are nothing but reflexes, make up the entire life of the child at this age.

But the time comes when the child makes its first attempts to walk and to speak. What about these capacities, are they, too, acquired mechanically? As far as the act of walking is concerned this is undoubtedly so. The help of the grown-up here is confined to supporting it when it first attempts to stand and when it begins to move its legs while standing, to lending its body points of support by leaning it against immovable objects. But in essence the faculty of locomotion by alternately *moving the legs is acquired by the child independently.* Whence this faculty? Why, for example, do adults swing their arms quite uselessly but at the same time regularly and systematically while walking, and why do they alternate the movements of arms and legs in exactly the same way as quadrupeds? The answer is obvious: generally speaking, the entire neuro-muscular apparatus of walking is inborn; that which we call "learning to walk" is actually not the creation of a new complex of movements but merely regulation of innate movements conforming to the surface on which the child attempts to walk. As physiological analysis shows, this regulation consists in the differentiation of the sensations caused by the child's movement on the solid surface supporting its feet. In some pathological cases the ability to experience these sensations is lost, with the result that walking becomes impossible.

The child's capacity to use definite words, when it sees a familiar object, hears a familiar sound, or, in general, when it experiences a familiar sensation, is acquired in much the same way as the capacity to walk. Just as the natural inclination of all birds to express their sensations by cries is the pre-condition for the parrot's ability to speak, the essential condition for the speaking capacity of the child is the presence of a central link between the organs of hearing and vision, on the one hand, and the whole complex of movements that participate in the formation of voice and speech, on the other. In itself, however, this link is insufficient and can lead only to abrupt dissonant sounds, as in the case of the deaf-mute; the sounds are turned into speech only under the regulating influence of hearing. It is true that now even the deaf-mute can be taught to speak, since the mechanism of speech is now fully known; but the movements of jaws, tongue and palate of the deaf-mute are determined by visual impressions. Here, then, we have the same process. It should be pointed out, however, that apart from the conditions determining the differentiation of the aural sensation and facilitating the transfer of movements from the organs of vision and hearing to those of voice and speech, another important factor participates in developing the faculty of speech in the child—the instinctive tendency to imitate sounds. A sound, or a *series of sounds, differentiated in* the child's consciousness, serves as a standard to which the child adapts its own sounds; it gives the impression of not being content until the sound of its voice fully reproduces this standard. We do not know the physiological factors underlying this property. But imitation, innate to all people, permeates the whole of life, playing a tremendous role even in the adult (social life is based on imitation which to a considerable degree determines the development of the national character, man's gregariousness, his daily routine, etc.); it is clear, therefore, that imitation is characteristic of the human species as a whole, just as visual-muscular imitation is characteristic of monkeys, or aural-muscular imitation, of birds. Under certain conditions excitation of the higher sense organs results in an irrepressible urge for expressing itself in sounds and words (in the consciousness it takes the form of a striving or inclination), and the basic condition for the fact that the movement proceeds precisely in this way and not in any other is already to hand (I mean here differentiation of the aural sensation). If we also bear in mind that apart from this aural standard, which is clearly differentiated, the only other things in the child's consciousness are the indistinct and varying traces of its own sounds, it will be more or less clear why it adopts itself to this standard. This standard alone remains clear and constant, whereas everything else is vague and inconstant. There is, apparently, a certain similarity between this act and the process of learning to move the eyes in order to obtain the brightest possible images in the consciousness, though ordinary people do not see any element of imitation in the latter.

Having learnt to see, hear, touch, walk and control its arms, the child, so to speak, is no longer tied to one particular place and begins a more independent intercourse with the external world. This world continues to act on the child as previously, i.e., through the sense organs; consequently, the child's actions are stimulated, as before, by impulses from without, but the influence now falls on different soil. The acquisition of mobility enables the child to analyse the impressions, just as the adult does when he wants to become acquainted with an object, and, not satisfied with the first glance, examines it from different angles and aspects. To this is added the perfected analytical faculty of the eyes which have already mastered the art of seeing—a faculty as important as body mobility. Instructive in this respect are the stories told by persons who were born blind and who acquired the faculty of sight at a mature age about their first sight of the external world after the operation. Although these people already had definite ideas about the spatial properties of surrounding objects—acquired by means of touch—their impression was that the entire field of vision was filled with one vast image, which, as it were, touched their eyes; so vivid was the impression that they hesitated to move, for fear they should collide with the image. The general picture in the field of vision of the trained eye is actually the same, but it is quite distinct: the objects seem to be located at varying distances from the eye, the empty spaces between the objects are clearly perceived, etc. In short, the trained eye discerns in the flat picture of the field of vision all three dimensions—i.e.: height, width and depth, and this capacity applies not only to the picture as a whole, but also to its separate images. The hand helps the eye in its spatial analysis at short distances. At this stage the grasping reflex evoked by visual stimuli is greatly developed in the child. Nor is the matter confined now to mere grasping; the child turns the object in order to examine it from all sides.

Helmholtz, one of the greatest thinkers of our time, who has contributed more than any other scientist to the psychological theory of the evolution of spatial concepts, has summed up all the facts obtained by observation on the evolution of spatial vision. According to him, concepts of magnitude, distance, outline and corporeity of objects *derive*, as it were, *from unconscious inferences*. Nor is this statement a mere figure of speech, as we shall see when we consider the elements that make up what is commonly called "inference". In the meantime I shall confine myself to the proposition that the process of forming concepts from sensations is engendered by *frequent stimulation of the given sense organ under changing conditions*. This is the sole possible, extreme generalisation of the facts relating to the development of the above-mentioned formations.

Such, then, at this stage of development, are the intermediate members of the psychical acts induced by stimulation of the sense organs. And such, too, are the intermediate members of the reproduced acts (when the child recollects something that it has seen, heard, etc.), since at this early stage the images are not yet differentiated to the degree that would give rise to concepts (it should be borne in mind that, as a process, a reproduced act is merely a copy of the real stimulation—a difference is observed only at the beginning of the two acts, and this is but a quantitative difference).

Now let us turn to the extreme members of the psychical processes at this stage and to the relationship between them and the intermediate members. The child, as everybody knows, uses its acquired movements with a vigour that is inconceivable in the adult. At one moment its attention is attracted by a bright object and it rushes towards the object; but on the way a fly catches its eye, so it makes for the fly. Then it hears the chirp of a bird and its energy is again diverted, when a cow is heard mooing in the distance, our child stops to imitate this sound, and so on. There is, however, an invariable motive force in this chaotic and never-ending fuss: the child wants to *grasp* everything it sees or hears; it is *attracted* to objects by the desire which was already manifested when it was still an infant in the arms of its mother or nurse; but now the desire more clearly results from a strongly pronounced pleasure. To test the strength of the desire, stop the child, say, from playing in the open air and compel it to sit quietly for an hour or so. The desire to move, which remains unsatisfied for a long time, charges, as it were, the child's nervous systém; as a result, even an insignificant impulse is sufficient to induce an outlet which is expressed in crying, tantrums and even in convulsions.

In terms of physiology this means that at this stage of development the products of the stimulation of the higher sense organs are predominantly of an emotional nature and, in their reproduced form, they leave an impulsive trace expressed in the desire to possess the source of pleasure; these desires determine the external activity of the child. This activity, then, begins with external stimulation of the sense organs and proceeds along the pathways (already known to us) linking the sense organs with the mechanisms controlling the movements of legs and arms, and with the organs of voice and speech.

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The next major steps in man's psychical development are seen in the first manifestations of the mind, in the rudiments of thinking and of free will. The child becomes aware not only of the separate objects of the external world, but also of the relationships between these objects and between their parts. It begins to understand the factors of the material reality which link the objects of the external world and which form the foundation for the outlook of layman and scientist. The child's elementary meditation develops little by little into a vast system of knowledge which begins with the most superficial analysis of the facts of the surroundings and ends with an exact, sound and strictly mathematical knowledge of these facts. The other aspect of mental development consists in the gradual emancipation of man's actions from the direct influence exerted by the surroundings. These actions are now based not only on sensory impulses, but also on thought and morality; hence they acquire a definite sense and a conscious character. Man can now choose his mode of behaviour, and in this sense he, theoretically, is regarded as being morally independent.

I shall now try to determine the elements of the processes of thinking.

For the purpose of solving this problem we shall take as our starting-point the general viewpoint from which logic regards thought, or, to be more precise, its verbal image, and afterwards try to find the real grounds for each of its logical elements. According to logic, in every thought there are two things, two objects, which are comparable one with the other: in the psychical aspect these objects can be extremely varied. It is possible to compare two objects or two different states of one and the same object; the object can be compared with one of its parts and, lastly, one of its parts with another. The modes of the comparison, which are even more diversified, determine the nature of the final element of thought—the inference—and, through it, the so-called content of the thought as a whole In elementary cases the comparison is restricted to proving the separateness of the two objects of the thought; in others it reveals the similarity or the dissimilarity of the objects (an extensive category of thoughts dealing specifically with comparison); in still other cases comparison establishes the causal relationship between objects, one, the cause and the other, the effect, etc. *In this sense, such phrases as "the* tree is green", "the stone is solid", "the man is standing, lying, breathing, walking", etc., contain all the essential elements of thought, namely, 1) *the separateness of the two objects*, 2) *their juxtaposition* (in the consciousness), and 3) the *inference* (in the foregoing examples it is confined to proving the separateness of the objects of thought).

So our chief task is to establish which of the psychical realities conform to the three basic logical elements of thought.

I shall base the consideration of this question exclusively on the category of thoughts the content of which is *comparison*: I shall do so because this category is the most extensive one, because here it is easier to disclose the material substratum of thought, and, lastly, because *comparison* plays an outstanding role in scientific thought.*

*Countless examples of thoughts of this category are encountered in everyday life and in science when man compares objects with a view to establishing their similarity or dissimilarity.* The impressions produced by objects on the sense organs serve as the standards for this comparison, and only homogeneous impressions are compared, i.e., visual with visual and tactile with tactile, etc. The adult, however, can compare objects even if at the given moment he does not see the real standard with which he is comparing the object (visual appreciation of shape, colour or size, manual determination of weight, etc.). But even in this case there is a definite standard: this is the mental reproduction of the object that would be taken as the standard were it present at the given moment. Moreover, comparisons can be made not only between two objects, but between many; *in this case the process is absolutely the same, because the comparison is effected in pairs, giving us a series of comparisons instead of one.* When two

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* Of no less interest and importance is the category of thoughts which concern *the causal relationship between the objects of the thought*. But it is impossible just now to trace the development of this category (from the point of view of our principles, of course), because, in the main, if not exclusively, it is based on man's faculty to separate *himself* mentally from his actions, a faculty which develops as a result of comparing *oneself* in a state of inactivity with *oneself* in a state of activity. Particular cases of disintegration of concrete forms can be considered only in a special treatise on voluntary movements.

distinct objects (for example, two stones, two trees, etc.) are mentally compared, *two successive impressions, separated in time and space*, comprise the act of *comparison* (the eyes pass from one object to the other); hence no special mental process takes place in this case. But what happens when we mentally juxtapose an object with one of its properties (for example, when we say that a tree is green, tall, etc.)? Here, too, the process is the same. In point of fact man's faculty of decomposing concrete sensations is an indispensable condition for the emergence of such thoughts; clearly, this faculty must already be present, i.e., it predates thinking. And, as we know, it develops at an early age, when the child's sensations are beginning to decompose and develop into notions. Once this faculty has been acquired, it makes no difference to the consciousness whether there are two separate impressions (according to their real substrata) or two similar impressions obtained under different conditions of perception. Lastly, when an actual impression is compared with a reproduced old one, we again get a real condition of the separateness of the objects of thought, since the reproduction appears *after* the actual impression. Now let us turn to the second element of thought, i.e., *comparison*. Here, too, comparison of the two separate concrete objects is most instructive, especially if it is a visual comparison. In this case the eyes perform in respect of each object the series of movements usually aimed at establishing definite aspects of visual sensations; they measure (by movements) the length or width of one of the objects, then of the other, compare curvatures with curvatures, angles with angles, spots with spots, etc. In short, the mental images of the objects are, as it were, superimposed one upon another, just as the student of geometry superimposes one triangle upon another in order to prove that they are equal.

Exactly the same thing takes place when an actual impression is compared with a reproduced identical impression, although the real substrata are not visible to the layman. The fact that the child can think in visual images means that it perceives things and that its visual sensations are decomposed to the degree of notions (since both acts—the process of learning to see and the decomposition of the sensations—are simultaneous, as we know from the textbooks on physiology). In this case, if a glance at an object reproduces in our mind the image of a similar object (recollection of something seen before), the third member of the reflex, i.e., the movement of the eyes (in sum the ability to perceive) is reproduced simultaneously with the second member. And this reproduced movement, or habit, experienced a thousand and one times, is the real substratum of the comparison in assessing the attributes of single objects. But the mind is familiar with another result of object comparison—their dissimilarities are more pronounced the more rapid the sequence of impressions compared, other conditions being equal. This is the *phenomenon of contrast*, by virtue of which light seems brighter after darkness, cold seems colder after heat, a small object looks smaller alongside a large one, the ugly seems to be beautiful, and the disgusting a source of delight. As to the deduction or the inference, self-observation or introspection fails to reveal any specific process for it; the mind simply affirms that the comparison has revealed similarity or dissimilarity. The content of the inference, which is determined by the nature of the thing stated at the given moment, is a different matter. When in connection with a whole we affirm the dissimilar attribute (a part) of the whole, we are dealing with the actual substratum of the thoughts which usually define the quality or state of the object; for example, we say: "*the oak* is green", "*the diamond* is hard", "*Peter* is sitting", "*Ivan* is walking", etc. And conversely, when we affirm a similarity in the features of the objects compared, we are dealing with the actual substrata of thoughts in which the relationship between all the members is identical, but the object is decomposed to a greater degree; a part of it is, so to speak, abstracted and raised to the level of a *concept*; in this sense, we say: "*the tree* is green", "*the stone* is hard", "*the man* is sitting, walking", etc. But the process of decomposition can be carried further—not only the object, but even one of its attributes can be decomposed. Along with dissimilar attributes (the tree is *green, yellow, brown*, etc.) the mind can affirm (one should not forget that this word is used figuratively!) similarities in the attributes. Just as in the previous case, this is an abstraction of a part from the whole; the real elements of thought here are the same, but in this case, the attribute is decomposed as well; in this sense we say: "the tree is *coloured*", "the man is *motionless*", "the man *moves*", etc. (but in the thought "*the stone is hard*" the second member does not undergo change, the reason being that hardness, like cold, hunger, the desire to urinate, etc.), is the product of a sensation that cannot be decomposed.

When more and more decomposed concepts are juxtaposed, it is not the concrete forms, but their attributes which become objects of comparison. Hence it is possible to compare the most dissimilar forms (for example, a man with a tree, stone, etc.). Thanks to this the boundaries of our thoughts are extended immeasurably, and the only obvious limit to comparison is set by the structure of the instruments which decompose the concepts into separate elements (in our case—the sense organs). Science shows, however, that even this limit is not absolute: whenever the natural powers of the sense organs do not suffice science equips them with artificial means of analysis, with the result that the decomposition of concrete facts and the comparison of objects with their parts, and of the separate parts, is resumed. Science has been doing this for centuries; our knowledge of reality ends where the limit of comparisons (even if aided by artificially perfecting the sense organs) is reached, and where the possibilities of the perfecting have been fully exhausted. In this endless chain of thoughts, arising in the course of comparison, it would seem that the real substrata of the mental process remain invariable; the starting-point is the decomposition of the image in keeping with the analysing capacity of the sense organ, an act which makes it possible to concentrate on a particular aspect of the image; the second phase of the process, or its end, can be designated as commensuration of the decomposed image with a previous similar image, reproduced mentally according to the law of association (a mental standard), or if two objects are compared with another real image. The first phase is of prime importance, because it is then that the child's capacity to compare objects and to deduce things is perfected. This is proved by the fact—already mentioned—that the entire spatial aspect of vision (concepts of size, distance, corporeity, etc.) which can be expressed by a number of examples similar to those cited, is, according to Helmholtz, developed, as it were, by means of unconscious inferences. Now, having brought our analysis of the form of thought to this point, I am in a position to formulate the essence of the actual processes underlying it.

Repetition of one and the same stimulation of a sense organ under varying conditions of perception leads to the decomposition of the sensations; this determines their conversion into *notions*.[51] Simultaneously the conditions for the mental reproduction of impressions are multiplied; the reproduction takes place in accordance with what is known as the law of similarity, and the result of this reproduction is a mental comparison *of similar things. Reproduction of a psychical act in the body* simply means that it is repeated in full; consequently, in the case of a visual impression the act of reproduction also includes the movements performed by the eyes during examination of the object. These movements, falling upon the real image, are the real substratum of what we call commensuration of images from the point of view of form, length, etc. No new processes are introduced into our consciousness by these acts; they are merely a repetition of the habitual acts of seeing, hearing and touching, but applied to a new object. It is clear, however, that commensuration is accompanied by effects: experience teaches that thorough knowledge of even the purely external attributes of an object always presupposes frequent and repeated *stimulation of the sense organs by similar objects.* We are accustomed, for example, to the faces of Europeans and we easily discern even their most delicate features. But we seldom see Negroes or Chinese; hence, their faces seem to us so much alike that I, personally, made the mistake of taking a Negro girl for a Negro boy; this means that in this case I was unable to distinguish even the most typical features of the faces of young people of different sexes.

If we accept the viewpoint outlined above it will become quite clear that, *essentially, the comparison of two real objects* does not differ from the commensuration of a real object with a mentally reproduced image taken as the standard. The moment I glance at the first object the image of a similar past object is reproduced in my mind together with the acquired movements peculiar to the act of seeing; this is the first phase of commensuration. Then my eyes turn to the second object, and the act just experienced is reproduced in my mind; this is the second phase of commensuration. This makes it clear why repetition of the impressions produced by individual objects, together with the mental reproduction of similar objects seen in the past, can be a standard for improving the capacity to compare objects.

Thus, *in essence, the mental process of comparison is nothing but frequent stimulation of the sense organs and simultaneous reproduction of similar past impressions together with their motor effects.*

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Before passing to the second turning-point in psychical development it will be necessary to dwell on the application of the foregoing conclusions to two particular cases of highly abstract thought—mathematical and metaphysical thought.

The first case is striking for the following reasons. Mathematics, as a science which analyses spatial and quantitative relations, is obliged to decompose its initial concrete concepts. And it does this to a greater degree than all the natural sciences, reducing the notion of space to the concept of a mathematical point which has no dimensions, and, in general, the notion of value to the concept of infinitesimal quantity. This process does not necessitate instruments that would improve the functioning of our sense organs, such as the microscope which is indispensable for investigation of extremely minute objects, or the magnetic needle which is necessary for recording electrical phenomena The decomposition is a purely mental process (this is one of the many reasons why mathematics is called a purely theoretical science). The mind acts, as it were, in advance of the sense organs and penetrates deeper into the spatial and quantitative relations. How are we to reconcile these facts with our previous conclusion to the effect that thinking begins with analysis of real impressions under the control of the sense organs? And how are we to explain the fact that mathematical speculation, which deals with pure abstractions, is foolproof, while its supposed source—concrete thought (or to be precise, thought dealing with realities)—swarms with errors and blunders? At first sight this looks like a contradiction, but *the point is that mathematical speculation has its source* in realities as well. It is easy to see that to decompose space to a mathematical point, and, in general, to decompose any value to the concept of infinitesimal quantity, is by no means *a difficult mental process; it can be done quite easily even* by those who are not particularly strong in mathematics (for example, myself) and by children. On the other hand, it is obvious that these notions, taken separately, cannot evoke definite images even in the best mathematician in the world, so that in this respect, too, all men are equal. Taken separately, the mathematical point can be understood only from the viewpoint of its *logical* origin: it is a material point deprived of its *essential* attributes, i.e., of the three dimensions; it is, as it were, form without content (a symbol!). Actually it is the antithesis not only of space but of reality in general (the concept of space is invariably included in the concept of reality as part of the whole); thus, it is *nothing.* The logical origin of the *"mathematical point" is clearly seen from the fact that it can* be obtained by direct application of the mental process of decomposition not only to real objects (spatial, of course), but also to the *verbal image* or *verbal definition* of the material point. *For the mathematician, this material point* is a value which possesses only one property or attribute—measurability in three dimensions. Since we are able mentally to separate the attributes from the object (the separation is effected verbally), *we can do the same in this case and, by so doing,* obtain the same (?!) object, i.e., the point minus its attribute. The concept of "infinitesimal value" is of a still more general nature than the concept of the mathematical point, but of the same origin; from the standpoint of disintegration it, too, is the antithesis of everything finite and real—a value which, as we say, is approaching nought, but which is actually *nought itself,* i.e., *nothing. But how can mathematical speculation be foolproof* if it deals with pure abstractions? The answer is that these concepts are never applied by mathematics independently; they are included in the process of analysis as a logical element.

In this sense, it is said that any finite value is infinitely greater than any infinitesimal value, that a mathematical line has but one dimension, that continuous motion is an infinitely rapid series of infinitesimal separate impulses, etc. In some of these inferences we can detect echoes of reality (for example, decomposition of the continuity of motion), others express the capacity of the mind to apply the result of the analysis of the more complex and concrete forms—and consequently, the analysis itself—to simpler, generalised forms (for example, the inference that the line derives from the motion of the mathematical point). Particularly striking examples of this capacity are again offered by mathematics. For instance, it divides all values into two conventional categories—positive and negative—and in a purely logical way performs one and the same operation on both; the result is the concept of imaginary values, in itself an absurdity, but, taken as a logical condition, becomes a means of analysis. As to the infallibility of the mathematical inferences this, obviously, is the outcome not of the application of some special logical methods by mathematicians (science knows countless examples of the absurd being inferred in a purely logical way), but rather of the property of the material handled by mathematics, namely, its extreme simplicity. Convincing proof of this is provided by those cases in the sphere of concrete physical phenomena to which the method of mathematical analysis can be applied. Here the phenomenon must be so decomposed that further decomposition is impossible, when this is done the elements enter into the analysis of the phenomenon in the shape of *strictly definite* conditions which can lead *only to definite* conclusions or inferences. It might seem that the sole condition for extinguishing a candle is to blow out the flame, in reality in such a general form this condition is far from being definite and does not necessarily lead to extinction of the flame; it is necessary to blow with a definite force and from a definite distance; besides, the wick must not contain any of the substances usually contained in the phosphoric composition of matches in order to make them burn in the wind It is these conditions, which cannot be further decomposed, that constitute the absolutely definite factors of a mathematical phenomenon.

Metaphysical theories have their origin in the natural and, consequently, perfectly legitimate human desire (its physiological basis is known to us) mentally to separate the attributes of the facts and to classify these attributes in accordance with their importance and constancy. This is the starting-point for any scientific classification; furthermore, it is a well-known fact that a rational classification contains all the essential inferences of a science; hence, as far as its purpose is concerned, metaphysics has every right to exist. Unfortunately, however, it makes a grave blunder at its very next step: instead of decomposing its objects within the limits of reality (in the same way as the zoologist divides animals into vertebrates and invertebrates) and instead of basing its inferences exclusively on the facts obtained in this way, metaphysics holds that in all cases without exception, i.e., in all the principal branches of gnoseology (the external world, the human spirit, etc.), the mind can go beyond the limits of strictly sensory cognition (*indirect cognition* as distinct from *direct* cognition, i.e., via cognition by the mind or by *pure speculation*) in the same way as the mathematician arrives in a purely speculative way at the concepts of the mathematical point, infinitesimal quantity, positive, negative, imaginary values, etc. Proceeding from this idea, the metaphysician, compelled to disregard all that is visible, audible and tangible, i.e., the world of real impressions, turns to a more delicate sphere—to *notions* of things seen, heard, etc., i.e., to the world of thought. But what kind of world is this? A thought always retains in greater or lesser degree the features of its primary image, i.e., of the actual impression which produced it. By no means, however, is it an exact photographic copy of the image; as the thought moves away from its primary source, it becomes, so to speak, increasingly less tangible; the extraneous is lost and only the quintessence of the object is left. This *abstraction from all that is sensory, now no longer divisible,* is regarded by the metaphysicians as the *essence of things*—as the fundamental property of objects (a kind of soul) accessible only to *direct cognition* through pure speculation. And this essence is the subject-matter of metaphysics.

But before tracing the development of metaphysical thought I consider it necessary to cite two well-known facts which show whither metaphysics leads.

The phenomena of the external world have long been studied both experimentally and in a purely speculative way, i.e., from the philosophical point of view. These two trends have existed side by side almost up to the present time; whereas the first modestly limited its study to phenomena perceived by our more or less perfected sense organs, the second has always tried to penetrate deeply into the essence of things. The development of the philosophical trend was crowned (and terminated) by German natural philosophy; as to the experimental trend, it still exists. Whereas natural philosophy was about as useful as, say, the ravings of a madman and has long been forgotten, the experimental natural-science trend has penetrated into life, often determining its forms and, at the same time, deepening and extending our knowledge of the external world. The speculative method ended in absurdity, whereas the experimental method is gradually approaching the very goal of metaphysics—ever deeper penetration into the essence of phenomena.

The reason for the predominance gained by the purely speculative method in the study of psychical phenomena is that the principles on which the methods of natural science can be more or less widely applied to the sphere of psychology were established only recently. The speculative method had been widespread in Europe since the rise of Greek civilisation, whereas the more or less considerable application of the methods of natural science to the study of psychical phenomena dates only from 1838, i.e., from the invention of the stereoscope by Wheatstone.* In our times leading men of the metaphysical school have arrived at conclusions that are considered absurd not only by naturalists; at the same time the methods of natural science have proved that the development of concepts from perceptions is directly associated with the material structure of the sense organs. This is a truly important achievement

* The stereoscope was invented by Wheatstone in 1833, but the theory of stereoscopy in the sense mentioned above appeared only in 1838.

especially if we take into account that it was precisely the absence of scientific data explaining this phenomenon which led to the efflorescence of the metaphysical approach to psychical life.

But why does the metaphysical method of studying psychical phenomena lead to absurd deductions? Does the fallacy lie in the logical form of metaphysical reasoning, or only in the objects of the reasoning?

We are already acquainted with the logical side of reasoning: it *consists in comparing two objects (i.e., either two concrete forms or the whole and one of its parts, or two parts of one and the same form, or of two separate forms) and in their* commensuration from the point of view of similarities, *dissimilarities, causal relationships, etc. Besides, we can detect* by intuition any, at least serious, fallacy in logical reasoning; in such cases we say: "the inference is illogical", "the reasoning is inconsistent", etc. Metaphysics, however, cannot be accused of inconsistency; otherwise its doctrines would not have held sway for such a long time. On the contrary, it is the consistency of metaphysical reasoning, along with the universality of the problems it undertakes to solve, that attracts most. Hence the error must lie in the objects of metaphysical investigation. This circumstance is of extreme importance to us, because it convincingly shows that *the real substrata of all psychical processes are invariable, no matter whether* our *reasoning is based on reality or on pure metaphysical abstractions.*

But what kind of error is contained in the objects of metaphysical investigation?

When the metaphysician in his desire to obtain more profound knowledge ignores the world of real impressions (which for him are a kind of profanation of the *essence of things* by our sense organs), and turns of necessity to the world of ideas and concepts (since there is no other place to which he can retire), and does so with the conviction that that which is *truly ideal*, that is, *the least real*, is what *really matters*, he inevitably deals with abstractions; he forgets that these abstractions are fractions, i.e., conventional values, and, without a moment's hesitation, objectivises or transforms them into *essences.* I say, and I say it with deep conviction and without any exaggeration, that the metaphysician tries to prove that 1/2=1, 1/10=1, 1/20=1, etc. He does the very thing a mathematician would do if he were to take it into his head to isolate a mathematical point or an imaginary value without acknowledging their conventional character. What is more, conventional mathematical values even in their isolated form *are still abstractions,* while the ultimate objects of metaphysics, or its essences, are *products of decomposition not of real impressions but of their verbal expressions.* This is the second deadly sin of metaphysics, a striking example of which is confounding the name of an object, i.e., mere sounds, with the object itself, for instance, the name Peter with the man Peter; this lapse is rooted in the peculiarities of language and in the attitude of the human mind towards its elements.

Being the outward expression of concepts or thoughts, language is a kind of sound photography which, by means of definite but purely conventional symbols reproduces the decomposed elements of the concepts. For example, when I look at a tree the colour of its leaves is separated in my mind from the general impression; I express this decomposition by way of the conventional symbols: "*the tree is green*". When I see a tree that has been felled, the picture consists of four distinct elements the tree, its position, the ground and the contact between the tree and the ground. If this picture be drawn on paper, we shall see that these four elements actually determine the whole matter, and that all of them as parts of the picture are equally important. The photographic vocal reproduction of this picture consists of four members "*the tree—lies—on—the ground*" according to the four basic elements of the picture. Photographic precision of this reproduction is reflected even in the order of the four members: the chief figure occupies the foreground, its attribute comes next, then comes the borderline between chief and auxiliary figures, and lastly, the second figure. Now let us ask any thinking person to decompose these visual and vocal pictures into their basic elements, and he will at best answer that the visual picture contains but two elements, namely, the tree and the ground, since they alone can be separated from each other, while the photographic vocal picture contains four really separate members, i.e., four words. Where, then, is the photographic precision of the vocal reproduction? The point is that the decomposition of any visual impression (isolating a part of the impression, i.e., a certain attribute of the object, its position, etc.) is a fictitious, mental act which has nothing in common, for example, with the act of cutting a cucumber into pieces; but vocal photography or speech is articulate by nature. This divergence between the real substratum of the thought and its sound image in the matter of the divisibility of objects should never be lost sight of when operating with thoughts; otherwise *reality* can be easily confused with *fiction*. Very often we overlook this circumstance, owing to the habit (acquired in childhood) of thinking in words even of objects perceived visually or by touch. Confusion is all the more easy because in many cases, the verbal expression of thought and its real substratum do not coincide in respect of their mental separateness (for example, the copula "is", being a logical element of speech, often does not reflect reality, as in the phrase "the cat is an animal"). But the source of the errors caused by the peculiar properties of language is not confined to this. It has been pointed out that in the visual picture of a tree lying on the ground all four basic elements are equally important as *parts of the picture*; but as *parts of speech* the corresponding verbal elements are not equivalent. To the eye all the elements of the picture are, so to speak, substantives, whereas in speech only two are substantives, one a verb and one a preposition. This is another, apparently fundamental difference! Ask anyone with a bent for metaphysics to explain this and he will probably say: "A real impression is rough and inert compared with thought. But speech, being the daughter of thought, is ten times more delicate and mobile than all visual images taken together. Take, for example, literature and painting: whereas one will bring out but the prominent features of psychical life the other is able to convey every nuance and the delicate shadings of thought", and so on. In this answer there are many reservations, substitutions of the part for the whole and, consequently, erroneous inferences. The real explanation is quite different.

Man analyses the verbal forms of thought in the most diverse ways. He can divide a thought into separate words and regard the latter as individual elements (aural analysis of the first degree) related to hearing just as the stone, tree or sun are related to vision. Then these individual elements can be acoustically divided into syllables and alphabetic sounds (products of aural analysis of the second and third degrees); they can be juxtaposed according to their significance in speech (grammatical classification of words). Further analysis relates to the thought as a whole. In this case it is the verbal structure of thought and its content that are studied. This kind of analysis brings us to the realm of logic. But in addition to these mental operations the results of which are well known, the mind is able to generalise the names of objects and their interrelations independently of generalising the objects themselves or their relations. For example, in the phrases "a flock of birds", "a drove of horses", "a herd of cows", the words "*flock*", "*drove*" and "*herd*" are equivalent; they are *specific* names which designate definite relations between objects; but the word "*assemblage*", which can be used in all cases, is a generic name for the same relations. Here is another example. Ivan, Isidor and Stepan are the specific names of three servants in a public-house, while the words "*waiter*" or "*garçon*" are their generic names. Properly speaking, these words can be easily distinguished from those which denote real generalisations or concepts: here the general is always related to the particular, just as the part is related to the whole (for example, the word "animal" implies an actual process of abstraction, because underlying it is the abstraction of a part from the whole—"anything that breathes, feels and is able to move is an animal"), but specific and generic names are essentially identical. Thus, the word *man* is generic for Ivan and Peter; the word *bird* is generic for jackdaw, sparrow, etc. It is true that even in these cases we have a kind of abstraction: I can draw the outlines of a man, a bird, a fish or a tree; but it is clear that when I say "the man walks", "the bird flies", or "the fish swims", I by no means associate the objects of my thought with the outlines of the respective objects (which is an abstraction of the form from the visual image) but with real objects designated by these conventional collective names.

Naturally this attitude of the intellect to the elements of speech can lead *to diverse complications if we lose sight*—*even* for a moment—of the originality and conventionality of speech. To illustrate this, I shall refer to two examples, one simple and the other more complicated.

When I say "Isidor Ivanovich has a heart of gold", everybody *understands the absurdity of these words if taken literally;* indeed, a name cannot have a heart, and a heart cannot be made of gold. But if I compare, for instance, the following thoughts: "blue is a colour", "red is a colour" and "green is a colour" and then assert that the concept "colour" relates to all *tints, this would not seem as absurd as the other statement;* but it is an absurdity nonetheless, since "colour" is merely a generic name for all tints. Further I say: "In addition to colour every *object* has shape and size." What is the significance of the word "object" in this statement? Again it is only a generic *term for all visual objects, because it cannot be even drawn as* in the case of "*man*", "*bird*", etc. I go on reasoning in the following way: "Shape, size and colour are the *attributes* of all *objects*." This idea is absolutely true and conforms to reality if by the words "object" and "attributes" we imply generic terms *and not concepts; but if we regard the words as denoting prod*ucts of the decomposition of realities the idea would be extremely absurd.

We shall now try to perform mental operations on the sentence "All objects have attributes". Let us reason thus: "All *the attributes of an object, namely, its colour,* shape and size, are variable, *but this does not signify any change in the nature of the object itself;* a stone remains a stone no matter whether it be large or small, grey or blue, round or pyramidal, etc. Hence, *the stone's nature is not exhausted by its attributes.*" This reasoning appears to be perfectly logical but, in reality, it is pure metaphysics; the main cause of our error is that at the very beginning we isolated the attributes from the *real objects and opposed them to objects devoid of attributes,* i.e., to absurdities taken as realities. In other words, we have confused Ivan with Peter.

But are the metaphysicians really so entangled in their generalisations that they are unable to distinguish between the diverse ways. He can divide a thought into separate words and regard the latter as individual elements (aural analysis of the first degree) related to hearing just as the stone, tree or sun are related to vision. Then these individual elements can be acoustically divided into syllables and alphabetic sounds (products of aural analysis of the second and third degrees); they can be juxtaposed according to their significance in speech (grammatical classification of words). Further analysis relates to the thought as a whole. In this case it is the verbal structure of thought and its content that are studied. This kind of analysis brings us to the realm of logic. But in addition to these mental operations the results of which are well known, the mind is able to generalise the names of objects and their interrelations independently of generalising the objects themselves or their relations. For example, in the phrases "a flock of birds", "a drove of horses", "a herd of cows", the words "*flock*", "*drove*" and "*herd*" are equivalent; they are *specific* names which designate definite relations between objects; but the word "*assemblage*", which can be used in all cases, is a *generic* name for the same relations. Here is another example. Ivan, Isidor and Stepan are the specific names of three servants in a public-house, while the words "*waiter*" or "*garçon*" are their generic names. Properly speaking, these words can be easily distinguished from those which denote real generalisations or concepts: here the general is always related to the particular, just as the part is related to the whole (for example, the word "animal" implies an actual process of abstraction, because underlying it is the abstraction of a part from the whole—"anything that breathes, feels and is able to move is an animal"); but specific and generic names are essentially identical. Thus, the word *man* is generic for Ivan and Peter; the word *bird* is generic for jackdaw, sparrow, etc. It is true that even in these cases we have a kind of abstraction: I can draw the outlines of a man, a bird, a fish or a tree; but it is clear that when I say "the man walks", "the bird flies", or "the fish swims", I by no means associate the objects of my thought with the outlines of the respective objects (which is an abstraction of the form from the visual image) but with real objects designated by these conventional collective names.

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But are the metaphysicians really so entangled in their generalisations that they are unable to distinguish between the nominal and the real? The ranks of the metaphysicians have known many brilliant minds. I am not saying that their errors were caused exclusively by the properties of language. The latter merely aggravated the errors; but, as stated earlier, the basic source of the metaphysical fallacies is the conviction that man can acquire absolute knowledge without the help of the sense organs. This conviction is so widespread and seems so sound that I feel compelled to say a few words about the causes of this self-delusion.

Man has his place among all the things which exist on our planet, and even the whole of his spiritual life, to the extent that it can be the subject of scientific study, is an earthly phenomenon. Mentally we can separate our body and spiritual life from our surroundings, in the same way as we separate in our minds colour, shape or size from the object as a whole. But can we say that this separation is real? Clearly, we cannot, since this would mean isolating man from all the conditions of his earthly existence. And yet it is precisely this isolation of man's spiritual life from his material existence that constitutes the fundamental principle of metaphysics; and this self-delusion is constantly fostered in people by the clarity of their self-perceptions. Once committed, this error leads to the following logical argumentation: "Since the environment is something external to me it must have a specific form of existence unlike that which reality conveys to me through my sense organs. And this latter form, being mediate, cannot be true; the truth is contained in the original form of existence, independent of the perception of my sense organs, and I gain my knowledge of this form by means of a more delicate, non-sensory instrument —the mind." Now everything in this argument is absolutely correct except the last idea, but it is precisely this last idea that contains the above-mentioned error; separating the mind from the sense organs is the same as separating something from its source, or an effect from its cause. It is true that the external world exists apart from man and has its independent life, but man acquires knowledge of this world solely through his sense organs because the results of their activity are the source of all mental life

I shall sum up this rather long argument concerning the real psychical substratum of thought in the following proposition.

1. Thinking develops in the child simultaneously with the process of decomposing the complex sensations transmitted by the sense organs because at this stage all real psychical elements of thinking, namely, the *decomposition of concrete, integral sensations and the reproduction of previously experienced sensations* are already present in the organism.

2. When the child has learned to see and hear, the process of decomposing its visual and aural sensations becomes much more developed. The first objective indications of this are the signs by which the mother knows that the child now recognises her voice and face. At this stage the real psychical elements of elementary thinking, contrasting the characteristic attributes of the objects—are, perhaps, already present.

3. But when the child begins to manifest an obvious capacity to distinguish the distances of objects (for example, when it grasps the mother's nose without stretching its body, or when it attempts to reach more distant objects), this shows that new processes are developing in its mind, processes which have absolutely all the features of visual thinking, including comparison and inference. These are the processes that Helmholtz designated "unconscious inferences".*

4. With frequent stimulation of the sense organ by the same or similar objects, the sensation becomes ever clearer, owing to the fact that certain changes are constantly taking place in the conditions of perception; in the child's mind this produces

* We know from physiology that man can determine the distance of an object even at first glance, by the degree to which his optical axes are converged, or, to be more exact, by the strength of the muscular sensation accompanying the contraction of the muscles turning the eyeballs inwards. The purely visual sensation is reinforced by a muscular sensation which serves as a means of measurement and the intensity of which determines the degree of remoteness of the object. The similarity between this process and the conscious determination of the distance of objects is stressed by the fact that the well-known geometrical method of finding the distance of a definite point by determining the angles formed by straight lines connecting the point with a given base is merely a slight modification of the same process: the base corresponds to the straight line linking the centres of the eyes, while the angles at the ends of the base are equivalent to the intensity of the muscular contraction.

the effect which examination of an object not from one, but from different aspects produces in the adult.

5. But along with each new real impression, or to be more precise, after each impression, a similar act which took place in the past is inevitably reproduced in the mind; consequently, every time the two intermediate members are compared in the mind, the reproduced impression, i.e., the older and more familiar one, serving as a sort of mental standard. I shall cite an example. I am used to seeing a certain man without a pimple on his nose. But suddenly I see a pimple, and the sight affects me strongly. Why? Because I mentally compare the familiar image (serving as a standard) with the new impression.

6. In the visual acts which form the substratum of completely formulated thoughts, whose essence is comparison, we know also the real substratum of the last element—the mentally reproduced muscular process of the act of seeing, the end member of the reproduced act. It is now superimposed on the real impression, and a *real* commensuration takes place which resembles the superimposition of triangles in geometry.

7. An inference has no real substratum; but its content, and consequently the content of the whole thought, is determined by the way in which the real factors of the thought are compared (it should be borne in mind that it is possible to compare an object and one of its attributes or states, two whole objects and, lastly, the attributes and states of two objects). For example, when the actual impression of a complete image is compared with a mentally reproduced attribute of a similar past impression this makes it possible to ascertain the attribute in the complete image; if we compare two dissimilar facts, which constantly and inevitably follow each other, it is the causal relationship between them that constitutes the content of our thought.

8. The process of thinking remains unchanged, no matter whether we compare many real objects, or juxtapose objects already decomposed by means of scientific methods, although it is this thinking that gives us all our knowledge of the real world

9. Even in mathematical reasoning the process of thinking remains the same, though in this case the objects of thought

are often abstractions—products of decomposition—which go far beyond the bounds of the analysing capacity of the sense organs.

10. Lastly, this process remains unchanged even in the case of erroneous philosophical reasoning when the objects of the thinking are not realities but pure fiction. This is explained by the fact that the thinking, itself correct, operates with correctly obtained products of the decomposition of the verbal expression of the thinking, which products, being abstractions, do not correspond to anything real.

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To solve the last problem of our investigation—the voluntariness of human actions—it is necessary first of all to elucidate the approach of physiology to voluntary movement.

So far physiology divides all the movements of the body into two large groups: those that are in no way subordinate to will, and those which can be influenced by will. In its general form, this division is absolutely correct, because movements take place in our body of which we know thanks only to research (for example, peristaltic movements of the intestine, contraction of the gall-bladder, ureters, womb, etc.). But the subject becomes much more complicated when we try to establish the general principles of this classification. The old anatomical principle which ruled that only the striated muscles are subordinate to will, while the smooth muscles are not, is invalid. The heart, for example, consists of striated fibres but is not controlled by will; on the other hand, the muscles which serve to evacuate the urine from the urinary bladder are controlled by will, yet they are smooth. Another principle of classification is, therefore, possible: the category of absolutely involuntary movements should include those which serve the purely vegetative functions of the organism—the processes which ensure the material preservation of the body, such as blood circulation, the movement of food along the alimentary canal, the secretion of digestive juices in this canal, etc. Indeed, it is to the advantage of the organism that these processes should be completely free from the influence of will and have an absolutely mechanical character, which alone can ensure the regularity and constancy of the processes independently of external factors. But this view cannot be accepted as an absolute principle of classification, no matter how sound it may seem. The process of respiration and the entire process of eating (the grasping of food, its introduction into the mouth, mastication, etc.) play an important role in securing the necessary material supply to the organism and should, from this point of view, be absolutely automatic and fully independent of will; but as everyone knows that is not so. The third and last possible principle of classification of movements may be formulated as follows: only movements that are distinctly reflected in the mind can be controlled by will. From this standpoint the movements of the arms, legs, trunk, head, mouth, eyes, etc., which are visible acts clearly reflected in the mind in the form of combined cutaneous and muscular sensations, are subject to will. This explains the subordination of the movements of the urinary bladder to will: the different states of the bladder are reflected in the mind in the form of corresponding sensations. It also explains the subordination of the vocal cords to will, since different vocal sounds conform to different states of the vocal cords. In short, it explains all movements inaccessible to direct perception through the sense organs but accompanied by distinct sensations perceived in an indirect way

Thus, the third principle, while acceptable, does not convey any clear idea of the difference between voluntary and involuntary movements.

When analysing voluntary movements separately, physiology immediately encounters the following significant fact. The number of voluntary movements performed by man (movements of the arms, legs, head and trunk) is extremely limited compared with the number of the potential movements deriving from the anatomical structure of the skeleton and muscles. In the human body there are muscles which in the overwhelming majority of people are never brought into action; for instance, the muscles of the ears and the skin of the head. In some cases the muscles can be combined only in a single, definite direction; for example, it is easy to converge the eyes, but only very few can diverge them beyond the parallelism of the optical axes. It is doubtful if there is a person capable simultaneously of moving one eye upwards and the other downwards, performing circular movements with the leg in one direction and with the arm of the corresponding side in the opposite, or turn the forearm outwards and the shoulder inwards, etc. Since the pathways along which the voluntary impulses are transmitted to the muscles (*i.e., the nerve fibres*) *are isolated, one would think* that the same simple movement, for example, the bending of an arm or of a leg, could be performed in diverse ways; in reality, however, we observe the opposite. Everyone knows that respiration can be controlled by will; but try to inhale or exhale using only half of the thorax (anatomically this is possible and is actually observed in certain diseases), and you will see that it cannot be done at will.

What is the explanation? The reasons are several. The conditions of human life from generation to generation do not necessitate exercise of the muscles of the ear or of the skin of the head; hence they remain unexercised in the same way as man would not master the art of swimming if there were no water in nature. On the contrary, the faculty of self-locomotion, of grasping objects with the hands, of pushing objects away, etc., must be at the very base of the organisation of human life. Without these faculties man could not exist. Consequently, the conditions for the development of those movements which secure man's material existence must be present in his neuro-muscular organs already at birth. It is in this sense, as stated earlier, that the neuro-muscular apparatuses of vision, walking and even speech are, to a certain extent, inborn. Physiologically speaking, this means that there are definite innate neuro-muscular combinations in the human body which at first act as complete groups of nerves and muscles, and later, influenced by the conditions of life, become differentiated to a greater or lesser degree. For example, because of the necessity to grasp small objects the simultaneous clenching of all fingers may develop into the bending of fingers in pairs or separately. The process of respiration, on the other hand, cannot be differentiated even in two separate halves, since life does not create conditions which would necessitate respiration with one side of the thorax only. Thus the nature of the movements differs according to their purpose. In some cases there is no movement at all, though the necessary anatomical conditions for it are present; in others the movement is performed exclusively by large groups of muscles simultaneously (for example, respiratory movements); in still other cases the movements are highly differentiated (movements of the fingers and of the vocal cords in speech and singing); there are also cases when the movements are performed only in one direction (simultaneous circular movements of an arm and of a leg in one direction), etc. *Are not all these forms of movement voluntary?* Does it not follow from this that any voluntary movement is, eo ipso, a movement acquired by learning and influenced by the conditions of life?[52] In such a general form this conclusion may be arrived at in a simpler way. The new-born infant can perform only involuntary movements (such as sucking, swallowing, breathing, coughing, sneezing, etc.), it cannot perform properly co-ordinated movements (looking, walking, speaking, grasping objects with the hand or with separate fingers, using the arms as levers, etc.)—these movements are acquired gradually; yet these are the movements which for the most part become voluntary, although the adult can perform in a voluntary way even such involuntary movements as sucking, swallowing, breathing, coughing, etc.

No less significant is the fact that different forms of voluntary movements are controlled by will in varying degree. In some cases they are fully subordinated to will; in others, they are possible, or at least facilitated, given the habitual external conditions under which they normally take place; lastly, there are cases when will controls the movements only superficially. The acts of bending and straightening the trunk, the arms and the legs can be taken as examples of the first category of voluntary movements; the voluntary convergence of the optical axes in the presence, and in the absence, of a real image, voluntary swallowing, which is possible as long as there is something to swallow, for example, saliva in the mouth, etc., are illustrations of the second category of voluntary movements. Finally, the relationship between will and the respiratory movements is a typical example of the third category; as everyone knows, we can stop the respiratory movements at any moment, and we can change their depth and rhythm. But, we can do so only for a very short time, after which the normal course of the *interrupted or modified respiratory movements is resumed* contrary to our will. It is these extremes which determine the limits of the voluntariness of our movements. In all cases without exception the form of the influence exerted by will remains invariable: will can initiate, discontinue, intensify and weaken movements, and only the intensity of its influence is, apparently, highly variable. How can this difference be accounted for? *Physiology gives a definite answer to this question.* All voluntary movements, both acquired and those which are a kind of artificial reproduction of natural acts (such as voluntary swallowing and voluntary breathing), become *habitual movements* as a result of frequent repetition; consequently, they are influenced by all the conditions which determine habitual actions. For example, the act of clenching the fingers takes place under the influence of the real necessity to grasp more or less small objects, but actually it is frequently repeated without any special need, as a result of which the, so to say, "*aimless*" bending of the finger gradually becomes a habit. We are accustomed to look and to swallow only when there is a real object to look at or something to be swallowed, just in the same way as we are accustomed to walk only when we feel firm ground under our feet; consequently, when these real factors are absent, the process is either greatly impeded or is rendered completely impossible. As to respiratory movements, they are inevitable by their nature and, therefore, very little subject to will.

It is this habitual character of voluntary movements which, according to physiology, explains why the more habitual these movements are the less perceptible are the external impulses which engender them. It is common knowledge that this imperceptibility of the external impulses is the essential feature of voluntary movements. From what has been said it follows that the movements of our fingers, being the most habitual, appear to us as the most voluntary of all movements.

It should be pointed out, however, that it is not only the respiratory movements that are only superficially regulated by will, a fact explained by the automatic nature of these movements; the same applies to all acquired movements of a complex nature, even if they are not associated with such vitally important body processes as respiration. Take, for example, the act of walking. Once it has been acquired (this takes place in childhood!), will can in every case start or stop it; accelerate or retard it at any of its phases; but it cannot change the very mechanism of walking. Physiologists rightly say that the automatic regularity of walking is due precisely to this fact.[53] Indeed, the moment we begin to think of every movement performed by us during the act of walking, the latter becomes constrained and uneasy. The same is true of all acquired movements, even when acquired at a mature age (take, for example, the skilful movements of the artisan or the musician); lastly, *it is true even of speech. As the role of speech in the psychical* life of man is extremely important, I will dwell on this factor before formulating the general conclusion to be drawn from the foregoing arguments.

For the sake of clarity, I shall draw parallels between speech and walking. The speech of every individual has, as we know, its own peculiarities: one drawls, another speaks rapidly, a third lisps, burrs, or pronounces "*sh*" instead of "*s*", etc. When, as a result of frequent repetition, these peculiarities become habitual, it is impossible to change them at will, although the given individual is still able to pronounce the separate sounds "*r*" or "*sh*" in the right way. The same thing can be observed in the process of walking; the gait of every individual is different—laboured, slow, rapid, easy, hopping, mincing, etc. But suppose the person makes an effort to control his steps with the aim of changing his usual manner of walking, you will observe that he is unable to do so for very long; this is because the interference of will constrains his movements, making strenuous that which in natural conditions is accomplished with the greatest of ease. It is known, further, that we can interpolate at will any extra sounds in our normal speech or invert the order of syllables; and we can change our gait too, for example, by skipping, rhythmically bending the knees, jerking a leg, moving backwards, etc. After long exercise, we can become so accustomed to these abnormalities that correct speech or walking become quite difficult; but as long as these abnormal movements have not become habitual, the interference of will does not last very long. Thus, externally the processes of speech and walking are equally subordinated to will. But let us see whether this parallel between the two processes can be extended. If we look beneath the surface of the phenomena, we shall see in each acquired movement a link with the sensation by which it is regulated; the linkage can be easily demonstrated, although it is not observed by the ordinary man. It is a well-known fact that a man can memorise a long poem in a language which is absolutely unknown to him, in exactly the same way as he memorises a new melody. When reciting this piece of poetry the man is actually repeating for the thousandth time an action frequently performed in the past; at that moment the aural trace of the poetry retained in his memory flows through his mind somewhat in advance of speech. As long as this trace is reproduced without interruption, the recital is fluent; but when a break occurs in the aural trace (for example, a particular word is forgotten) the movement immediately stops. Has human will the power directly to restore the forgotten sounds? Apparently, not. We always remember the forgotten words in a roundabout way. Now let us turn to the act of walking. When walking I am actually repeating one and the same movement for a hundred thousandth time. And while walking there is also a kind of melody in my mind, consisting this time not of sounds, but of inaudible cutaneous-muscular sensations which, however, are clearly perceived by my consciousness.* As long as there are no sensory blanks in the melody, the act of walking proceeds smoothly. But the moment the foot, instead of touching even ground, suddenly gets into a rut, a break takes place in my sensation and I stumble.** Is not, then, the analogy between speech and walking complete? The only difference is that when walking the man sees the ruts and the elevations and adapts

* If during the act of walking the muscle contractions were accompanied by simultaneous acoustic phenomena, as is the case when talking, the melody of walking would be exceedingly popular; proof of this is that we can tell people by their footsteps, even though in normal conditions the sounds only partly express the act of walking (we hear them only when the feet touch the floor).

** Musicians are said to experience this when playing a familiar melody on a badly-tuned instrument.

his gait to them. This is due to the fact that when we are learning to walk, we simultaneously learn to avoid obstacles under the control of our vision (blind people learn to do this by tapping the ground with a stick); but the process of memorising a melody or a piece of poetry has nothing to do with our vision and therefore the eyes are of no help to us in this respect. On the other hand, speech is characterised by another specific factor, in addition to those just mentioned: this is its relationship to the process of thinking. When a man relates something he has seen, or, in general, something which he retains in his memory in the shape of thoughts, his vocal movements are accompanied by the process of thinking. Does this differ absolutely from reciting a piece of poetry in an unknown language? The answer is that it does and does not. If a man is narrating for the first time something he has just seen and if he does it in the chronological order in which the separate elements of the picture were fixed in his memory, this means that the visual impression mentally reproduced in the form of images, flows through his mind simultaneously with his speech. But if the man relates the same thing after having thought of it for some time (as is known, it is possible to think in words), then in all probability it is not the images that are reproduced in his mind during the narration but only the verbal photography of them. In this case the process is, of course, the same as in the case of reciting poetry in an unknown language, apart from the emotions which accompany the narration of some past experience and apart from the order of the story which is regulated by the train of thought. It is the last-mentioned new element which distinguishes this case from that of reciting poetry in an unknown language; but, as everyone knows, here, too, will is absolutely powerless. If we turn now to the act of walking, we shall fail to find in it any similar element; consequently the analogy between talking and walking does not go beyond the influence exerted by emotional thought on the character of the two movements as a result of which they may become impetuous, smooth, rapid, slow, etc.

Thus, an analysis of all acquired complex movements shows that, when properly performed (which is the normal thing!), the entire process resembles the work of an automatically functioning, well co-ordinated mechanism (the comparison with a music box comes to mind); human will *can* but put this mechanism in motion, slow it down or accelerate its operation and, ultimately, *stop it* altogether, and that is all.

How can this be reconciled with the absolute power of will over such simple forms of movements as, for example, bending and unbending the fingers? Are they exceptions to the general rule? *Apparently not, because, in origin, they are acquired by* learning, like any complex movement, consequently, here too a decisive role in bending and unbending the fingers is played by the habitual character of the movement, while will can but initiate and end the movement, as well as modify its velocity.

The same scheme of the action of will is applicable from *a* to *z* to all kinds of voluntary interpolations into well-co-ordinated movements (for example, interpolating extra sounds into otherwise normal speech, transposing syllables, jerking the legs in walking, moving backwards, etc.). These interpolations, voluntary by origin, are possible only as a result of exercise and habit. Everyone knows, for example, that it is much easier to insert an extra sound between separate words than between the syllables of the words, and that it is easier to transpose the syllables of dissyllabic words than those of polysyllabic, etc. On the other hand, it is well known that habit overcomes even these difficulties, with the result that interpolated speech acquires the automatically regular and fluent character of normal speech.

My purely objective, physiological analysis has come to an end; I, therefore, deem it necessary to sum up all that has been said, before turning to the psychological side of the phenomena. Here, then, are the general conclusions.

1. All elementary movements of the arms, legs, head and trunk, like all the combined movements acquired by learning in childhood, such as walking, running, speaking, moving the eyes in the act of looking, etc., become voluntary only after they have been acquired.

2. The more habitual the movement, the easier it becomes subordinated to will and vice versa (an extreme fact is that the will has no power whatever over those muscles which, owing to definite conditions of everyday life, remain unused).

3. In all cases will can but initiate an act, discontinue it, and intensify or weaken it; as to the movement itself, it proceeds without the interference of will, being the actual reproduction of what has been performed many thousand times in childhood, when there can be no question of any interference of will.

Now let us pass to the psychological side of the problem.

Here we meet with various theories of will; some of them directly contradict the foregoing conclusions, to others our conclusions are related in the same way as a distant and incomplete echo is related to a complete harmonious melody. Indeed, whom can we convince that our first conclusion is fully applicable also to movements acquired by learning at a mature age, for example, to the decorative and technical skill of the artisan, where the process of learning is prompted by the practical purposes of which the artisan is fully conscious, and where the success of learning actually depends on his *free will*? And how is it possible to cram the extreme diversity of human voluntary actions into the narrow, rigid frame of our third conclusion? Will can bring into action not only that form of movement which is most appropriate to the given moment, but any other action known to man. For example, I can dance and sing gay songs though actually I want to cry; I can go to the left in spite of the fact that I long to go to the right; the instinct of self-preservation prompts me to stop because mortal danger awaits me, and still I may go further. Will is not an impersonal agent in sole control of our movements; it is the active side of our mind and of our moral feeling which directs our movements in the name of certain principles, and in many cases even contrary to the instinct of self-preservation. The question of whether will interferes with the mechanism of acquired complex movements is immaterial; what is important is its capacity (of which man is profoundly conscious) to interfere at any moment with the natural course of a movement and to change its intensity or direction. Precisely this capacity, usually expressed by the words "I want and I shall", is the seemingly impregnable citadel which shelters the popular concept of will.

I shall now examine these questions in turn.

To solve the first one, it is, apparently, necessary to decompose the process of mastering a certain trade into its elements, and then to establish the role played by will in each of these elements. The process of learning a trade requires: 1) that the hands should be sufficiently mobile, i.e., that they should be able to turn in all directions, to bend and unbend in all joints, etc.; 2) that they should obey the eyes (which is self-understood, since all hand movements are acquired under the control of the eyes); 3) that man should be able to imitate the form of movement shown to him; 4) that he should be able to distinguish between good results of correct movements and bad results of incorrect movements, and finally 5) that he should practise as much as possible until normal results are achieved. In the case of the first of these items, will plays the same role as in the case of the elementary movements of the hands acquired in childhood (i.e., it can initiate the movements, stop, intensify and weaken them, but no more), because the first practical lesson in the production know-how is merely the application of previously elaborated hand movements to a new case. The second and third items are in no way connected with will. But will plays an important role in the acquisition of more or less new movements in which the hands have not previously been trained. In such cases the hands must, obviously, act in the same way as we act when we try for the first time in our life to interpolate extra sounds between separate words in our otherwise normal speech, or when we try artificially to jerk the legs when walking. The more complex or rapid are these unusual movements, the more complicated is the process of their acquisition, because the visual control of such movements is more difficult. This is why for complex trades there are special schools in which the hands are trained to perform movements of gradually increasing complexity. But once the essence of the movements has been grasped, i.e., once the sequence of the movements has been memorised and the eye, or the eye and the ear, have become reliable controllers of these movements (which takes place without the least participation of will!)—the process of learning comes to an end. The rest is a matter of practice and regular exercise; but here again will plays the role of the agent which initiates the movement, stops it, or increases and decreases its velocity—but no more.

Thus, when an adult is acquiring complex movements, his will participates in the process of learning* in exactly the same way and degree as in any other acquired movement. In other words, here, too, will can (and man is perfectly conscious of this) interfere at any moment with a movement and change its character. From this it follows that the first point of our summary must be solved later, simultaneously with the third one.

To elucidate the second point in the teaching of common psychology on the voluntariness of human actions, I shall examine two parallel examples.

Let us imagine two aged men, peacefully living out their days free from any practical activity. Both are wise, kind and honest; both have received the same education and have more or less the same views on life. That which is considered good or evil by one is good or evil in the eyes of the other; both find pleasure in helping their neighbours in need, both are tolerant of other people's frailties, etc. Even the way of life of our two veterans is almost identical; both cultivate the virtues which result from their clear and calm world outlook. Judging by their actions, they are morally absolutely equivalent personalities: everyone will say that boundless friendliness towards people is the characteristic feature of their lives. And no intelligent person will change this judgement in the least, even if the two old men differ in nature—if, for example, one does good gently, tactfully and always with a smile, while the other does the same with an air of indifference or even with a frown on his face. In these conditions the moral equivalent of the two is not determined by the manner in which they perform their good works, but by the inviolable constancy of these works. If two men of their fibre were presented to me, I should unhesitatingly say that it is their habit of doing good which I value most in their characters, because it clearly shows that the two men not only have done and are doing good, but will continue to do it in future. In this respect they are equal. But

* Here we speak only of the participation of will in the process of learning a craft, irrespective of the practical purpose of the latter.

now let us suppose that before they reached their venerable old age, they had led different lives. One had lived all his life in peace and prosperity, in an atmosphere of understanding and affection, and had learned to do good after the example of others. His good works had been prompted by the feeling of moral satisfaction which had determined his behaviour ever since childhood. Small wonder, then, that in these extremely favourable conditions this feeling, a feeling of moral uplift, should have gradually become (as a result of frequent repetition) a necessity; and it is understandable that in old age, in an atmosphere of peace and quiet, with the mind untroubled by the endless worries of everyday life, this feeling should be the decisive factor determining the old man's attitude towards his fellow men. The good works of such a man derive from his moral feeling; they come of themselves, in a natural way, without the slightest effort on the part of the man himself. And if I were asked in what way does will interfere with the actions of this man, I must confess that I should be at a loss for an answer. Indeed, why should will interfere with actions, the value of which, in the eyes of man, lies precisely in their habitual nature and in their inevitable dependence on the moral feeling by which they are prompted? Of course, the old man might abstain from performing good works; but would such manifestation of will make his moral make-up any better? I do not think so; in my opinion, the ideal should be defined in the following way: "he cannot but perform good works." In any case, the third point of our summary can, apparently, be applied to this kind old man (because it is fully within his will not to hearken to the voice of his moral feeling); we shall, therefore, revert to him later on. Now let us turn to the other, severe old man. His life was quite different: he had experienced hardships and trials before he reached the material security which, in old age, enabled him peacefully to cultivate his moral virtues. With him the negative rather than the good sides of life were more in mind. While the first man lived all his life amid blessings, smiles and tears of gratitude, the second had witnessed tears of hunger and had heard people curse their fate. The one knew evil only from hearsay, the other from personal experience. Whereas in the first case the man was not tempted by evil in the least, in the second he had to fight for good even at the risk of his life. And yet, in old age the latter proves to be as kind and responsive as the former, even though he looks somewhat stern and reserved.. How to explain this? The layman will say: This person has two virtues—a highly developed moral feeling (a good heart) and a strong will; to this it is often added that the harder the struggle of life, the stronger the will of man who comes through morally unscathed. This idea is so widespread and we are so used to it that we tend to take it for granted. But is this really so? If I emerge from the struggle of life morally as pure as I was at the beginning, why should this be regarded as the result of the moral feeling + will, and not of an elevated moral feeling alone? Indeed, we know that men who risk their lives voluntarily are prompted by some strong feeling, conviction or belief which makes them face death fearlessly or at least accept it as a justified necessity. It is true that in some cases men meet death stoically, out of mere submission to fate. But even this feeling may be of a fanatical character; besides, unlike the previous case, such people await death passively. On the other hand, everyday life and the history of mankind in general do not know of any heroic deeds which would be performed merely by the power of cold-blooded, abstract will. The act of will is *invariably accompanied, and determined*, by some moral motive—a passionate thought or emotion. Even during profound moral crises when, according to common psychology, will must bear a particularly pronounced character, it does not act by itself, but always in the name of reason or sentiment. In other words, cold-blooded, abstract will does not exist; that which is held to be the result of the combined action of will and reason or of will and sentiment, can be equally regarded as the direct result of reason or sentiment alone. Of course, here again, we can abstract will from its attributes and regard it as man's inherent freedom to act in this or that way. For example, our second old man resists temptation and emerges from the struggle with a clear conscience: his moral feeling impels him forward, temptation draws him backward, but the first is stronger and the man obeys it. Such, at any rate, is my view, while according to the common psychology it is necessary to insert abstract will between the moral feeling and the action, because *our self-consciousness clearly tells us that we are free to follow either the voice of temptation or the voice of morals;* if I chose the latter—my will is strong, if I go in the opposite direction—it is weak. This brings us back again to the third point of our summary. Let us now consider it.

At a very early age the child begins to separate in its consciousness its self from all the things which it sees or touches (the development of this phenomenon is described in detail in the *Reflexes of the Brain*). When the child reacts differently to the caresses addressed to it than it does to caresses addressed to a nearby object within its range of vision, this means that a certain degree of differentiation is already in evidence. Gradually developing, *this analytical process soon includes the child's own personality already isolated from its surroundings. When you ask the child:* "What is little Peter *doing*?" and he answers quite correctly, i.e., in conformity with the facts: "Peter is sitting, playing, running", this means that the analysis of his own personality has reached the degree when he begins to separate his *self* from his actions. What is the essence of this phenomenon and how does it take place? The child, while standing, sitting, running, etc., constantly obtains certain complexes of sensations from its body. Along with sensations which are common to all the above-mentioned acts, these complexes include specific sensations which are peculiar only to one definite act. Since all these sensations follow one another very often there are numerous occasions for their mental commensuration. The result of this commensuration is expressed in the idea "Peter is sitting", or "Peter is walking". Of course, here the word "*Peter*" is by no means an abstraction of the constant from the variable members of the complex of sensations, since such an operation is difficult even for the adult; but this means that in its mind the child distinctly separates its body from its actions. Later, or perhaps even simultaneously, the child begins *mentally to separate also the sensations which evoke a desire to perform an action;* the child says, for example, "Peter *wants* to eat", "Peter *wants* to go for a walk", etc. *While the previous ideas indifferently expressed the state of the body as a single sensation, here we have a conscious dif-*

ress of psychical development, inhibited reflexes occur more and more frequently, even when the desire to perform a given action is more or less pronounced (i.e., when the second member of the reflex is of an impetuous, emotional character). In such cases there takes place a clash of opposed motives, with the result that the person is tugged in different directions; and since the inhibitory motive takes the upper hand in one case and does not in another, the commensuration of such cases *provides new and striking arguments for separating one's self* from one's actions. Thus the conditions for attributing the initial cause of one's actions to one's self by no means diminish in the course of psychical development, but, on the contrary, increase. To this we should add the excessive use of phrases beginning with "I" expressing the cause, and ending with an active verb expressing the effect. But the error of omitting the intermediate members of the reflex acts, i.e., of the inner impulses evoking certain actions, becomes, of course, less and less frequent. These impulses, in contradistinction to the external commanding voice, are correctly designated "inner voices"; in many cases it is even admitted that they determine the course of man's actions (for example, man obeys the voice of emotion, the voice of reason, etc.). And yet it is our Ego which is commonly considered the initial cause of all our actions. How can this contradiction be explained?

The point is that we are accustomed to attribute to the Ego not only the cause and the possibility of an action which takes place at a given moment, as well as of any known action in general, but also the cause of our inaction (I want to do something so I do it; I do not want to do anything so I don't; I can do something and I do it; I can abstain from performing an action and I do so, I can perform it, but I don't; I can abstain from doing it, but I don't). Try, for example, to cast doubts on the strength of a young man of, say, five years, who imagines that he is a Hercules; he will at once go to the wardrobe with unruffled calm and self-confidence to show you that he can move it. Is not this child absolutely sure that he can do anything he wants? Everyone knows that, of all the people in the world, children are the most self-confident, and that this is characteristic also of juveniles. It is clear that if the child thinks it can do anything in the world, it will have even less difficulty in thinking that it is all-powerful with regard to inaction. In order to bend a finger a certain effort, even though negligible, is needed; but no effort whatever is required to refrain from bending it. Yet the child cannot but be aware that if it does not walk, does not bend its finger, it and *it alone* is the cause of all its actions and states. It is true that in childhood the voice of the mother, the nurse or the teacher greatly limits such inactivity, but when the child makes a new step in defiance of the order to stop, or when it is intently watching a fly during a lesson with a strict teacher, this is already proof of its *power not to do* what it has been told to do. The same idea, apparently, is present in all those naïve tricks by means of which the child tries to evade doing what the adult wants it to do. When, with the lapse of time, the child is under less supervision, the opportunities for it to exercise the power of disobeying orders, will be greater, with the result that it will come to the idea: "If I want to, I can refuse to obey." It is easy to see that this has nothing to do with the will of the child; it does not do what it is told, because another, stronger voice is urging it in a different direction; but accustomed as it is to ascribing the cause of all its actions to itself, the fact of disobedience cannot be an exception to the general rule, especially if the disobedience entails punishment of the guilty body. At school the child experiences a double yoke: besides the image or voice of the teacher there is an additional compulsory element—the lesson; but the schoolboy has the *right now and then to disobey* the voice of the teacher. Immediately after school the smart boy, conscious of his right to disobey, makes fun of the teacher who caused him to tremble only a minute before. At this stage of life the positive meaning of "can" consists in following blindly the voices which call the child out into the fields to play, run, throw stones at passersby, chase dogs, etc., while its negative meaning is to evade in every possible way the tiresome voices of the mother or teacher. The time comes, however, when a certain change takes place in the mind of the schoolboy: the former voices begin to fade away, and instead, new images begin to appear: at one time it is Alexander the Great, in armour and helmet, of whom he has heard at school; at another, it is the life of ants or bees; at a third, it is a picture seen in a book, etc. The voice of the mother or teacher no longer seems so annoying, although it is every bit as commanding as before. This is a very important period in life, the period when it is easiest to develop the voices of duty, honesty and kindness. Unfortunately, this is done only in rare cases. In still rarer cases the development of these voices lasts throughout the whole youth; but under these exceptional conditions that noble type of man is created who has forgotten that it is possible to disobey the voice of reason or of the heart and who, therefore, does good spontaneously, without any constraint, or effort, being deeply convinced that this is the right and natural thing to do. Usually, however, the course of development is quite different. The story of the child repeats itself in the youth and in the adult: in their behaviour they often obey those inner voices which speak to them in the same way as the loving mother or the stern but wise father speaks to the child. However, very often and, apparently, under the same conditions, the opposite takes place; and then the former mode of behaviour comes to mind not only to evoke mental suffering, but to strengthen the idea formed in childhood that man can disobey certain voices. Only one little thing is forgotten: man disobeys one voice merely because he obeys another.

Our actions are not governed by phantoms, such as our Ego in all its diverse forms, but by our thoughts and feelings. In normal people they are fully correlated: if, for example, an action is the result of moral feeling it is called noble; if it is caused by egoism, we designate it as selfish; if it is dictated by a mere animal instinct, it is foul. Even in the acts of lunatics there is a conformity between these elements. In this sense, the conscious and rational activity of man can be compared with the motor side of the lower nervous processes where the intermediate member of the act, i.e., sensation, regulates the movement in order to make it more beneficial to the organism.

## A FEW WORDS IN REPLY TO MR. KAVELIN'S "LETTERS"

Having read the "Letters of Mr. Kavelin" and being fully convinced that it is hopeless to think of reaching agreement with him on the psychological problems under discussion, I have come to the conclusion that any further discussion on the subject would be useless; I cannot, however, leave unanswered *his charge that I read his book without due attention, and that I ascribe to him ideas which had not even entered his head. Since this charge questions my good faith, I cannot leave it un*answered.

The main reason why Mr. Kavelin often fails to recognise himself in my critical review is this.

In *The Tasks of Psychology* he departs from the idea that *positive science has not yet applied itself to the psychological phenomena* (p. 9), and he ends the first chapter by saying that he intends to show *in general outline how the methods of strict scientific research can be applied to psychical facts.*

I, of course, took this statement seriously and regarded all the subsequent chapters as an attempt to create a new system of psychology based on positive foundations. I reasoned thus: in order to create a new system of psychology it is necessary either to use another kind of raw material for elaboration instead of that used hitherto, or to change the method of investigation, because to follow the old paths in either direction would simply mean a repetition of the old errors. I frankly confess that, approaching Mr. Kavelin's book from this standpoint, I found it somewhat contradictory; nevertheless, I had no doubts whatever about the correctness of my suppositions, especially in view of the statements made by Mr. Kavelin in *The Tasks of Psychology* on these two points.

On pages 23 and 24, for example, we read: "*Positive knowledge of man's spiritual life together with knowledge of nature,* has become possible solely as a result of the discovery of psychical life in external objects and phenomena. Only if we base ourselves on the external manifestations of psychical life can we speak of law, art, philosophy.... The objective definiteness of these traces has made it possible to create the history of religion, language, political doctrines and institutions, the arts, sciences, philosophy and culture. By comparing the kindred phenomena observed among different nations, or of one and the same nation throughout its history, we learn how these phenomena change and we note the laws governing these changes which, in turn, furnish material for research into the laws of psychical life and activity. Thus, all sciences furnish material for psychology, and *the positive aspect of the psychological researches depends on the degree to which the elaboration of this material has been perfected.*"

I ask, am I not entitled to think and to say that Mr. Kavelin anticipates raising psychology to the level of a positive science by way of historical study of the countless relics of human activity? One of the two: either in writing the sentences which I have underlined he allowed his pen to run away with him or they are the result of his profound reflection. I took them, naturally, in the latter sense.

Now for the second point, i.e., the method of elaborating the scientific material. Here Mr. Kavelin charges me with having imposed on him *psychical vision as an instrument for analysing psychical activity.* It is true that his book does not contain any definition of psychical vision precisely in this sense; but then I make this reservation in my *Observations on Mr. Kavelin's Book* (pp. 194-95) when I said that *Mr. Kavelin did not qualify psychical vision anywhere.* And if despite this, I took the liberty of attributing to psychical vision the role of an analyser, there was nothing accidental in my doing so. For I based myself on Mr. Kavelin's idea that *anything psychical is* *accessible to psychical vision only*, from which I, naturally, inferred that psychical vision must at the same time be an instrument for studying or analysing psychical facts. Let Mr. Kavelin turn once again to chapter 5 of his book and judge whether I really sinned in drawing those conclusions. In point of fact if he had not analysed psychical facts by means of psychical vision, *how could he have arrived at his concepts of the structure and properties of the psychical organism?* Now, what prompted me to illustrate my point of view on the validity of psychical vision by the case of a person who analyses his past and future thoughts, a case not cited by Mr. Kavelin in his book? I did so for the purpose of investigating a controversial point by means of an example where a person obeying exclusively the voice of self-consciousness perceives the existence of psychical vision with particular vividness.

The third major charge is that with no grounds for doing so I regard Mr. Kavelin as a philosopher of the old school, i.e., a metaphysician.

In doing so I proceeded from the fact that the methods on which his scientific system is based are similar to those used by the metaphysicians. *First he tries to establish on the basis of exceedingly unreliable data the essential distinctions between the psychical and the material.* Then, considering this task accomplished, he begins to build up the spirit and its attributes on the basis of psychical facts, all unmindful that these facts constitute the scientific material which should be investigated by psychology, the X-es which are to be defined by science. Lastly, having built up the spirit solely on the basis of these X-es, he uses it to explain the Y-s and the other X-es which appear to him to be still more enigmatic (see Chapter V). What is it but metaphysics!

So I don't think *I can be accused of having read Mr. Kavelin's book without due attention; my fault, if fault there be, is that I gave credence to what he says in the preface,* with the result that I believed in his intention to create a new system of psychology and approached his book precisely from this point of view. This, of course, would not have happened if, when reviewing *The Tasks of Psychology*, I had been aware that in the matter of explaining psychical facts the differences between the psychologists, according to Mr. Kavelin, are no less and no greater than those between the chemists and the physiologists (*Vestnik Evropy*, March 1874, p. 413). In this case I should not, of course, have comprehended the purpose of his book, but then I would have known beforehand that our views on the concept of science, on the positive method, on the manner of explaining things, etc., differ far too much for us to argue with one another.

## THE ELEMENTS OF THOUGHT*[55]

The study should begin with the development of the child's mental activity from sensation. The modern development of the anatomy and physiology of the sense organs, especially the works of *Helmholtz*, makes this study feasible. *Herbert Spencer*'s service in solving the general problem of the relationship between thought and sensation.—The essence and significance of *Spencer*'s theory compared with the views of the sensualists and the idealists on the same subject.—Co-ordination of *Spencer*'s hypothesis with the views of *Helmholtz*

1. In the mental life of man it is only in early childhood that thoughts or the shaping of ideas derive directly from psychological products of a lower order which do not bear the character of thought. It is only here that observation reveals the existence of a period when man is not yet capable of thinking and then, gradually, begins to manifest this faculty.

It is true that even at a mature age man sometimes forms new ideas and new views; this is proved by the mass of discoveries in the intellectual sphere; but when we subject these cases to analysis, we invariably see that the new ideas or the new viewpoints take shape in the adult in a way different from that in the child, i.e., not from the lower forms that precede thought, but from a chain of equivalent states of what we can term ideation, by way of long and sometimes quite unexpected confrontations. The point is that the mind of the adult no longer knows the elementary forms which precede thought and which overflow the child's mind in the pre-thinking period.

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* This article, first published in 1878 in the *Vestnik Yevropy*, is reprinted with some corrections and considerable additions.

Further, even simple observations show that the source of the child's thinking lies in sensation. This is because all the intellectual interests of early childhood are concentrated exclusively on objects of the external world which are perceived in a primary way, apparently, by sensation only (chiefly, by sight, touch, and hearing). Man can think only in terms of those objects, properties or relations which are known to him; consequently, the ability to distinguish between objects, to recognise them and subsequently to differentiate their properties and relations must precede thought; this is originally acquired through sensation.

We are, therefore, able to reveal the roots from which thought develops in early childhood and to affirm that the preceding forms are of a more elementary nature than their derivatives.

In the adult the process of thinking is not so simple. Here, in every case of the development of thought (thousands of cases take place in any educated person) there can be no question of a thought arising directly from sensation, as in the child, because between the given product and the sensual root (if it still exists!) there lies in most cases such a long chain of ideational transformations that very often the visible link between thinking and its sensory prototype is completely lost. The fact is that the adult thinks in terms not only of sensory concrete objects, but also of their derivative forms, or so-called abstractions His intellectual interests are concerned not so much with the individual characteristics of the objects, as their interrelations. The intellectual world of the child is peopled more with units than with groups, whereas for the adult the entire external and internal world is divided into a series of systems. The thought of the child is, from beginning to end, confined to the sphere of sensation, while the mind of the adult follows the path of abstraction, and, as a rule, goes beyond the limits of sensation into the so-called supersensual domain. The adult regards matter with its invisible atoms as the basis of external reality; he explains the phenomena of the surrounding world by the play of unseen forces; he speaks of interrelations, causes and consequences, systems of laws, etc. Consequently, even in the sphere of object thinking the adult goes far beyond the limits of sensation. Moreover, his mind can penetrate into the sphere of the purely mental and moral relations, where the thought is preoccupied either with formations for the perception of which there is nothing similar to our sense organs, or with intellectual products which are separated from their sensory roots by a still deeper abyss than that separating atoms from real objects.

It is clear that the mind of the adult either presents derivative forms of the child's mind, i.e., higher stages of development of the same processes, or it is based on altogether different activity and forces. In any case, being immeasurably more complex in form, it cannot serve as the point of departure for the study of thinking as a process.

*The beginning of this study must be the history of the development of the child's thinking from sensation, or the history of the development of object thinking from sensation, in general.*

It is not only the natural course of the development of the human mind which leads us to this conclusion, but also the wise rule adopted by natural science, according to which the naturalist begins his study of a series of related phenomena with the forms simpler in content or where the conditions of development are more distinct. It is necessary to start this study from the natural beginning, even if later on it proves that the development of thinking from sensation is inapplicable to the subsequent, superior forms of thought.

2. There is no doubt that this point of view has long since been shared by many thinkers belonging to the various philosophical schools; but until the second half of the last century it did not lead to any practical results, and the theory of thinking was doomed for ages to develop exclusively on ready-made patterns of thought embodied in speech. In other words, the study began not from the natural beginning but from the middle, and, what is more, not from the primary, basic forms, but from the secondary, derivative ones.

This was due to the following circumstances.

However natural it may seem to begin our study with the child's mind, this way of research presupposes knowledge of the source of the process, i.e., the system of primary sensations. But it is absolutely impossible to become acquainted with them solely by observing children; then, the elementary forms of sensation peculiar to the child no longer exist in the consciousness of the adult. It is clear that in these conditions the primary forms of thinking inevitably remained inaccessible to researchers until anatomy and physiology elucidated the structure and functions of the different elements of the sensory organs of our body.

At present, thanks to the progress made in the spheres of the anatomy and physiology of the sense organs, and particularly to the works of the German physiologist Helmholtz, these difficulties no longer exist. Those who know, for example, the anatomy and physiology of the visual apparatus do not need to observe children in order to ascertain the composition of elementary (i.e., primary) visual sensations; this composition, so to speak, follows logically from the anatomical and physiological structure of the eye.

*Consequently, we are now in a position to study the process of thought from its natural beginning.*

3. For another, equally important achievement in the study of thinking, or of man's mental development generally, we are indebted to the famous English thinker Herbert Spencer. Spencer's hypothesis concerning the successive stages of neuropsychical evolution from generation to generation enabled the human mind to find a satisfactory solution to the secular philosophical problem of the development of mature thought from the initial forms of the thought of the child, or, what amounts to the same thing, to solve the problem of the *development of thinking as a whole from sensation.* To Spencer we are indebted also for establishing, on the basis of very broad analogies, a general type of mental development in man, and for the proof that the ways of evolution of the mind remain invariable at all stages of the development of thinking.

Since the present essay is based on Spencer's theory, we will begin by expounding its basic propositions. It would, however, be wrong to start with this exposition straightaway. The essence of Spencer's hypothesis will stand out only if we *compare it with the preceding philosophical* views concerning man's psychical development, namely, with the views of two famous schools—the "sensualists" and the "idealists"; since the theories of these schools are the two extremes, they, it follows, summarise all the intermediate opinions, i.e., all possible views on this subject, in general. But in order to obtain a better understanding of the views of the two schools, it is essential to know something about the basic features of the *development of thinking which have always been accessible to observation and which have long belonged to the domain of empirical psychology*, constituting the basis of both the sensualist and idealist theories. We shall, therefore, begin with them.

4. Although the abyss between the thinking of the adult and that of the child seems very deep from the point of view of their objects, their close structural relationship has always been acknowledged. When expressed in words, they both assume the same form, the principal type of which is known to everybody as a sentence consisting of three parts. And because this form is the same in people of different age, different epochs and different levels of development, we can understand *with equal ease the thoughts of the savage and of the child, of our contemporaries and of our ancestors. This also accounts* for the succession of thinking from generation to generation.*

Consequently, in its external form thinking is as constant as any other phenomenon based on a definite organisation. In other words, *there must be a common aspect in all thinking as a process or chain of vital acts, irrespective of its content.*

This aspect can be expressed quite simply in a general formula, if for the time being we admit (later it will be strictly proved) that the subject and predicate of a sentence consisting *of three parts are psychologically equivalent and if we designate them as "objects of thought". Every thought, then, irrespective of its content, can be considered *as a confrontation of objects of thought from the standpoint of a certain relationship between them.*

If we analyse from this point of view the largest possible

* Sometimes we hear or read that thought is capable of progressing; but *this does not mean that the form of the thought progresses with the development of man.* On the contrary, it remains invariable; it is only the variety of the objects of thought and of the relations between them which widens, owing to perfecting of the instruments of observation and to the expansion of the sphere of possible comparisons.

number of verbal images of thought, we shall see that the thought may be extremely diverse as regards its objects, but the relations in which these objects are confronted are far from being equally diverse.

The first part of this proposition does not call for elucidation. It suffices to remember that man takes the objects of his thought from various spheres of the external world in its entirety—from a grain of sand to the universe—and of the entire internal world (the world of the mind) not only of his own, but that of mankind as a whole. The second part of our proposition can be corroborated by the following.

By taking at random any thoughts in the sphere of object thinking and comparing them with thoughts in the sphere of purely intellectual and moral relations, or even with extrasensory thoughts, we shall see that in these higher spheres there is not a single relation between the objects of thought which cannot be encountered in object thinking. It might seem that man, after his primary acquaintance with the external world, transfers all the links, interdependences and interrelations between the objects already known to him to new objects, despite the fact that in the eyes of man, these links and relations are real when they are in their proper place, and assume a conventional or figurative sense when the transfer takes place.

Whatever may be the explanation of this fact, it is highly significant for the following two reasons.

Firstly, it indicates *a close relationship between thoughts of different orders from the standpoint of not only the general type of their structure, but also of the relations in which the objects are confronted with each other*, i.e., from the standpoint of the element which is perhaps of greatest importance in thought, because it is this element which imparts to thought the character of a rational act.

Secondly, it indicates *the possibility of studying the entire range of the relations embraced by man in the primary school of object thinking, which originates undoubtedly, in sensation.*

Further, from the comparatively lesser diversity of object relations it follows that while all the components of verbal thinking can be divided or classified into groups, the relations in which the objects of thought are confronted are subject to this classification in even greater degree. Three principal categories of relations are recognised at present—*similarity, coexistence* and *succession*; this conforms to the fact that in thought objects appear only in three main forms of confrontation: as members of related groups or systems of classification, as members of spatial combinations and as members of series succeeding each other in time. In any case, this shows that of all the organic foundations of thought those which correspond to the acts of confrontation of objects of thought must be essentially uniform.

The fourth fact, equally indisputable, revealed by observation is a certain progressive succession in the process of thinking from childhood to a mature age. This aspect is aptly and correctly described as the intellectual development of man. Externally, it is manifested in the multiplication of the number of objects of thought and in the resulting increase of the number of their possible confrontations (even if the general directions of the confrontations remain unchanged), as well as in the so-called idealisation or symbolisation of the objects of thought.

The first point is obvious. It suffices to compare the objects of the narrow sphere of the child's thought to those of the intellectual world of the adult. Nor does the increase in the number of possible confrontations brought about by the multiplication of the number of objects call for any explanation. As to the general meaning of symbolisation, it can be explained as follows.

In the initial stage of his development the child thinks in terms only of separate objects, for example, the fir-tree, the dog, etc. Later, it thinks of the fir-tree as the representative of a definite species of trees, of the dog in general, etc. Here the object of thought already departs from its prototype; it is no longer the mental expression of a particular object, and it turns into a symbol or sign designating a group of related objects. With the further expansion of the sphere of comparison by similarity, there appear among the objects of thought such as "*plant*", "*animal*", *etc., i.e., groups of objects immeasurably* larger than "fir-tree" or "dog", but also expressed by a single (though different) symbol. It is clear that this course of development of thought is bound to communicate to the objects an increasingly pronounced symbolic character separating them from their sensory concrete prototypes.

But this is not the only way in which thought develops. Another direction is determined by decomposition of the concrete objects, or by mental separation of parts from the whole. Each of the separated parts, individualised, acquires the right to independent existence and receives a corresponding symbol. When the mental separation of a part takes place simultaneously with the process of physical decomposition, the former may be devoid of a symbolic character (for example, when we speak of a certain part separated from a given object); but in the absence of this condition, or if the separated part serves as a generic symbol for a group of similar parts, it again acquires a symbolical significance; this occurs also when the decomposition exceeds the limits of sensation.

The third direction of thought development is determined by the reunion of the separated parts into groups by virtue of their coexistence and succession. The extent to which this combinative activity results in the formation of symbolic products is best seen from our faculty to think in terms of hour, day, year, century, sand, landscape, Europe, terrestrial globe, universe, etc.

All these transformations which are indispensable to all spheres of thought, beginning with object thought, add up to what might be generally described as *an ideational transformation of the primary sensory or mental material.*

These, then, are the basic features of the acts of thought which have been long known to the researcher, thanks to the analysis of the verbal images of thought by means of comparatively simple psychological observations—features used so differently by sensualists and idealists.

5. The sensualists approached the foregoing results of psychological observations in a direct way.

From generation to generation, in the life of any newborn there has always been a phase of complete absence of any (even sensory) manifestations in the sphere of the higher sense organs. This phase is followed by another, when sensory impressions are perceived precisely by these organs, but without any conscious reactions on the part of the child indicating the presence of ideas. Each of us has passed through this premental period; consequently, the mental development of every individual and of mankind as a whole begins from zero (?) and invariably passes through the sensory phase. During this phase the external world furnishes material for sensation, and the transformation of this material into sensory products of the mind is accomplished by the developing natural sensory organisation of man.

In the next stage of development the sensory product is transformed into object thought; but, according to the sensualists, the factors in this process of transformation remain unchanged. The external world is not a mere conglomeration of objects; there are certain relations, connections and interdependences between the objects, and it is the elucidation of the latter in the sensory perception which constitutes the essence of the transformation of sensation into object thinking. Being a product of experience, thought always presupposes a series of encounters with the object perceived under different conditions. This makes the sensory product varied in content; it acquires the faculty of decomposing into parts as a result of comparison; because of certain common aspects it can be grouped with other products; it is capable of development, in general. As the number of encounters grows, the products of the sensory experience become more and more diverse, and the conditions for their decomposition as well as for their grouping into systems, increase.

The sensualists attribute these processes not only to primary products, but also to all their derivatives; thus, they reduce the entire successive chain of intellectual development to a repetition of the activity which lies at the base of sensory transformations.

Denying the presence of any organisation in man, except the sensory one, they regard the influences emanating from the external world with all the relations and interdependences existing between its objects as the sole source of thought, both in form and content. In their view, the entire rational side of thought is determined not by man's intellect and not by some extra-sensory organisation of his nature, but by the relations and interdependences of the objects of the external world. To this school, thought is merely a sensation developed as a result of diverse groupings of its elements.

The idealists approach this question in a totally different way. Proceeding from the idea that the external world is perceived and cognised by man in a mediate way, they regard the entire rational aspect of thought not as a reflection of the relations and interdependences of objects, but as forms innate in man or as laws of the perceiving and cognising mind which accomplishes all the work of transforming impressions into ideas, thus creating what we call relations and interdependences of objects.* Whereas the sensualists consider the external world with all its variety of relations and interdependences as the basic determinant of mental life, the idealists believe that this role is played by man's inborn spiritual organisation which, obeying its own definite laws, transmits to the external world the symbolic forms known to us as impressions, notions, concepts and thoughts.

The scientific groundlessness of the two systems is, in our days, evident.

Sensualism had always lacked the data needed to determine the properties and limits of man's sensory organisation; for this reason the followers of this school have never had any solid scientific grounds for their claim that the phenomena of association, reproduction and commensuration, both of the sensory products and of the ensuing states of ideation—which they could not ignore—are the outcome of sensory organisation.

No less groundless, however, was the theory of the idealists. Their first error was that, contrary to all the evidence, they tried to deduce man's entire psychical life from one factor only—his spiritual organisation, completely disregarding the other factor—the influences exerted by the external world, on the grounds that direct cognition of these influences is impossible. But who in our day would be bold enough to assert that the external world does not exist outside man's consciousness, that the inexhaustible wealth of its activities has not served

* The extreme view in this respect is the well-known idea of Fichte that the external world is nothing more than the product of our "Ego".

as a source of material for the endless chain of acts of thinking which have produced the science of the external world? The other error of the idealists is that they isolate the subjective factors participating in the psychical development into a special group of agents which differ from everything else on earth not only by virtue of their cognoscibility, but also by virtue of their innate properties. One would think that some of the idealists tried to deduce psychical activity from all the known earthly principles, and only after exhausting their efforts in this direction, were compelled to admit the specific nature of the psychical factors. Judged from this standpoint, the views of the idealists are at least premature.

Naturally, in the history of the philosophical problem which we are considering now, there were, along with the men of these extreme schools, other thinkers who adhered to intermediate opinions, i.e., who did not run to the extremes of the antagonistic schools. But as long as the discussion remained on the soil of pure speculation and traditional philosophical dialectics, no conciliation of the extreme views was possible. Some attempts were made to reconcile, to obliterate the flagrant contradictions of the two schools by finding examples which would fit in with both; but in the absence of any well-established principles, the basic contradictions could not be resolved. Modern biological science has, however, furnished these principles, and their application to the problem we are investigating here is the merit of Herbert Spencer.

6. I shall try first to expound as briefly as possible the substance of Spencer's theory.

Psychical activity, like the structure of organisms and the physiological functions of the body, is one of the aspects or manifestations of organic animal life. These three aspects of the animal organism are not only always concomitant, they stand in definite correlation to each other, simultaneously varying from one animal species to another in complexity, variety and precision of individual manifestations. This correlation is necessitated by the fact that in the vital processes which ensure the existence of the organisms all three factors (structure, physiological functions of the body and psychical activity) cooperate; consequently, their activities must in some way or other be co-ordinated.

Granting that all the three aspects of organic life develop along parallel lines from one animal species to another, let us allow for a moment that in one of these aspects, say, the structure of the body, the entire animal world is simply a successive chain of past transformations or evolutions from one form to another; it follows, then, that the two other aspects of organic life also derive from the parallel transformations or evolutions of corresponding substrata. In other words, the evolution of all the three aspects, i.e., form, functions of the body and psychical activity, take place in the animal kingdom along parallel lines.

As we know, Darwin's theory of the origin of species has placed the question of evolution, or successive development of animal forms on such a solid foundation that the overwhelming majority of naturalists now accept his theory. Consequently, the same overwhelming majority of naturalists cannot but recognise in principle the evolution of psychical activity.

Actually Spencer's hypothesis can be called Darwinism in the sphere of psychical phenomena. Having appeared simultaneously with Darwin's theory and being but a part of the general theory of the evolution of organic life, it has the same strong and weak points, the same merits and demerits. Even from the point of view of probability, the two hypotheses are equal.

It is the exposition of these general principles that forms the principal part of Spencer's theory.

Spencer's entire work is aimed simply at proving the following two points (which are, however, of tremendous significance):

1) the existence in various representatives of the animal world of parallel correlations between the three aspects of organic life, i.e., between the form of the body, the functions of the body and the psychical functions, from the point of view of complexity, variety and precision of their individual manifestations;

2) the idea that in all animals, man included, the type of evolution is basically the same in all the three aspects.

Fortunately, these two aims can be attained at once, or at least by studying the same material. Thus, if we arrange the entire animal kingdom in a progressive order and compare each of its representatives with the other from the standpoint of the gradually increasing complexity of their material organisation, physiological functions and psychical activity, we shall get three parallel lines the links of which are the phases of the progressive development of all three manifestations of animal organic life; *the type of evolution* can then be determined by examining the links of each line separately. By comparing the links of the three lines we will arrive at a solution of the problem of the parallel development of the material organisation and of the functions of the body and mind.

It should not be forgotten, however, that the line of succession in the chain of animal development is but a hypothesis; hence, when determining the general type of evolution, it is highly important to use all the known particular cases of non-hypothetical progression in the animal kingdom, so long as their phases are accessible to observation and analysis.

*Of great help in this respect is the study of the development* of animal embryos. Here a complex organism develops in a *comparatively short space of time from such a simple initial* form as an egg.

Another non-hypothetical cycle of successive transformations providing important data on the general type of the intellectual evolution of man, is the progressive development of knowledge among cultured peoples, as far as the phases of these transformations have been preserved in the annals of science.

Finally, the third, undoubtedly progressive cycle of transformations is the mental development of the human being from birth to maturity. But since this last cycle is the subject of our present investigation, we shall not refer to it in determining the general type and the factors of organic evolution; what is more, we shall consider it as being still unknown.

In higher animals the type of embryonic evolution (or the so-called *history of development of the embryo*) has in the main been established quite definitely, beginning with the initial *form—the ovum—and ending with the developed organ-*

ism. The change here consists primarily in the increase of the mass at the expense of the material brought from the outside. But this is not a mere accumulation of substance; it is associated with the process of reproduction of the cellular elements and their agglomeration in a growing number of groups or systems. The cellular elements undergo various changes and ultimately assume the distinctive morphological features characteristic of the elements of the tissues and organs of the grown animal. Consequently, from the point of view of form, this type of evolution can be described as the disintegration of the primary simple form into groups of metamorphosed forms having, however, a common origin. From the physiological point of view it consists in an extreme complication of the manifestations, owing to the growing specialisation of the vital functions, or—what is the same thing—to the distribution of physiological functions among an ever-growing number of life instruments or organs.

The type of evolution of forms and vital functions in the animal kingdom (from one form to another) is actually of the same nature. The progress of the material organisation here takes the shape of an increasing differentiation of the body into parts and of the isolation of the parts into groups or organs performing different functions. But, as the successive forms become separated from each other, certain details of the development become more pronounced than in the preceding case. Thus, a comparison of the forms which do not differ greatly from each other shows that the differentiation is not a process of the formation of new organs and of new vital functions, but rather of the development and isolation (both in form and function) of that which existed in non-separation at the preceding stage of evolution. If we generalise these facts we shall come to the conclusion that the substrata of developing life must possess general or basic features which remain invariable at all phases of development. The comparative study of animals shows, further, that the progress of the material organisation and of life does not follow straight lines; it branches off and deviates in a number of details. Here, at the cross-roads of organisation, the influences exerted by the environment, or, to be more precise, by the conditions of existence, on the organisms are manifested with particular force. This influence is so pronounced and the correlation between the details of organisation and the conditions of existence are so obvious that there is no need to dwell on them. It is only necessary to indicate the general conclusions to which the foregoing facts lead. Firstly, they enable us to define life at all stages of its development as the adaptation of the organisms to the conditions of existence; secondly, they prove that external influences, in addition to being indispensable to life, also modify the material organisation and the character of the vital functions.

From this general standpoint any line of demarcation between the life of the individual, species, class or even the animal kingdom as a whole becomes obliterated, no matter whether we consider it at certain moments of the separate existence or in its successive development in the course of centuries.

*At all times and in all places life derives from the co-operation of two factors: a definite but variable organisation and external influences.* It makes no difference whether we consider life from the point of view of its final aim, i.e., preservation of the individual, or from the point of view of evolution, because the preservation of life at any given moment is achieved through continuous transformations.*

Another factor in the successive evolution of the animal organism is heredity, i.e., the capacity to transmit the modifications acquired in the course of life. This property cannot, as yet, be analysed, but in a way it is subject to the general conditions of evolution: the accumulation in a successive, evolutionary line of the modifications acquired by the separate members, though due solely to heredity, takes place only if the modifying phenomena which determine the deviation from the initial form are still in existence. The degree and stability of the

* This follows from the well-known fact that in all organisms preservation of the integrity of the body and of life is achieved not by the immutability of things established, but by continuous partial decay and restoration of the elements of the body. As long as the development of the organism is positive, i.e., as long as growth is in the ascendancy, the process of creation predominates over that of decay; in maturity the two processes are balanced; in old age, or in the period of decline, the process of decaying prevails.

modification are always directly proportional to the duration of the action of the changed external influences (or conditions of existence) or to the frequency in which they are repeated, if their action is not of a continuous, but of a periodical character.

Together with this general progress of organisms, there takes place, of course, the separate development of their component systems or organs (actually the general progress of the organism is the sum total of the progress of its separate parts); consequently, the progress of the nervous system as a whole presupposes the progress of that of its parts which should properly be called the sensory organisation. It is precisely from this point that the special part of Spencer's theory begins.

At the lowest level of development of the animal kingdom sensibility is equally distributed throughout the body, there being no signs of any differentiation in this respect or formation of special organs. In its initial form sensibility hardly differs from the so-called irritability of certain tissues (for example, muscular tissue) in the higher animals, because anatomically and physiologically it is represented by a piece of protoplasm capable of irritation and contraction. But with the progress of evolution, this single form gradually breaks up into separate organised systems of movement and sensation: the *contractile* protoplasm is now replaced by muscular tissue, and the equally distributed irritability—by a definitely located sensibility which develops parallel with the nervous system. To continue, the sensibility becomes specialised, so to speak, qualitatively—it breaks up into the so-called systemic senses (hunger, thirst, sexual attraction, respiration, and others), into the activity of the higher sense organs (sight, touch, hearing, etc.). Here again the type of evolution is much the same, namely, the division or differentiation of the whole into parts and their isolation into groups performing different (specialised) functions. But what a considerable advance is made by the animal organism, as compared with the initial form, in adapting its life to the conditions of the surrounding world! Where sensibility is evenly distributed throughout the body, it can serve the latter only if the external influences act immediately on the sensitive body; but where sensibility has developed into sight, hearing and smell, the animal is able to orientate itself even in influences emanating from a distance, or, in other words, to orientate itself *in space*. This, of course, presupposes the capacity of the animal body to move; but the evolution of the senses always proceeds parallel with the development of locomotion (by virtue of the law of correlative development of all parts of the body aimed at ensuring its adaptation to the conditions of existence), because even in the initial form sensibility is connected with the contractibility of the body. Let us now advance the complexity of the sensory organisation a step further; let us, for example, endow the eye with the capacity to distinguish the movements of surrounding bodies; the animal will then be able to orientate itself not only in space, but also in *time*.

In this case, too, it is the environment which determines the organisation of the animal. When the sensibility is evenly distributed throughout the body, which excludes the capacity to move in space, life can be preserved only if the animal is directly surrounded by a medium capable of maintaining its existence. The sphere of life here is limited. On the contrary, the higher the sensory organisation, by means of which the animal orientates itself in time and space, the wider the sphere of the possible life contacts and the more diverse the medium influencing the organisation of the animal, as well as the means of possible adaptation to the environment. From this it clearly follows that, in the long chain of the evolution of animal organisms, the complexity of the organisation and the complexity of the medium acting upon it are interdependent factors. This becomes clear if we regard life as a process of co-ordinating the animal's vital needs with the conditions of the environment: the greater the needs, i.e., the higher the organisation, the more the organism demands from the environment for the satisfaction of these needs.

But is it possible that no other factors, apart from the inborn changeability of the initial sensory form and the modifying action of the external influences, participate in the break-up of the general sensibility into such qualitatively different forms as the sensations of light, sound and smell? While there is no direct proof of this a number of facts indicate that separate forms of sensibility differ in quantity rather than in quality.

Basing himself on these facts Spencer advanced his hypothesis about the existence of a general unit of sensation in the form of a nervous shock; from this he drew the conclusion that all complex forms of sensation are the result of various combinations of these units. From this point of view, the evolution of the senses from an initial elementary form is really analogous in type to the development of the organism from an egg; it should, however, be admitted that this part of Spencer's hypothesis seems at present to be rather bold.

In any case, it is clear that the evolution of sensation in the animal kingdom is associated with the extension of the sphere of vital adaptations in time and space, and especially with adaptations to a greater variety of spatial combinations (coexistences) and of successions in time. This is clearly seen, for example, from the evolution of vision in the animal kingdom from its most elementary forms, when the eye can but distinguish light from darkness, to the higher forms, when the eye can discern the shape and details of objects, their colour, distance, motion, etc.

The next stage in the evolution of sensation can be defined as co-ordination of the activity of the special forms of sensation with each other and with the motor reactions of the body. Whereas the preceding phase consisted in a grouping of the units of sensation and motion in various directions, the subsequent phase is a combination of these groups (of course, still more varied) among themselves. Being equipped with specific instruments of sensation, the animal must necessarily receive highly diverse groups of simultaneous or consecutive impressions, but even at this stage of development sensibility as a whole is bound to be a means of orientation of the animal in space and time, and this orientation is, apparently, much more precise than that of which lower animal forms are capable. Consequently, it is necessary that the separate elements which constitute the sensory group (or chain) be co-ordinated, or the sensory group be decomposed into its elements, because without this the sensation would remain a chaotic and fortuitous mixture.

These two processes take place simultaneously at this stage of development; both co-ordination and decomposition are achieved by the same means—by the inborn variability of the *sensory organisation (in animals which possess the five higher* senses the organisation of the latter is undoubtedly progressing), as well as by the variability of the external influences.

The results of evolution are so numerous at this stage of development that it is impossible to follow them one by one; *fortunately, however, we know two definite forms of transformation:*

*The decomposed and co-ordinated sensation ultimately develops into instinct and intellect, and when combined with motor reactions—into instinctive and intellectual acts.*

If we recall all the known facts of animal life which involve sensations, even the most elementary ones, and, on the other hand, any rational human acts, and if we thoroughly consider the essence or significance of these phenomena, we shall see that sensation always has but two functions: it serves as an instrument for ascertaining the conditions in which the actions are performed and as a guide for actions conforming to these conditions (i.e., expedient and adaptive actions). But if this formula can be applied in equal measure to the elementary acts of sensation and to the manifestations both of instinct and intellect, this means that the last two forms are only different stages of the development of sensation (which is already decomposed and co-ordinated).

According to Spencer the difference between instinct and intellect is purely quantitative; in instinct the sphere of distinctions is much more limited, and this, naturally, severely restricts the aims of the actions. Moreover, instinctive actions are more monotonous in relation to the conditions by which they are caused; their interconnection is, therefore, more fatalistic, more automatic. Among other proofs of the equivalence of instinct and intellect Spencer reckons the impossibility of determining the exact demarcation line between the two. Thus, along with the inborn, automatic capacity to perform certain actions, animals often show a capacity for using the circumstances of the moment or the conditions of the locality, which can be explained only by their intelligence, by their faculty of reasoning, or more generally, by their capacity to think. On the other hand, man's habitual actions are usually so automatic that in this respect they hardly differ from the instinctive actions of animals.

This last circumstance, i.e., that actions acquired through learning assume an automatic character when they become habitual owing to frequent repetition, is regarded by Spencer as proof that the instincts of animals have not always been inborn, but have been acquired gradually, from generation to generation, by experience and by the accumulation of changes in the sensory organisation due to external influences. In this sense, he defines *instinct as the organised experience of a race**.

We could stop here. As soon as the development of sensation into instinct and into intellect proves to be similar both in type and in the nature of the factors which determine it, the development of the entire psychical life of man from the sensory acts which initiate his mental life becomes a logical necessity, as a particular case of general evolution. But the habit of seeing an unbridgeable gulf between the mental life of man and that of animals is so ingrained that our thought involuntarily stops before drawing a conclusion about the existence of a certain succession between them.

Fortunately, we have at our disposal another strong argument in favour of this conclusion.

Let us pass from the psychical development of the individual to a still higher level in the shape of the monuments and relics of the continuous activity of civilised races down the centuries; let us take, for example, the development of the positive sciences, in general, and of individual branches of knowledge, in particular. No one, of course, will deny that this stage is in all respects higher than the infinitely brief cycle of man's individual development.

Indeed, what do we see here?

The march of science, generally speaking, shows an almost unlimited growth from a relatively small number of primary roots, i.e., it shows an ever-increasing differentiation of forms which at each preceding stage were less divisible than at each subsequent stage. What, then, is this growth if not a differentiation of knowledge? It is accompanied by the accumulation

* By analogy with reason, it is also called *organised reason*.

and isolation of facts into more and more specialised groups (specialisation of knowledge), and into groups with a growing number of common properties. With this differentiation of knowledge, the points of contact between the hitherto disjointed facts increase in number. In this respect too the evolution of knowledge resembles the evolution of organs. But this similarity manifests itself with particular force in the factors which determine the development of knowledge. No one doubts nowadays that it is experience which lies at bedrock of all positive knowledge; and what is experience but the result of encounters with the surrounding world, the result of external influences. We know, further, that the manifestations of every experience, in life and in science, are all the more complete and definite the more frequent and diverse are the variations in the conditions of the experience. Consequently, the development of experimental knowledge depends entirely on the variety of the external influences.

Thus, in the intellectual evolution of the human race, the highest cycle of organic life, we again see the same general type and the same basic factors of development typical of the lower stages of life. It is clear, then, that the cycle of individual mental development of man, as an intermediate stage is not an exception.

Here, too, evolution must:

1) *begin with the development of a relatively small* number of primary undivided forms, which can only be sensory products;

2) *consist in an ever-increasing differentiation of these forms and their grouping in different ways;*

3) *be determined by the interaction of two variable factors —inborn organisation and external influences.*

Such is the essence of Herbert Spencer's hypothesis. His theory is of great significance not only because it is the first serious and systematic attempt to explain psychical life from the point of view of its content and progressive development, and on the basis of the general principles of organic evolution, but also because it actually terminates the secular controversy between the sensualists and idealists and reconciles the fundamental contradictions of the two schools. Actually, Spencer's hypothesis accords with the theory of the sensualists in the sense that it regards external influences as factors determining the psychical processes at all stages of psychical development. But, according to Spencer's theory, in every man these influences act not on a shapeless, organic basis, as claimed by the extreme sensualists; they act on a soil which, owing to heredity, has been cultivated from century to century by the widening life experience of the race and which, influenced by this experience, has acquired a more and more complex organisation, with a path of further development mapped out. This aspect of Spencer's hypothesis includes the basic viewpoint of the idealists concerning the inborn nature of the psychical organisation. But this is not all: by reconciling the two extreme views on man's spiritual life, Spencer's hypothesis, in my opinion, puts an end to the existence of different schools in psychology, the more so since this hypothesis has no need to spiritualise the principle of the inborn organisation, as is done by the idealists, or to materialise it to the utmost, as is done by the materialists. For this hypothesis it is not absolutely essential that the subjective side of sensation should be a direct product of the nervous organisation; it merely attaches importance to the incontestable fact that sensory acts, as subjective states, are accompanied by definite nervous processes, or—which is the same thing—by activities of a definitely-organised nervous mechanism. This is the chief thing which Spencer proves in his work; in doing so, he departs from the identity of the basic physiological conditions which determine the origin of subjective sensations and nervous activities in general, leaving the question of the form of the linkage between them to future investigation.

In the particular case which we are considering here, Spencer's hypothesis serves as a general programme of research into the development of the process of thought, because it provides the primary material, shows the general character of its evolution and determines the factors that participate in it.

My task, then, boils down, in essence, to reconciling the physiological data concerning the evolution of sensation into thought, as established by Helmholtz, with Spencer's general programme.

7. But before tackling this problem I consider it necessary to say a few words about the contradictions which undoubtedly exist between Spencer's views and the principles governing the development of visual concepts from sensations advanced by Helmholtz in his well-known *Handbuch der physiologischen Optik* (1867).

After completing the special part of his voluminous work on vision, i.e., after examining the entire physiological side of vision more comprehensively than anyone before or after him, Helmholtz analysed the theoretical views of his predecessors concerning the development of visual *concepts* from visual *sensations*; he divides these views into two main groups: those held by the *nativists* who endeavour to explain the history of this transformation by the inborn organisation of the visual apparatus, and those held by *empiricists* who ascribe this transformation mainly to *personal* and *individual experience*, i.e., to the exercise of the visual apparatus under the control of the movements of the eyes and body and with the assistance of other sense organs (predominantly touch). Helmholtz, adhering to the empirical point of view, explains the co-ordination of visual sensations by the psychological law of association of impressions (*Optik*, pp. 798 and 804). He does not wholly deny the role played by the sensory organisation in the development of sensations into concepts, but regards it as an auxiliary factor only, not as a determinant (p. 800).

Bearing in mind that this point of view is advocated by one of the greatest naturalists of our time and touches precisely on that sphere of knowledge where he has made a number of brilliant discoveries, any disagreement with it might seem too bold, all the more so since Helmholtz arrived at this conclusion after a thorough study of the vast domain of visual phenomena. He who would disagree would be a bold man indeed, especially if the foregoing conclusion about the role of the innate organisation were based *solely* on a detailed study of the *visual acts*, because Helmholtz has indeed no equal in this respect. The point is, however, that the soundness of this conclusion does not depend on a detailed study of phenomena directly; the determining factor is whether this knowledge makes it possible to distinguish *with certitude* the products of the inborn organisation from the products of personal experience in the visual concept of the adult (in the latter all visual acts without exception bear the character of concepts). Unfortunately, this certitude is lacking. This could be foreseen on the basis of Spencer's hypothesis and is best corroborated by the general criterion of distinction formulated by Helmholtz himself on page 438 of his *Optik*. At the top of the page he states:

"*Nothing in our sensory concepts can be regarded as a sensation* (i.e., as a product of inborn organisation) *if it can be suppressed or directly distorted by factors obviously resulting from experience*" (i.e., by the skill of the eye acquired through exercise); a few lines later he adds that, in its reverse form, this criterion is no longer true, i.e., *not everything which is not distorted by the factors of experience is necessarily a product of inborn organisation; it can be also the result of exercise.*

Consequently, in Helmholtz's own words, a detailed study of visual phenomena has not provided him with an absolute criterion for distinguishing the *innate* from the *acquired*, or at least, the *innate* from the *ingrained*.*

Indeed, how could it be otherwise? An inborn organisation which has never been exercised in encounters with the real world is but a possibility, true, a definite one by virtue of the definite character of the organisation; still, it is not a reality, it is, so to speak, a form without content. We see the same, for example, in the case of the neuro-muscular mechanism of walking. In very many animals this mechanism is ready at birth, whereas in man this, apparently, is not the case, because the child learns to walk little by little. But does this mean that in man the mechanism of walking is not present at birth? On the one hand, it is common knowledge that teaching a child to walk is not the same as teaching an adult to perform complex movements (for example, to play a musical instrument), because the teaching of the child consists merely in supporting his body while he himself moves his legs. On the other hand, it has been convincingly proved that the regularity, and even the possibility of walking is closely associated with the sensations

* I use the term "ingrained" because in addition to the general criterion cited above, Helmholtz in speaking of *non-distorted* factors of *experience* has in mind habitual, ingrained forms of vision.

obtained by the body when the feet contact the ground in the course of walking. Consequently, the child must first become accustomed to this complex of sensations *which derive only from experience* (by walking on solid ground) and only then does he acquire the capacity to walk. *Thus, the inborn organisation of the mechanism of walking is at first a definite possibility which becomes a reality under the influence of personal experience or exercise.*

My view is that if Spencer's theory of neuro-psychical evolution had existed in its present complete form at the time when Helmholtz rightly argued against the ideas of the nativists[56] who ascribed to the visual apparatus taken by itself (i.e., separated from general locomotion and from other senses) an almost fully developed inborn capacity of spatial vision, he would have admitted that the inborn organisation, in the broad Spencerian sense of the term, plays not only an *auxiliary* but also a *determining* role in transforming sensations into concepts. I am led to this conclusion, above all, by the fact that Helmholtz, though resolutely denying any rational elements in the personal experience of the child, i.e., reducing this experience (as a series of processes) from the level of conscious and rational activity to that of automatic acts, did not regard his own theory as the last word in the matter; he simply considered it preferable to the opposite views held by the nativists who obviously went to extremes.

Thus, the contradiction between the views of the two thinkers is not of an essential character; actually it becomes reconciled if we assume that the psychical processes on which Helmholtz bases his theory are manifestations of the inborn organisation referred to by Spencer, i.e., if we extend the notion of inborn organisation far beyond that of the sensory organisation of the *nativists*. Helmholtz admits the possibility of this assumption; here is what he says on page 804: "*Will man diese Vorgänge der Assoziation und des natürlichen Flusses der Vorstellungen nicht zu den Seelenthätigkeit rechnen, sondern sie der Nervensubstanz zuschreiben, so will ich um den Namen nicht streiten.*"*

* "*Should someone prefer to consider these processes of association and natural development of concepts not as mental activity, but as manifestations of the nervous substance, I would not argue about the terms*"

The contradiction between the views of Helmholtz and Spencer is eliminated by this assumption for the simple reason that *experience*, as understood by Helmholtz, is simply the result of the interaction of external influences and the inborn organisation; hence, the general principles of mental development accepted by Helmholtz and Spencer are identical.

It should be remembered, however, that in using the term *inborn neuro-psychical organisation* I always imply not only all that we know about the sense organs and their inter-central links both with each other and with the locomotor apparatus, but also all the known facts relating to the parallelism between psychical manifestations and nervous activity. Accordingly, the term *developing neuro-psychical organisation* will be used to designate the sum of the parallel modifications produced in the mind and in the nervous system as a result of encounters with the surrounding world.

## II

### Our way of studying the process of thinking.—Conclusion

1. We have now at our disposal all the data needed for a general description of the way we intend to follow in studying the process of thinking.

This essay deals in the main with the particular case of development of thought in the individual, whose sensory capacity already at birth is formed into definite systems and organs producing so-called sensations under the influence from without. These sensations are, in our view, the starting-point of development of thought, and we get them, so to say, ready-made.

If Spencer's hypothesis concerning the duality of the factors of evolution is correct, then in the life of man, throughout his mental evolution, nothing is involved but the influences exerted by the external world on his neuro-psychical organisation; the reactions (and consequently, the structure) of this organisation gradually change, and, as a result, thought develops with its diversity of objects, its transition from the concrete to the abstract, from the general to the particular, from the domain of sensory facts to that of extra-sensory contemplations, etc. In short, it is one of the basic factors of the development of thought or the interaction of these factors which make possible the transformation of sensation into thought—both in form and content.

Further, if it is true that these transformations proceed according to the general laws of organic evolution, then the transformation must be reduced to a decomposition of uniform sensations and their re-combining—wholly or partly—into groups. In other words, either the neuro-psychical organisation, or the conditions of the external influences, or, finally, the co-operation of both factors should provide the data needed for analysing and synthesising whole or fragmentary sensations.

Previously we defined thought as a confrontation of two (at least) or more objects from a certain point of view. Consequently, the following general elements can be distinguished in thought: 1) the separateness of the objects, 2) their confrontation, and 3) the manner of the confrontations. Besides, it has been pointed out that the objects of thought are highly diverse, whereas the ways in which their confrontation takes place, being much more limited, can be reduced to a still smaller number of general categories.

It is clear, then, that our first task is to elucidate the general elements of thought (i.e., the elements of its general formula) from the point of view of the properties of the factors of whose interaction it results. In other words, we must first of all decide what properties of the neuro-psychical organisation or what aspects of the influences of the external world account for the phenomena termed "separatedness of the objects", "their confrontation" and "the manner of the confrontations". If we obtain a clue to the structure of thought in general, we shall have no difficulty in determining—on the basis of the properties of the neuro-psychical organisation and of the external influences —the general character of the mental processes owing to which thought is called rational, abstract, extra-sensory, etc.

Then we must show in the same fundamental principles underlying the transformation of sensation into thought the factors determining the multiplication of the objects of thought; it will be appreciated in advance that these factors must be the same as those which determine (in the conditions of the neuro-psychical organisation, or in the properties of the external influences, or in both together) the possibility of analysing and synthesising impressions. This will be easily appreciated because the entire diversity of thought actually consists in the evolution of its objects from primary integral forms to differentiated ones, by way of decomposition and subsequent recombination.

2. What, then, are the properties of the organisation and of the external influences by which the general elements of thought are determined? To answer this question let us first of all see in what way the impressions are modified by repeated external influences.

Imagine for a moment that the inborn neuro-psychical organisation of the child which produces chains of sensations remains unchanged under the action of external factors. This means that the child's eye would react to one and the same repeated stimulation for the second, tenth, hundredth and millionth time in exactly the same way as it did the first time. The same thing would occur with the ear and the other sense organs—no development or progress of sensation would be possible. On the other hand, everyone knows that the repetition of impressions, or of complex nervous acts in general, is of no little importance in man's mental life. The more frequent the impression, the clearer and the more stable the trace it leaves in our mind. The term "*stability*" denotes here the capacity of the trace to remain in the mind for a long time, while "*clarity*" means the capacity of the sensory image to become more definite as a result of repetition. This, as we know, is what takes place when man learns to perform certain movements: the more the movements are repeated, the better they are remembered.

It is clear that the inborn neuro-psychical organisation of the child possesses the faculty of being able to change under the influence of external factors. The latter leave their traces, in the same way as impressions leave traces in the mind, and the more frequent the action of the external factors, the more stable and definite the trace.

It is not difficult to express this in terms of the nervous organisation if we assume, as physiologists do, that along with sensation a process of nervous excitation takes place in the nervous system which irradiates along definite inborn pathways. But despite the seeming uniformity of the repeated impressions there is always a certain difference between them and, accordingly, the pathways along which the excitation irradiates are bound to differ. But since even a seeming uniformity presupposes a considerable preponderance of similarities over dissimilarities, it is easy to see that frequent repetition of so-called uniform influences is bound to lead to the isolation of the system of pathways which corresponds to the constant elements of the impression. Because of this, everything inconstant and casual gradually disappears from the impression. The same thing is observed when man learns to perform certain movements: little by little all the unnecessary, auxiliary movements responsible for the original clumsiness and awkwardness disappear.

But there is more to it than this. As a consequence of the repetition, the impression is *reproduced* ever more *easily*, as if the corresponding nervous mechanism reacts with greater *mobility and sensitivity to the stimuli. It actually becomes more* mobile and sensitive. Every nervous apparatus of the animal body can be regarded as a mechanism constantly charged with energy and always ready to discharge or to go into action under the influence of a stimulus applied to one or another part of it (in the sensory apparatus there are two possible points of the application of a stimulus producing the discharge—the periphery and the centre). The greater the charge of the nervous apparatus the easier it moves into action, and vice versa. As to the conditions of the charging, they, as far as we know, directly depend on the nutritive processes of the nervous system; and these processes in turn are dependent on the degree to which the nervous apparatus is exercised. Consequently, the greater the activity of the nervous apparatus, the more lively its nutritive processes and the greater its charge. The increased excitability of the nervous mechanisms, evoked by their exercise, is simultaneously the cause of the "physiological isolation" of the pathways of excitation. From a roughly anatomical point of view, the organisation of the acting mechanism may remain invariable; physiologically, however, it becomes isolated.

But not even this exhausts all the modifications which the impression undergoes as a result of repetition. Everyday experience clearly shows that habitual impressions are characterised not only by the ease with which they are reproduced in our consciousness, but also by the fact that their reproduction does not necessitate a corresponding complex of external influences; a mere hint or a certain casual impression is sometimes sufficient to evoke it. For example, if I am accustomed to see a certain person in various surroundings, I may remember him when I find myself in any of these surroundings. But if the impression is strongly habitual, i.e., if it has been repeated under highly diverse external conditions, it may be reproduced by a tremendous number of insignificant hints, many of which are not even noticed. On the basis of these phenomena it appears that in the organised trace corresponding to the impression the number of points of application of excitatory stimuli was steadily growing with the repetition of the impression.

It goes without saying that this increase in the number of points of excitation of a nervous act corresponding to a given impression is bound to be accompanied by the formation in the organic trace of an ever-increasing number of auxiliary groups alongside the main group. This, I think, is self-evident.

It follows, then, that *repetition of impressions of uniform appearance, or, to be more precise, closely similar, are bound to be accompanied, in respect of the neuro-psychical organisation, by an isolation of the pathways of excitation into groups of varying excitability and, in respect of the impression, by a transition from an indistinct and integral form into a more definite and differentiated one; at the same time the so-called basic nucleus of the impression and its satellites become manifest, and the external conditions giving rise to the reproduction of the impression in our consciousness are bound to increase in number.*

For the sake of simplicity, I have deduced this for a particular case of very similar isolated impressions repeated under various external conditions; now we shall consider cases of decomposition of complex impressions.

Even in its first encounters with the external world the child is influenced not by single, isolated external factors, but by groups, chains or complexes of factors which are part of the surroundings. If these complexes of factors and the conditions of their perception by the organism remained invariable, then, by virtue of the laws of association, they would be imprinted on the memory as an integral complex impression. But if in the course of repeated encounters the complex of factors is modified to the degree that some of its members disappear, the invariable members of the former complex group become isolated, and the more stable the members the more pronounced, of course, is the isolation. In short, in the case of a complex impression evoked by a group of external objects the process is the same as in the case mentioned above of an impression produced by a single object accompanied by secondary accessories. It will be appreciated, however, that if the decomposition of complex groups proceeded in this way only, much time would be needed before the final effect of the decomposition of the group into separate links manifested itself—the disappearance of one or another member of the group would be of a purely accidental nature. In reality, this is a very rapid process: the groups are decomposed every minute and in the most diverse ways, owing to the following property of the neuro-psychical organisation.

3. From observations carried out on children we know that even at a very early age external sensory influences call forth motor reactions of the body. These reactions, at first disorderly, gradually assume an organised character. This is manifested first of all in the vision of the child, in its ability so to converge the axes of the eyeballs as to permit the eyes to follow moving objects. Then comes the ability to sit, to move the arms and legs; still later appears the inclination to reach for bright objects, to grasp them, to put them in the mouth, etc. At a later age the power of objects and of sounds to attract and repel continues to exert its influence making the child move from one object to another. In short, during the first years of the child's life a tremendous number of its sensory impressions are characterised by a certain impetuosity or impulsiveness, as if its nervous mechanisms were more heavily charged than those of the adult, and as if the accumulated energy overflowed with greater ease the sensory sphere and dis-

charged into the motor sphere. I shall not describe here how these movements, at first disorderly and almost undifferentiated, become co-ordinated into more and more organised and regular groups; I shall merely point out that the course of their development is the same as in the case of the integral form of sensation. I shall, however, dwell here on the beneficial influence exerted by the movements on the development of impressions.

This influence is threefold. Ensuring the displacement of the sensory mechanisms in space, movements greatly diversify the conditions of perception and by doing so contribute to the decomposition of sensation; they divide a continuous sensation into a number of separate acts which have their own beginning and end; lastly, they serve as an indirect link between qualitatively different sensations (for example, optic and acoustic, optic and tactile, etc.).

There is no need to dwell here on the first of these influences, the thing is clear; but to understand the second it is necessary to bear in mind that the child is always surrounded by an environment in which the most varied simultaneous or successive movements take place continuously in the form of impacts or impulses and periodic shocks. But even in this chaos of light, heat, sounds, smells and tactile sensations there must be a current of stronger sensations corresponding to the more powerful impulses and fluctuations taking place in the external environment, it is this current, apparently, which helps the child to emerge from the chaos of sensations. But the current alone cannot perform this task, as it is indistinct and its intervals are irregular and casual. Things would be different if the organism possessed the means of reinforcing this current at the expense of contiguous sensations, and if these means were brought into action by the same factors which engender the current of stronger sensations. Then the current would, apparently, become more vivid and definite. These means exist in the neuro-psychical organisation, and we can describe them as *adaptive motor reactions of the body with the aim of intensifying the sensations* They include such phenomena as movements of the head, the eyes and the body as a whole in the direction of bright light, loud sound, or strong odour, and in general, all the movements by means of which the sensory mechanisms are placed in a position best suited for perception. I shall not dwell here on the types of the adaptive mechanisms or on the forms of their activity when the sensory mechanism is placed in a position suitable for perception and when sensation reaches maximum; the important thing is to know that the intervention of the motor reactions, in addition to intensifying the current of stronger sensations, transforms it into an intermittent variable chain in keeping with the movements of the head, body and with the change in the position of the sensory mechanisms in general.[57] It will be appreciated, for example, that if the eyes are fixed at a given moment on a definite group of objects, the fixation will last only until there emerges from another direction a sensory impulse strong enough to evoke an adaptive reaction in this new direction. The moment this reaction appears, the head changes its position in space; as a result, the eyes are focused on another group of objects and the previous intense sensation is replaced by a new one, the one that evoked the adaptive reaction. It goes without saying that in these conditions only those sensations, which are strongest at the moment the head is moved, can become the successive links in the chain; and since two equally strong and variously directed impulses rarely coincide in time, the change of sensation is almost invariably determined by one impression only. Because of this, each link in the chain acquires uniformity: a purely optic sensation is replaced by a purely acoustic or a purely tactile one, etc.

This, then, is the decomposition of groups into separate links, caused by the motor reactions which take place in the intervals between the links.

This picture of the child's mind based on the physiological properties of its sensory mechanisms is fully applicable to the adult mind as well; the only difference is that in the latter the strong current consists not of sensations, as in the child, but of various forms of decomposed perception—of ideas and concepts which, in the final analysis, develop from the same sensations.

Basing ourselves on this analogy, we can, I think, reject the theory of the so-called "unity of consciousness" with its anatomical and physiological substratum, the *"sensorium commune"*, the theory with which the psychologists have until recently tried to explain the succession of psychical acts in our consciousness. As we know, there is no absolute unity of consciousness; and as to its relative unity, which can be observed, the foregoing interpretation is sufficient, especially since it explains this relativity, while the former interpretation excludes it.* Moreover, from the point of view of our explanation we have no difficulty in seeing how the child emerges from the primary chaos of sensations, whereas by means of the theory of the unity of consciousness it is difficult, or even impossible, to explain this emergence.

At any rate, *the differentiation of the separate links in complex impressions too proves to be dependent on the variability of the subjective and objective conditions of perception, i.e., on the neuro-psychical organisation and external influences.*

4. Let us pass now to the capacity of the motor reactions to serve as a connecting link between contiguous impressions.

Imagine that I am sitting at my desk and the sand-box is placed far to my right so that I cannot see it without turning my eyes or head in its direction. If in the process of writing I need some sand I, naturally, recall the sand-box; without looking in its direction, I stretch out my arm and reach it. What does this mean? It means that my memory retains not only the image of the sand-box as an object, but also its position in relation to my body; and this last trace clearly took shape solely as a result of moving my eyes or head and arms in the direction of the sand-box. If, when remembering the sand-box, I had actually turned my eyes in its direction, this would have been a mere repetition of numerous past cases of actual vision. But this movement is unnecessary, because the position of an object can be reproduced in the memory not only in the form of the movement by which it has been determined. It is suf-

* The hypothesis of the "unity of consciousness" maintains that psychical acts are generated in a channel of indefinite width and before acquiring a conscious character enter a narrow channel through which they pass one at a time, it is precisely here that the psychical acts become conscious (passing, as some physiologists say, before the mind's eye like a series of pictures projected by a magic lantern).

ficient that the memory should retain, along with the movement, a corresponding sensory sign which can be reproduced in the consciousness simultaneously with the image of the sand-box. And it is these sensory signs concurrent with the movements, which in the aggregate constitute the so-called *muscular sense*. As we know, the latter originates from the complex of vague sensations accompanying every movement of the eyes, head, trunk, arms and legs, and its development proceeds simultaneously with the co-ordination of the movements into definite sensory groups.

Now apply the process of forming these sensory groups to our case of adaptive reactions, mentally connect them with the central parts of the sensory mechanisms and the result will be a general idea of the muscular sense as a connecting link between two contiguous impressions. As regards time, it is really located at the turning-points of the sensation, i.e., in the intervals between the two contiguous impressions; but being relatively vague, it can neither acquire a definite subjective character nor can it produce appreciable intervals in the current of stronger sensations. Still, it exists, and its presence is manifested in the following way.

The "capacity to objectivise impressions" is regarded as one of the inborn properties of certain sensory mechanisms. When the light from an object falls on our eyes, it is not the change produced by it in the retina that we feel, as might be expected, but the external cause of the sensation, namely, the object which is before us (i.e., outside us). Pain, on the contrary, is a purely subjective sensation. This externalisation of impressions in the direction of their sources is known as objectivisation of impressions. It is very difficult to establish the initial form of this aspect of sensation; but there is no doubt that its evolution takes place parallel with the differentiation and co-ordination of the muscular sense. This is because, first, objectivisation is inherent only in those sensory mechanisms which perceive impressions from a distance; serving as instruments of orientation in space and time, these mechanisms are characterised by their mobility and are provided with adaptive motor devices. Second, all the details of objectivisation are directly related to the degree of differentiation of the adaptive motor reactions. Thus, of all the human sense organs the eye possesses the most perfect motor system; at the same time it, more so than any other sense organ, is capable of a detailed localisation of sensations in space and time.

Just how these processes take place will be shown in detail below; for the present enough has been said to understand the essence of the following conclusion:

*The muscular sense which is located at the turning-points of sensation, i.e., in the intervals between sensations of a different kind, not only serves the latter as a connecting link, but also determines, in the course of objectivising sensations, the interrelations of their external substrata in space and time.*

This brings me to the end of my enumeration of the properties of the inborn neuro-psychical organisation. To proceed further in this theoretical direction, i.e., gradually to complicate the conditions of perception and to analyse the corresponding results, would be tiresome, confusing and, consequently, useless. It is much more convenient to omit for the time being many theoretical details of the child's primary mental development and, by giving a general picture, establish which of its aspects are determined by one or another of the abovementioned properties of the developing neuro-psychical organisation and whether the type and the factors of the development meet the requirements of Spencer's hypothesis. With this aim in view, I shall dwell now on the evolution of memory which is generally understood as the capacity to fix and reproduce impressions in the mind.

### III

#### Experimental data on memorising (registering) and recollecting (reproducing) impressions

1. Memory is rightly regarded as the corner-stone of psychical development; everybody knows that the basic condition for its manifestation is the repetition of impressions. And yet one can hardly find another phenomenon in the psychical processes of which the idea is as vague and confused as that of memory.

Most harmful in this respect is our tendency (though natural and, within limits, useful) to separate memory from the thing memorised and to consider it as an isolated capacity.

This can be easily demonstrated by the following simple argument.

If memory is really something separate from the thing memorised, and if it is the corner-stone of mental development, it follows that it must be particularly pronounced in the child during the first four years of life, because in this brief space of time the child learns many things, begins to think, often soundly, makes abstractions and generalisations; in a word, it has almost completed the school of thinking (of course, object thinking). But why does the mental life of early childhood disappear irretrievably from the memory of the adult? One of two things: either the child's memory differs from that of the adult, or it disappears together with the psychical products which fill the consciousness of the child. Everyone, I think, will agree that the second supposition is more probable.

Memory is inseparable from what is memorised. The latter, however, like any other psychical product, undergoes diverse transformations in the course of life, has its definite history of development, and, because of the transformations, can be modified beyond recognition. If man could remember his early childhood and all the phases of the transformation of the primary psychical products, there would be no cause for arguing about the principles governing his mental development, psychology, in this respect at least, would have based itself on a solid foundation from earliest times.

From this it follows that the evolution of memory actually means evolution of what is memorised and recollected. And if we substitute the modifications of the nervous organisation for the thing memorised, and the process of nervous excitation, as determined by external influences, for the thing recollected, we shall be able to bring all of this vast sphere of phenomena under Spencer's general formula.

Memorising or registering impressions can be best analysed by answering the question: Why does the mental life of early childhood vanish from the memory of the adult without leaving a trace?

When the child learns a fable by heart, it at first retains the fable in the memory with considerable omissions, distorted words and even distorted ideas. But gradually everything comes right, and the child memorises the fable perfectly. Ask this child to recite the fable from memory, and you will see that the correct form of the fable flows easily and smoothly; it may even be remembered for life, while the first, imperfect version with all its omissions and distortions is forgotten for ever.

Is it possible that the mental life of the child in the first years of life is related to the mental life of the adult in the matter of memorising things, just as the incomplete and distorted version of the fable is related to its correct version?

The answer is yes and no. Yes—because the mental sphere of the child is really an agglomeration of disconnected ideas, a multitude of blanks and even distortions, while the mental store of the adult is systematised and is often divided into very large groups by means of a relatively small number of principal or leading ideas (for example, scientific knowledge). No —because some of the mental manifestations of the child which are subsequently forgotten by the adult are as habitual and have the same regularity as those of the adult. As mentioned above, at the age of four the child knows much about the objective world and about the relationship between objects; it is able to reason quite soundly in its own narrow sphere, and, as we know, it sometimes manifests very strict logic in its conclusions. Yet all this is subsequently forgotten.

Is the difference between adult and child in memorising impressions and thoughts due to the different mental organisation of their memory, or to the different ways in which impressions and thoughts are evoked in their minds?

Let us imagine for a moment that the mental store of the adult is distributed in his memory approximately in the same way as books in a well-organised library, and that this arrangement gradually improves with age. Then it would be obvious that it is much more difficult to obtain something from the mental store of the child than from that of the adult, just as it is more difficult to find the needed book in a badly-arranged library than in a well-organised one. This analogy is so tempting that, involuntarily, the mind is attracted by it.[53]

Even very simple observations convincingly show that knowledge is really distributed in the mental store of the adult not at random, but in a definite order, like books in a library. The educated person rarely encounters an unknown word in the vocabulary of his native language; consequently, he knows tens of thousands of words. Yet if I were to ask my readers to reel off twenty nouns in succession, many of them, if not all, would fail to do so without my help. But given this assistance anyone would be able to cope with the task. If, for example, I added that all the twenty nouns should designate parts of a house, enumerated from top to bottom, the words chimney, roof, eaves, wall, window, etc., would come to mind at once. The same would occur if I were to designate the category of the nouns as victuals, toilet articles, etc.

Subsequently, many objects are registered and classified in the memory as parts of a whole (this is a very broad category and includes all cases of objects with their particular attributes). But this is by no means the only way of registration. With the help of very simple observations, similar to those mentioned previously, it can be demonstrated that in addition to the category of appurtenance, there is the category of similarity. If I were to ask the reader to name a few round objects, his answer would probably be: the globe, a billiard ball, an orange, a balloon, etc. Similarly, everyone would immediately include in the category of green objects a forest, a meadow, vegetables, and so on; the expert in dyes would without hesitation add a number of technical terms.

I shall not enumerate all the categories in which man's thoughts and experiences are registered in his memory; we shall revert to this later when we possess the means by which it is possible to establish all the conceivable directions of this registration. For the time being I shall merely point out that these directions are determined for each object by all its possible relationships to other objects, including its relationship to man himself. For example, wood can be registered in memory as a part of a large tract of forest or of a landscape (part of the whole); as an object related to shrubs or grass (category of similarity); as combustive or building material (here the word "wood" is obviously no longer associated with the same notions as in the preceding cases, but appears as a generic term, implying firewood, logs, beams, boards, i.e., various artificially-formed parts of a tree); as something endowed with life (as distinct from stone); as a symbol of insensibility, etc. In other words, the more varied the relationships of the given object to other objects, or the greater the number of its points of contact with other objects, the greater the number of the directions in which it is registered in the memory, and vice versa. We have here exactly the same principle as that governing the arrangement of a well-organised library. There, too, the books are registered not in one, but in several catalogues based on different principles (for example, according to the alphabetical list of authors, according to the branches of knowledge, chronological order, etc.); the greater the number of the categories in which the books are registered, the better the organisation of the library, and *the easier it is to find the book required.*

It is clear that in the mental store of the child's memory there is no such order. The child's personal experience is too short for it to apprehend the numerous points of contact which exist between different objects and which determine their registration in the adult memory. Even in the memory of the adult there would be tremendous blanks if his personal experience were not supplemented by learning since childhood, i.e., by transmitting to each individual the results of the entire experience of the race which are preserved in one way or another.

From this point of view, it is clear that the relatively disconnected and unsystematic impressions of the child have much less chance of being memorised than the properly systematised products of the experience of the adult.

However, it is obvious that the mental store of the child, too, must be organised to a degree and the principles of classification must be the same as in the case of the adult, since these are likewise determined by the interrelations and interdependences of the objects perceived, and not by variable contingencies. This is proved by the fact that the child of three to four already knows the properties of many objects, can classify many of them correctly and even interpret everyday phenomena in the way which the adult designates as knowledge of causal relationships. In other words, at the age of three or four the child is able to analyse objects, to compare them and to draw conclusions concerning their interrelations. It should be added that in most cases practically the entire external environment of early childhood remains unchanged till the child reaches the age when it begins to remember the past clearly; nevertheless, the adult completely forgets not only those impressions of which the substrata disappeared in early childhood (for example, memory of the village where the child had lived till the age of four, before it was brought to town, or the memory of a relative who died when the child was four years old), but also those impressions of which the substrata have not changed in subsequent years. What is the reason for this? It might seem that if the given impression has been correctly registered in the child's memory and the register remains the same, apart from being extended in subsequent life, there should be no cause for the disappearance of the impression. It is also difficult to understand why a child whose mother died, say, when it was two years old and who had seen her every day for the first two years of life, subsequently forgets her image completely, while the adult retains in his memory for years the features of a stranger in whose company he spent only one hour. Is not this also explained by the imperfect memory of the child?

The actual cause lies in the following property of the process of memorising closely related impression.

Were we to memorise every impression separately, then all the common objects, such as human faces, chairs, trees, houses, etc., which constitute our usual surroundings, would leave such an immense number of traces in our mind that it would be impossible to think of them, at least in verbal form. Would it be possible, for example, to find the tens or hundreds of thousands of different words needed to designate all the birches, faces and chairs seen, and how could we cope with such a mass of material? Fortunately, this does not occur in reality. All the repeated, closely related impressions are registered in memory not as separate units, but as complexes, though they retain some of their particular traits. Hence, tens of thousands of similar formations are combined in the man's memory, and this makes it possible to express in terms of hundreds the sum of all the things really seen. heard and experienced, which are expressed in the terms of millions.*

Consequently, all the separate impressions produced by the most usual objects and phenomena of our everyday surroundings merge, so to say, into average standards and they do so all the more, the greater the resemblance of the fusing formation, i.e., the more homogeneous they are in nature (for example, the fusion of linden and oak into tree), or *the more superficial and less differentiated their perception.* Clearly the impressions of early childhood are bound to be of a comparatively less differentiated character, and their chances of being completely merged are, therefore, quite considerable. There are, however, rare cases when certain events or impressions are accompanied by circumstances which strongly affect the child's consciousness; when this happens, the memory of the events and impressions is retained for life because of these special appendices to the average images. The memory of the adult must be rich in these appendices, owing to the greater differentiation of similar impressions; the recollections of the adult are, therefore, much more detailed than those of the child. We Europeans, for example, are not accustomed to the faces of Negroes and Chinese; that is why people of these nationalities seem to us very much alike; but in Europeans we immediately discern not only the general type, but also certain details or particular features of each face, i.e., we note its deviations from the general type. It is natural, therefore, that in

* Now that the physiologists have learned to measure the rate of elementary psychical processes, it is possible to prove with the help of figures that this calculation is not exaggerated. If we admit, on the basis of the experiments carried out by the famous physiologist Donders,[39] that the process of recognising an everyday object (tree, chair, etc.) lasts 1/15 sec. (according to Donders, it is even less) and if we assume that the child spends 10 hours a day on the perception of usual objects, then more than half a million perceptions can take place in the space of the 10 hours. If we further suppose that the number of the different objects recognised is 100, each of these objects would be perceived by the child more than 5,000 times. If, lastly, we assume that the perceptions are separated from each other by intervals of 1 sec., then 5,000 repetitions of one and the same impression would require 15 days, and a million repetitions would take one hundred months, i.e., less than 10 years.

these circumstances, all kinds of distinctive features, even *when the encounter with a person is brief, should be better* fixed in the adult memory than the detailed image of the mother in the child's memory, because this image merges almost completely in the subsequent average images.

Thus, the disappearance of the impressions of early childhood from the memory of the adult is explained by the imperfect mental organisation of the child; though based on the same principles as that of the adult, it contains in the early periods of life many blanks, its elements being comparatively slightly differentiated.

Were this to be illustrated by an example from everyday life I would compare the mental past of early childhood with a series of pictures in which there are colours, images and even some thoroughly elaborated details (mostly casual ones, having nothing to do with the idea of the given picture), but which are deprived of general and particular subjects imparting a single idea to the picture as a whole and a definite meaning to each of its parts. This absence of unifying ideas is due not so much to defects or irregularities in the arrangement of the figures and images (their grouping may even be quite correct), as to the imperfect (undifferentiated) character of the images and, consequently, to the absence of a definite content and of distinctive features in them.

2. Now, as mentioned at the end of the previous chapter,* I shall try to establish a connection between the memorising of impressions and the general properties of the developing inborn neuro-psychical organisation of man.

The following consideration will show that my method of investigating the evolution of the content of memory instead of reasoning in a purely theoretical way is quite justified.

The gradually accumulated content of memory constitutes man's entire mental store, all his intellectual wealth. Preserved *in a rather strange latent form, it is the mental store from* which man draws the elements needed by him at every given moment. Absolutely all the thoughts which pass through the man's mind during his lifetime are composed of elements reg-

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* See conclusion on page 300

istered in the memory. This is true even of the so-called new ideas underlying scientific discoveries.*

Hence, the study of the content of memory signifies studying the development of the entire mental content of man.

On the other hand, everybody knows that memorisation of impressions and their repetition are as closely linked as effect and cause, in general. It is likewise generally known that the more frequently an object is seen, and the greater the chances of observing it from different aspects, the more complete and differentiated becomes its image—the concept of it.

Consequently, if we approach the mental content of man from the point of view of the content of his memory, it will become clear that *its development derives from the repetition of impressions under the greatest possible diversity of the conditions of perception, both subjective and objective.*

Therefore, I believe the reader will grant that at least during *the first years of the child's life mental development takes* place because of the repetition of varying external influences on the equally varying neuro-psychical organisation; in other words, he will admit that these phenomena conform to Spencer's hypothesis.

In the sphere of sensation the result of this development is evident: more and more definite elements begin to emerge from the chaos of images, sounds and movements surrounding the child, due to a certain changeability of its links. The more constant elements of the picture are fixed best in the memory, the more variable ones are not fixed at all. Thus, the picture, as a group, decomposed into its real, and not casual, components, is registered in the memory in this shape. Subsequently, the same process takes place in each component of the original complex group; this leads to a similar isolation of increasingly stable elements from the components, and the general result is again a decomposition of the complex into parts.

Motor reactions manifesting themselves at the turning-points of sensation take a very active part in the decomposition of the sensory groups at all stages of their development.

* There is, however, one exception—the case when man sees an object for the first time without having heard of it previously, but *in this case* the act is not a thought, it is equivalent to a sensation.

Being accompanied by sensations, they do not violate the sensory integrity of the group and at the same time impart a more distinct character to its elements, because the muscular sense differs qualitatively from the sensations between which it is located. In its undifferentiated form muscular sense connects the elements of the group, thus ensuring its unity and integrity, while in its developed form it imparts to these connections the *significance of relations in space and time. It is clear that in* each sensory group the muscular links are memorised in the same way as the visual, aural and other links; consequently, the development of each group in memory is accompanied by the development of spatial and other relations between its links. This, precisely, is the classification of objects as parts of a whole.

Besides the memorising of impressions in the shape of constant groups, there is bound to be also a process of memorising by similarity. Indeed, among the impressions surrounding the child absolute constancy is encountered only as an exception; *where the constancy is not absolute, it is equivalent to similarity.* Hence, the repetition of even so-called uniform impressions corresponds in reality to the repetition of similar impressions. In this sense the isolation of a common nucleus and its accessory satellites from repeated integral impressions constitutes registration by similarity.

3. In terms of the neuro-psychical organisation this can be expressed in the following way.

In its inborn intact form the organisation undoubtedly contains a definite system of pathways of excitation with a preformed subdivision into sections, and with connecting links; thus, the entire route leading from any sensory point of the body to its brain ending, and all the ramifications of this route, already exist at birth. But in this general system of pathways *there cannot be a preformed decomposition into groups based* on grouping of external influences, since the latter vary considerably from one individual to another. As long as the excitation does not affect the mechanism, all its parts experience equal conditions of feeding and are equally supplied with energy; but the moment the excitation spreads over a certain section of the nervous system, the equality is violated for a lengthy period—the active pathways remain more excitable than the others, and the difference is the more pronounced, the more the excitation is repeated in the same form. As mentioned above, this results in the physiological isolation of the pathways into groups of varying excitability; here I shall only add that constant groups of pathways must necessarily correspond to constant groups of external influences and that the changes in both are bound to be parallel. This parallelism which can be strictly proved for the eye and the ear, is determined by the structure of the surfaces which perceive optical and acoustic oscillations.

In other words, definite groups of influences leave definite groups of traces in the organisation, and there exists between them the conformity that exists between the external influences and the acts of sensation, because the latter are inconceivable without a corresponding or parallel excitation of certain pathways.

From this it follows that the memorising of impressions is accompanied by definite traces of excitation in the nervous organisation; the number of these traces and the variety of their combinations increase with the repetition of the external influences in the shape of varying complexes.

In its intact state, the inborn organisation admits of an infinitely varied grouping of the pathways of excitation; but this possibility turns into reality only under the influence of actual excitations. Acting in groups, they isolate from the entire network of pathways groups of equal excitability, and this is followed by the decomposition or grouping of the organisation.

4. I shall cite only a few examples to illustrate the reproduction of impressions or the relationship between real and reproduced sensations, because this is one of the best elaborated questions in physiological psychology, at least from the aspect that interests us.

Do the real and the reproduced sensations correspond in content?

Here we must first of all consider the possibility of their identity. This is proved by our ability to learn poems and melodies by heart and to imitate the sounds of the surrounding nature. The same is true of the reproduction of sensations, which, complicated by an element of emotion, are accomplished by the same motor reactions both when they take place in reality and when reproduced in memory. It is a well-known fact, for example, that the face of an honest man blushes with shame, even when he is alone, at the thought of an improper action committed in the past. Cases of nausea at the thought of something repulsive, or of salivation in a hungry person at the thought of a dainty dish, are in the same category; in this category, too, is the case, described by me in *Reflexes of the Brain*, of the emergence of "goose-flesh" at the thought of cold. These last examples are particularly important because they show the identity of the real and the reproduced sensations *as processes*—the identity of the sensation produced by the sight of the dainty dish and of that produced by its reproduction in the memory, the sensation of actual cold and that of imagined cold, etc.; both forms of sensation produce identical motor reactions.

But although these examples actually prove the possibility of an identity of real and reproduced sensations, it should not be forgotten that, from the point of view of the conditions of their origin, the examples are exceptional. Some of them presuppose a frequent repetition of an impression in one and the same form, while others are cases of reproduction of elementary sensations with their motor consequences. This is almost the same as asking whether the actual sight of a pin resembles the reproduction of its image in our memory. The question which interests us is of a more comprehensive character and embraces all the conditions determining the origin of actions.

Fortunately, practice gives a definite answer to this broad question.

A photographic likeness between actual sensation and its subsequent reproduction in the memory is very rare, and the more novel (to the given individual) the links which form the impression or the manner of their combination into groups and chains, the lesser the likeness. That which is really novel in the given impression (for example, an abstract thought heard by an uneducated person, or the picture of a complex machine seen by a person not conversant with technology) is not reproduced at all; that which is insufficiently known is reproduced indistinctly, in a fragmentary way; and only that which is frequently repeated and which does not depend on changes in the conditions of perception is reproduced photographically.

When two persons of different age and of different character or education have witnessed the same event and subsequently describe it from memory, their accounts never fully coincide. Apart from the purely factual side of the story, usually presented in a more or less identical manner, the accounts differ considerably in their general tone, in nuance, and even in the interpretation of the substance of the event. That is why we usually say that along with the objective reproduction of facts, the narrator introduces into his account many subjective elements depending on his mental development, character, cast of mind, mood, etc. It should be said that this addition of subjective elements is so inevitable that if we make up a story and tell it to people of different character or temperament, we can predict their reaction: some will laugh, others will be moved almost to tears, some will say it is vicious, to others it will be innocent, etc.

Everything we see and hear contains elements already seen and heard previously. So that whenever we see or hear something new, similar elements reproduced in our memory are added to the new impression and not separately, but in the same combinations in which they are registered in our memory. To an insignificant episode in the given event the memory of one individual adds a similar episode from the past, but with a sad ending; in the memory of another there is nothing corresponding to the given event and the latter, being a novelty, produces a very strong impression; then, a third individual, one who has seen many such events in his life, is absolutely indifferent.

Exactly the same takes place when we reproduce scientific facts read in a book or heard at a lecture, though it might seem that in this case the conditions of reproduction are not the same as in the reproduction of everyday facts. In the sphere of knowledge the reproducible is that which has been assimilated and comprehended Photographic likeness recedes here to the background; it is the sense which is of prime importance in this case But if we consider carefully the conditions of the so-called *comprehension* of thoughts we shall see that in the final analysis the key to comprehension is our personal experience in the broad sense of the word. Any thought, no matter how abstract, actually reflects a real or at least a possible fact; in this sense it is experience generalised to one or another degree (whether the experience is right or not is another matter). Hence, a thought can be assimilated or comprehended only by the individual in whose experience it is included as a link, either in the same form (then it is an old and familiar thought) or in some of the nearest degrees of generalisation.

It follows, then, that real and reproduced sensations are rarely similar in content, because reproduction reflects not only the purely objective side of the impression, but also the differing mental ground on which it falls. In a real impression the group of external impulses and the corresponding series of vivid sensations predominate, whereas in the reproduced form there prevails the organisation of the trace left in the mind by the given group. And since this organisation is changeable and admits of a recombination of elements, *the content of the reproduced sensation is determined by the organisation of its trade in the memory at the moment of reproduction.*

5. This conclusion relates to two forms of sensation: one, when it is evoked by a series of actual influences and the other, when the impression is reproduced in memory without the intervention of these influences. However, even in the first case the external influences fall not on a *tabula rasa,* but on the same, or almost the same organised ground, which determines the reproduction. Can it be that this ground does not make itself felt during the very acts of seeing and hearing? And if it does, what is the reaction?

These questions, too, can be answered with the help of experiments.

When a certain impression acts on us not for the first, but for the fifth or tenth time it is invariably accompanied by the emergence in our mind of an imperceptible movement which we usually designate as "recognition" of the object. It is easy to guess *a priori* that this imperceptible movement is the reproduction of an old impression alongside a new one; but in addition to guessing this, it can be proved.

Suppose I have stained my face with ink and one of my acquaintances sees me in this state. Immediately, before any thought has appeared in his mind, he will be conscious of the abnormal change in my appearance. Why? Simply because at first glance the old impression, i.e., the image of my face without the stain, is reproduced in the memory along with the new one. This explains why my acquaintance becomes immediately conscious of the abnormal change in my face.

The confrontation and commensuration of actual impressions with reproduced old ones is illustrated even more clearly by the powerful influence which novelty exerts on man. For example, our man has in his memory an average standard for the size of the human nose, so much so that when he sees a face with an abnormally big nose, the impression is very pronounced. But the more frequently he sees this face, the weaker the force of the impression. The reason is that at the first encounter the actual impression could be mentally confronted only with the average standard, while now it is confronted with the impressions previously produced by the same face. Whereas previously a large object was confronted with a small one, now the objects confronted are of equal size.

The same explains the distorted impression produced by the stature of a man and woman when they exchange their clothes: the man seems to be taller, the woman shorter. The deep voice of a woman produces the impression of a bass, although its deepest tones come within the tenor register. Lastly, here we get the entire field of contrasts expressed in the dependence of sensation not only on the strength of the impulse, but also on the properties of the preceding impression. The small object gives the impression of being still smaller after a big one, a weak impression may even pass unnoticed after a strong one.

Consequently, the phenomenon of confrontation and commensuration is perfectly clear.

It is the *sensory prototype of comparison*—an act of the consciousness accessible even to animals and sensed directly, without any reasoning.

The mechanism of this process will be described later (see section V of this article); now let us consider the conditions for the reproduction of impressions.

Everyday experience shows that even fugitive hints are sufficient to reproduce in the memory familiar things or something experienced previously; the only condition is that the hint must enter, directly or indirectly, the impression which is being reproduced. Rapid silent reading is a common example. The rate of the reading is determined by the fact that the words are recognised by their halves or even quarters—we can easily read a manuscript written with abbreviated words. The same is true of the cases when poems or songs learnt by heart are reproduced on the basis of a few lines or chords. In these cases the hint directly enters the composition of the reproduced impression, but there are also cases when the hint is a particular circumstance which accompanied the impression reproduced in our memory, i.e., an accessory of the impression. Every corner in the house in which we spent our childhood is full of pictures of the past. The hint here is indirect, but the essence of the phenomenon is the same: events and people registered in the memory together with their surroundings form the same indivisible group or association as poetry learnt by heart, and such a group can be reproduced by a hint at any of its links, as in the foregoing examples. Then there are cases when the reproduction arises in the consciousness, as it were, spontaneously, without any external impulse. These are cases of reproduction of accustomed impressions, i.e., impressions frequently repeated under various external conditions and therefore registered together with numerous secondary accessories some of which may even be imperceptible. We are so accustomed to the complex of minor influences acting upon us morning, noon and evening that we pay no attention to them; yet they are indispensable links of our impressions. Still more obscure to our consciousness are the satellites of any impression—the elements of muscular sense which accompany all the motor reactions of our body. In a word, every impression is associated with the equally obscure systemic sensations of the given moment. Consequently, if we grant the possibility of a primary excitation of one of these obscure elements it becomes clear that the reproduction of the association derives from the excitation produced by the external impulse, which remains unnoticed.

Suppose I have stained my face with ink and one of my acquaintances sees me in this state. Immediately, before any thought has appeared in his mind, he will be conscious of the abnormal change in my appearance. Why? Simply because at first glance the old impression, i.e., the image of my face without the stain, is reproduced in the memory along with the new one. This explains why my acquaintance becomes immediately conscious of the abnormal change in my face.

The confrontation and commensuration of actual impressions with reproduced old ones is illustrated even more clearly by the powerful influence which novelty exerts on man. For example, our man has in his memory an average standard for the size of the human nose, so much so that when he sees a face with an abnormally big nose, the impression is very pronounced. But the more frequently he sees this face, the weaker the force of the impression. The reason is that at the first encounter the actual impression could be mentally confronted only with the average standard, while now it is confronted with the impressions previously produced by the same face. Whereas previously a large object was confronted with a small one, now the objects confronted are of equal size.

The same explains the distorted impression produced by the stature of a man and woman when they exchange their clothes: the man seems to be taller, the woman shorter. The deep voice of a woman produces the impression of a bass, although its deepest tones come within the tenor register. Lastly, here we get the entire field of contrasts expressed in the dependence of sensation not only on the strength of the impulse, but also on the properties of the preceding impression. The small object gives the impression of being still smaller after a big one, a weak impression may even pass unnoticed after a strong one.

Consequently, the phenomenon of confrontation and commensuration is perfectly clear.

It is *the sensory prototype of comparison*—an act of the consciousness accessible even to animals and sensed directly, without any reasoning.

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Thus, the arguments in favour of the above point of view are numerous; still more numerous are the advantages which result from its acceptance. From this standpoint, the law of reproduction of impressions (as sums of separate sensations) is that not all the elements of the sensation are initially excited by external stimuli, as in the case of an actual impression, but only one or two elements, often accessory ones.

When the excitatory element enters the sensory spatial group or consecutive chain as a clearly perceived member, we can say that the reproduction is accomplished by virtue of the appurtenance of the element to the group or chain, or by virtue of its similarity to the corresponding elements of the group or chain.

Consequently, *any impression is reproduced in the same main directions in which it is registered in the memory by similarity and contiguity, i.e., according to similarity and contiguity in space and time.*

Another, even more important consequence of this concept is that it greatly simplifies the approach to the whole external aspect of psychical activity, reducing its external origin to the action of grouped and separate external factors.

## IV

External influences as complexes of movements.—The grouping of their foci of action in space and time.—Correlation between the grouping of external influences and that of sensations, as determined by the structure of the mechanisms of perception.—The eye as an instrument of spatial relations and relations of succession.—General summary

1. The greater part of the preceding two chapters was devoted to elucidating in general outline the first steps of evolution or decomposition of integral sensations. True to Spencer's hypothesis, I have tried to deduce the entire process exclusively from the repeated interaction of two variable factors—the external influences and the ground on which they fall, i.e., from the repeated external influences and the reactions of the neuro-psychical organisation, both sensory and motor. I have partic-

ularly accentuated the fundamental properties of the nervous organisation which determine the possibility of decomposing integral sensations and recombining their elements into groups or chains; the general role of the nervous organisation is now clear enough to enable me to define some of the general elements of thought (the reader will recall that these elements are: the separateness of objects, their confrontation with each other, and the general ways of this confrontation). But it is impossible to define all the elements of thought until we have completely elucidated the general role of the second main factor, *i.e., of the external influences.*

I have already touched on this point, though in passing and in a very general way. To explain the isolation of the impressions from the integral forms of sensation I had to present the external influences in the form of "variable sums" or chains, admitting at the same time that a definite group of sensations always corresponds to a definite sum of phenomena. But I did not pursue the point. The formula of the "variable sum" sufficed to elucidate the processes of decomposition and grouping of impressions in general, and to show the importance of the participation of external influences in these processes; but this formula, being too general, does not disclose the directions of *the variability. It must, therefore, be extended.*

But the reader may ask whether I intend to treat the external influences such as they are, irrespective of the sensations which they produce in us, or whether it is my purpose to consider the grouping of impressions proper and, on this basis, draw conclusions concerning the external influences. The first would signify intruding into the sphere of metaphysics, while the second would be tantamount (at least in appearance) to an admission that there is no need to take cognisance of the external influences when studying *the development of sensations because their properties are known to us solely through sensation.*

Clearly an explanation is imperative here, since it concerns the application of Spencer's theory to the study of psychical phenomena.

First I should like to point out that at present it is doubtful if even among the professional philosophers a man could be found who does not believe in the objective reality of the external world and in its influence on our senses. This inevitably leads to the idea that external influences are factors of the acts of sensation. It is impossible, of course, to imagine these factors in an extra-sensory form; but on the other hand, we know definitely that when the external influences change in a certain respect, the sensation is modified accordingly; the entire physical and physiological theory of light and sound—the principal forms of sensation—speaks in favour of this conformity. The above-mentioned branches of knowledge can actually be considered as consisting of two parallel halves: one deals with the variable forms of sensation, the other—with the variable objective conditions of seeing and hearing. The constantly increasing numbers of these conformities enabled the physicists to separate the two halves and to express the external influences in the purely mechanical form of movements and impulses arising as a result of their contact with the sensory surfaces of our body. This made it possible not only to consider sensations and their external physical causes separately, but even to predict the modifications in the character of the sensation with every additional confrontation of the external influences expressed in terms of movement. This was a big step forward, especially if we take into consideration that these concepts departed from concrete sensations, with the result that it became possible to isolate a certain sum of comparatively simple (i.e., easily and definitely decomposable) mechanical relations, as the external factors determining this or that aspect of sensation. Altogether the study of any complex phenomenon consists in decomposing it into simpler factors or relations, and once this is done, the more elementary relations explain the initial concrete sensations, despite the fact that they derive from the latter.

After this explanation I will be safe in saying that, when referring to the external influences as independent factors in the evolution of sensations, I imply the same thing as the physicist, i.e., various forms of movement; I shall attribute to them only those properties which are attributed to optic and acoustic oscillations or movements in general, assuming at the same time that although to man these properties are products of his differentiated sensory experience, there is something positive and real behind them.

So let us see whether it is possible to find in the properties of external influences, regarded as movements, criteria for grouping the influences in a more differentiated form than the "variable sum".

2. For this purpose, let us imagine a receptor organism surrounded by optic and acoustic oscillations, or simply by immobile foci of light and sound dispersed in space. Let us suppose that we have three sound-producing bodies, the farthest being located at a distance of not more than one kilometre and the nearest at a distance of not more than half a kilometre.

If we mentally divide the duration of the external influences into very small periods with blank intervals between, and if we assume that the organism remains immobile during the entire action of the external factors, we shall easily see that at the first moment only the light oscillations reach the organism almost simultaneously from all points in space, owing to the extremely rapid propagation of light. At the same time acoustic oscillations may not reach the organism even from the nearest point. Consequently, at the first moment there will appear an almost simultaneous (practically an absolutely simultaneous) group of optic influences proceeding from the foci dispersed in space, and nothing else. At the next moment the character of the action of the optic influences will be the same—it will retain the form of a simultaneous group; but to it will now be added an acoustic influence emanating from the nearest point. A moment later these will be added the acoustic influences from a second point, then from a third, and only at the fifth moment will the acoustic and the optic factors begin to act simultaneously, provided the form of the influences remains unchanged. Let us now omit the intervals between the separate moments of the action and see what will happen. The optic influences will again be *a simultaneous group of actions* proceeding from various points of the space, while the acoustic influences will merge into *a variable consecutive chain;* since *this difference is determined by the difference in the speeds of* light and sound, our conclusion, clearly, will be valid for all cases when other movements slower than sound are compared with light.

If light and sound issuing from certain foci vary in intensity or period of oscillation and we again divide the time of their action on the organism into brief periods, the picture of the acoustic influences will change only in one respect: the consecutive chain will be still more variable. As to the optic influences, we shall have at every given moment a simultaneous group as before, but a group varying in content from one moment to another. So that on the whole what we get is a line of variable groups.

Lastly, the character of the action is identical when luminous bodies are displaced in space, because if we break up the time of their action into brief periods, the character of the action will be the same as that issuing from a succession of foci arising along the line of the displacement.

Consequently, of all the external factors light alone acts constantly on the organism in the form of simultaneous groups, no matter how dispersed their foci in space and how short the duration of their action may be. The chances of acting in this simultaneous way are less for sounds, and still less for movements slower than sound, i.e., for most of the displacements of terrestrial bodies. In the latter case, a grouping in the form of a successive chain, more or less variable in time, is more likely. Given this condition the principal feature of the light group must be the immobility of the light foci and their spatial and topographical separateness, while the chain must be characterised by the variability of its links in time.

Thus, the external influences act on our senses in two principal forms.*

| | |
|---|---|
| In the form of a group differentiated in space, and | In the form of a chain differentiated in time. |

When the influences are repeated the group and the chain vary only quantitatively:

* For the sake of clarity, the reader is asked to keep in mind that one form corresponds, for example, to a simultaneous light group, the other —to a chain of varying sounds

| | |
|---|---|
| The group: in its general spatial extent, *number of foci of varying* action (their intensity and other specific features of their movements), and topographical position of the foci. | The chain: in its duration, number *of foci of varying action* (their intensity and other specific features of their movements), and succession of their actions in time. |

It will be appreciated that the diversity of the possible modifications compressed into these general headings is tremendous. If the external influences are seen as *simultaneous* and *consecutive* complexes of movements, there comes to the fore not the question of their diversity, which is obviously quite considerable, but the question of the structure of the sensory receptor mechanisms by means of which man is able to emerge from this chaos of external influences when they really act on his *senses in groups and chains.*

3. Were we to dwell in detail on the adaptation of the three higher sense organs—sight, touch and hearing[60]—to this way of perceiving impressions we would have to include in this work practically the entire anatomy and physiology of the sense organs; but since this would considerably exceed in volume the whole of the present treatise on the process of thought, I shall confine myself to a few general remarks and refer the reader to the physiology textbooks for the details.

*If we really perceive impressions as simultaneous groups or* successive chains, then, in keeping with what we know about the properties of the action of light, the eye must be better adapted to the perception of simultaneous groups than any other sense organ. We shall see that this is really the case.

The space covered by our vision greatly exceeds in depth and breadth the sphere of audition and olfaction (and still more the sphere of touch and taste which are effective only at short distances); this is due, on the one hand, to the extensive field of vision of the eye as an optical instrument, and, on the other, to the extreme sensitivity of the retina to light, which enables us to see objects situated at a distance of many miles.

The influences produced by light are discrete, because we can visualise them as emanating from different foci separated from each other in space; in *sensation, too, they* are discrete since external pictures are reproduced on the receptor surface of the eye (retina) almost photographically; besides, the retina *is so built that each of its points*, when subjected to the action of a ray of light, singles out the latter. As we know, the photographic likeness of the external pictures and their images in the eye is due to the fact that light is refracted in the eye exactly in the same way as in the lense of an optical instrument; as to the retina perceiving each point of the image separately, *the explanation is that each point of the retina is linked to the nervous centres by a distinct nervous pathway.* Consequently, there are as many perceiving points of the retina as are covered by the given image. It should be noted that the images of objects fixed always fall on the same part of the retina, owing to which one and the same group of nervous pathways always *corresponds to one and the same external group.*

Movements emanating from different foci of a light group are not identical; they differ either in intensity or in their periods of oscillation (foci of different action). Accordingly, the eye reacts to the intensity of the action of light through all points of its retina (perceives greater or lesser intensities of light); *it is also adapted to distinguishing colours.**

Finally, the light-group is characterised by topographic links or relationships between the foci of different action; in sensation, this is expressed by our capacity to distinguish in the optical picture the proximity or remoteness of objects, their position, size, contours, relief, etc. This is due to the intervention of the adaptive motor reactions of the eye in the act of vision. Apprehension of the remoteness, proximity, size and shape of objects is the product of the differentiated muscular sense.

But this is not all. The different parts of the retina do not distinguish forms with equal precision: near the centre of the retina, directly opposite the pupil, is situated the so-called yellow spot, which is best adapted to the distinct vision of forms. Here the separate points of light perception are much

* The first property of the eye is accounted for by the general faculty of greater excitation of the nervous substance the greater the intensity of the stimuli. Since colour vision has not yet been positively explained, I will not dwell on the subject, especially since an exposition of the hypothesis of colour vision would require too much time and space.

smaller and closer to each other; thanks to this, the parts of the image which fall on the yellow spot are perceived by a larger number of points than any other part. This corresponds to a picture placed before our eyes, one part of which is better illuminated than the other parts. It is obvious that this structure ensures the capacity to single out certain parts of the general optical picture, i.e., to decompose a whole into its parts.

Such is the structure of the eye as a mechanism by means of which we perceive simultaneous light-groups.

The sensory mechanism of the hand which serves for perceiving tactile groups is, in the main, of the same type; but it, of course, is adapted to the direct contact of objects with the surface of our body.

As to hearing, its organisation, naturally, is aimed not so much at perceiving spatial relations between the foci of sound, as to differentiating acoustic stimuli in time and delimiting between preceding and subsequent ones. This is best illustrated by our perception of speech and music where the characteristic features of the chain are reduced to the specific properties of the component sounds, their duration, the intervals between them, etc., irrespective of the topography of the sound foci.*

It is true that physiology has not yet succeeded in deducing from the structure of the auditory apparatus all the subjective properties of acoustic phenomena; still, the brilliant researches of Helmholtz in this sphere have greatly advanced the elaboration of this problem. We can now affirm with almost complete certainty that, in the matter of perceiving the so-called musical tones (oscillations with regular periods) and the vowels of speech, the main role is played by the cochlear system of resonators—a kind of musical instrument with thousands of differently tuned strings. Each of the strings, it is thought, responds (resounds) only to one tone of a definite pitch, and is connected with a separate nervous pathway. This explains why simultaneous and consecutive groups of sounds excite, also simultaneously or consecutively, strictly definite groups of nervous pathways. Modern physics reduces the entire qualita-

* Animals with mobile ears can, apparently, distinguish the topography of the sound foci much better than man whose helix is practically immobile.

tive aspect of the separate musical sounds and vowels, and of their pitch and timbre, to the elementary tones of varying pitch of which the sounds consist, while physiology reduces them to various pathways of excitation. Finally, the degree and the duration of the excitation correspond to the intensity and the duration of the sound. In this respect, hearing is similar to the muscular sense. These two forms alone have a direct sense of time; this is proved by our capacity to perceive sounds and muscular movements as something that lasts continuously, and also by our habit of measuring time by the short intervals between sounds or by periodical muscular contractions.

4. The last important point in the matter of adaptation of the sense organs to the perception of external influences in the form of groups and chains is the *visible* (i.e., perceptible by the sight) displacement of external objects.

*As we know, every movement includes two elements—space* and time; it is clear, therefore, that the eye as an instrument for perceiving the visible displacement of objects must possess everything needed to distinguish both position in space and succession in time; in fact, this task is brilliantly accomplished thanks to the combination of the visual activity of the eye with a whole system of movements that are co-ordinated with the displacement of objects. Even as an instrument for separate perception of immobile light foci, the eye can in a way determine the direction and speed of the displacement of moving objects (this can be seen, for example, from the fact that when a luminous point moves in front of the immobile eye in the dark, we feel both the direction and the speed of its displacement), *but this perception is far from being complete. Imagine,* on the contrary, that the structure of the eye enables a man, while stationary, to run alongside a moving object not only in the same direction but at the same speed, and you will obtain an idea of what is actually accomplished by the motor system of the eye. Indeed, we constantly follow the moving objects with our eyes; we always participate in these movements (this is not a metaphor, but a reality!), and thanks to this, our perception of the movements is more complete. But this is not the most important fact; the main thing is that the external movement is transformed into movement within the organism itself, which can be reflected directly in the sensory sphere by definite signs—the muscular sense. That is why the so-called pure movement is the only natural phenomenon, whose reflection in our sensation is closest to reality; being simple and understandable, it constitutes the extreme limit of simplification admitted in analysing complex natural phenomena.

In conclusion, I shall try to illustrate the functions of the eye by means of a more demonstrative example, in order better to elucidate the role of the eye as an instrument for distinguishing relations in space and time. Imagine for a moment a man who throughout his life looks at the surroundings through a kind of magic tube which allows him to see only one object at a time. In these conditions his perception and memorising of objects would be a series of isolated acts knowing no other relation except the *occasional* shifting of the tube from one object to another. The material world within his vision would appear as an incoherent series of images devoid of the connecting links known as relations and interdependences of objects, and which fill the perceived external world with life, meaning and mobility. In this man's mind the world would have a sufficient diversity of forms; but the man would be unable to apprehend the linkage between the objects until such time as the shiftings of the tube are performed according to a definite law. Some knowledge in this respect could be acquired by him, for example, if the tube rotated like a radius moving along equal, small and always registered arcs within the area of a horizontal circle, with the eye in the centre, and if after each horizontal displacement it would also move vertically, up and down, at definite angles. Although this would be exceedingly tiresome, it would yield some knowledge concerning the mutual disposition of immobile objects, and, what is more, the knowledge would be acquired *by means of a definite system of movements devised by man.*

If, in addition to the horizontal and vertical displacements, the magic tube were equipped with a special adaptive mechanism for determining the distance between the objects and the eye, this third series of data would make known the topography of the objects in depth, and the eye would actually distinguish the spatial relations between immobile objects.

But it would still be neither an instrument for the spatial analysis of groups—the perception of the latter being impossible to it—nor an instrument for distinguishing movements. Indeed, if the field of vision of the eye were always occupied by the fixed object only, the latter, as a result of its displacement in space, would quickly disappear from the field of vision; all the more so because every displacement of the object in a direction intermediate between the vertical and the horizontal would force the eye to move horizontally and vertically, in alternation at extremely brief intervals of time in order to keep the object within the field of vision.

Now let us suppose that a man, on the contrary, always sees considerable groups of objects, that, in addition, he uses our magic tube which enables him clearly to distinguish certain parts of the group, that his eyes can assess the distance of the objects and, lastly, that the shiftings of the tube take place according to a definite law *which, however, is determined not by the man himself, but by the characteristic properties of the immobile or moving elements of the group.* This will be a normal man, with the yellow spot as an equivalent of the magic tube, with the muscular sense as the recorder of the degree, direction and speed of its displacements, and with a ready canvas for the latter in the surrounding nature.

The groups and chains and their relationships in space and time exist outside us, i.e., independently of us, and probably in a form which differs from that in which we perceive them, but this form is invariable when the corresponding sensation is constant, and changeable when the latter is modified from one perception to another. A landscape seen under certain conditions of illumination and observed from the same point is a constant group. A certain tree, observed under the same conditions, is also an invariable group, though smaller in size; a tiny insect is, in turn, a group, etc. In general, everything that is optically distinct is a *visible* or *optical* group. The landscape, tree and insect, observed under different conditions of illumination and from different points, on the contrary, vary (from one case to another) but are identical in their interrelationships.

As to the chains, they correspond to perceptible changes in the state of the objects. A thunderstorm is a constant chain in the sense that it is successively formed of clouds covering the sky, the howling of the wind, thunder, lightning and rain; at the same time it is a changeable chain in the sense that the intensity of the natural phenomena and the rate of their succession vary from one storm to another. A barking dog, a fly in flight, a falling star, the chattering of a sparrow—these, too, are chains.

Thus, the simultaneous and successive complexes of movements in the external world are reflected in sensation by groups and chains, by *coexistence and succession*. In the first the links are connected exclusively by spatial relations, while succession in time is an indispensable element of the second. If the given complex of movements is repeated in the same way all the time, it is registered in the memory and reproduced as an invariable group or chain (the face of a friend, a fable learned by heart). But if the repetition is associated with frequent modifications of the complex, as happens in most cases, those of its elements which remain invariable during the repetition, or which change but slightly, are registered best in the memory and reproduced best in this shortened form. And so, little by little, the group is decomposed. But how is the constancy of the decomposition ensured? Apparently by the strict conformity of the complexes of external movements and the pathways of excitation: a definite group of these pathways invariably corresponds to a definite group or chain. As shown above, this condition is strictly observed in the organisation of the visual and aural mechanisms. So that generally speaking *a definite sensory group always corresponds to a definite simultaneous complex of external factors, and a definite sensory chain corresponds to a successive complex.*

We know, however, that all our sensations, at least all sensations of the higher order, become objectivised, i.e., exteriorised in the direction of their outer sources; it is clear, therefore, that the entire inner system of sensation is projected to the external world and adjusted to its content, i.e., to the external objects and phenomena. I shall avail myself of this for the purpose of summing up the grouping of both the external influences and the corresponding sensations.

*Inasmuch as the complexes of external influences are constant, any external object or phenomenon (i.e., objectivised sen-*

*sation) is fixed in the memory and reproduced in the consciousness only as a member of a spatial group or as a member of a successive chain, or both.*

*Inasmuch as the complexes of the external influences are variable, any external object or phenomenon is fixed in the memory and reproduced in the consciousness as a similar member of variable groups and chains.*

Or more briefly:

*Any external object or phenomenon is fixed in the memory and is reproduced in the consciousness in the following three main directions: as a member of a spatial group, as a member of a successive chain and as a member of a similar chain* (in the sense of our systems of classification).

This determines the three main directions in which the objects of thought are confronted with each other and which have been mentioned on pages 269-273, and also the principal categories of the registration of impressions mentioned on page 300 and subsequent pages.

In conclusion, it will not be out of place to cite the following simple example:

The window of a house, as an immobile object, is a member of a spatial group.

The window of a church, palace or hut is a similar member of variable groups.

A window thrown open by the wind during a storm and broken to pieces is a member (casual, not indispensable) of the storm chain

5. Now that we have at our disposal all the data relating to the general elements of thought I could proceed at once to the determination of the most elementary or primary forms of thought in animals and in the child. But first let me summarise, briefly, all that has been said in order to remind the reader of the fundamental propositions of our essay.

External influences, acting on us as simultaneous and successive complexes of movements, are reflected directly in our sensation by groups and chains, i.e., by what we call (in their integral, undifferentiated form), complex sensations.

The nervous process which develops along definite pathways of excitation leaves a trace in the *neuro-psychical organisation,* *and this is accompanied by the fixation of the sensory group* or chain in our memory.

One of the essential features of the trace is the intensification of excitability in the corresponding pathways as a result of repetition of the excitatory process. Thanks to this, it can be excited by stimuli much weaker than those which acted originally and it can, lastly, be reflected in consciousness (i.e., become excited) under conditions totally different than those first encountered. Cases of this kind come under the heading *of acts of recollection or reproduction of impressions (produced by what has been seen, heard and experienced, in general).*

The originally integral sensations are gradually decomposed as the influences are repeated; the chief factors of this decomposition are: the variability of the sum of external influences associated with their repetition, and the faculty of the organisation to fix best that which is continuously repeated. Owing to this, all the similar elements repeated from one observation to another are impressed in the organisation (in the memory) *more firmly than any other elements. This is what we call the* decomposition of the group—the isolation of its constant elements and, at the same time, their registration by similarity.

The external influences acting on the organism engender, along with the specific sensations (light, sound, touch, smell, etc.), motor reactions which, in turn, are accompanied by sensations (muscular sense). The sensory group and chain become, therefore, decomposable; the elements of the muscular *sense acquire the significance of border-lines between the members of the group or chain,* at the same time serving as connecting links between them. Later, when the motor reactions of the body and the sensations accompanying them become strictly definite (the law of the evolution of movements into definite groups or systems is the same as in the sensory sphere) the same elements of the muscular sense inserted in the intervals between the members *of the group or chain become factors determining the relations* between the latter in space and time.*

* This, however, does not mean that the relations between objects are products exclusively of the neuro-psychical organisation, as the idealists

In view of this, *the relationships between objects are conceivable only in the following three principal forms: as a similarity, as a spatial or topographical connection, and as a succession.*

When a group or a chain decomposes and the relations between its links become clear, it does not lose the capacity to emerge in our consciousness in its entirety; on the contrary, it appears in its complete form at the slightest allusion to any of its members. Consequently, two contrary courses of grouped sensation are possible in the consciousness: from the group to a separate member and vice versa—from a separate member to the group as a whole. In the visual sphere an example of the first case is the vision of an entire group or picture at the first moment, and predominantly of one of its parts (which, so to say, attracts more attention)—subsequently; the second case can be illustrated by the reproduction in the memory of the whole picture as a result of an allusion to one of its parts.

## V

*Concrete thinking*—Distinguishing and recognising external objects—Distinguishing parts, attributes and states—Abstraction of parts, attributes and states from the object as a whole

1. The lower forms of a differentiated complex (i.e., grouped) sensation—*distinguishing* and *recognising* external objects, are innate not only in the child, but also in animals capable of locomotion. No matter what it is that makes the animal move, it must at every step apprehend the topographical conditions of the locality in order to adapt its locomotion to them; sometimes the animal grasps the topography of the place while on the run, i.e., when careful examination of the external objects is physically impossible. Consequently, even this simple case presupposes, on the one hand, ability to take in the properties of the locality at a glance and, on the other hand, ability to appreciate

used to claim; the interconnection and interdependence of objects have their origin outside us and take their sensory form from our neuro-psychical organisation, in exactly the same way as the objective aspect of the optic and acoustic phenomena.

the advantages which they offer for locomotion, i.e., the animal must know these properties from experience. Still more complicated is the process of distinguishing when in pursuit of prey; in this case the animal adapts its movements not only to the conditions of the locality, but also to the movements of the prey; it is obliged to distinguish time as well as space relationships. The capacity to choose food, to discriminate between friend and enemy and to find the way home shows that the animal apart from distinguishing objects, in the sense of their isolation from groups, can also recognise in them old acquaintances.

There is no need to dwell here on how the child and the animal learn to distinguish different objects; the whole thing, clearly, lies in the differentiation of complex groups and chains. But what do we mean by recognition of objects?

In everyday language (for the sake of simplicity I shall confine myself to visual recognition), it signifies a quick, sometimes instantaneous, recollection at first sight of an object, that we have already seen this object before; this definition is absolutely correct. Recognition is simply the reproduction of a previously experienced impression by the same external stimulus, followed by the confrontation or comparison of the old sensation with the new. If, for example, the sight of a familiar tree evokes in our mind a definite image the eyes involuntarily begin to look for the distinctive features of that tree; the moment these features are found, we *immediately* realise that this is the tree with which we are familiar and no other. This search for distinctive features, accomplished through the eyes and which is actually a reproduction of previous eye movements is the essence of the confrontation or comparison of the old image with the new. Consequently, the comparison of images is due to the reproduction of the motor reactions of the eyes, without the intervention of any special agent for the comparison of impressions. Nor can we discover any such agent in the final act of the process which can be defined as apprehending or ascertaining identity between successive sensations, because we are conscious of this identity at once, having no time for reasoning, i.e., for drawing conclusions from the given premises. Still, we distinguish in the process of recognition:

1) the discreteness of the two sensory acts, 2) their confrontation, and 3) the manner of this confrontation, namely, according to similarity—in short, all three fundamental elements of thought. Consequently, *recognition of objects, the most elementary of all the psychical acts, bears all the hallmarks of thought* (both as regards content and as a series of processes).

It possesses even that aspect of thought which imparts to the latter its rational character. Indeed, in the sphere of object thinking any thought, taken separately, expresses simply knowledge of the relationship between its objects; from this point of view, it is a sensory reflection of the external objects and of their interdependences, a reflection which can be more or less true or false, but never rational. Rational thinking begins from the moment it acts as a guide to our actions, i.e., when the latter are based on relationships perceived by us. Then the actions acquire a definite sense and purpose, and become expedient; for the animal recognition of objects is, evidently, a guide to purposeful action; without it the animal would be unable to distinguish a piece of wood from food, it would take a tree for an enemy and, generally speaking, would never be able to orientate itself among the surrounding objects. Thus, the act of recognition is every bit as rational as the thinking which guides our purposeful and rational actions.

Lastly, the process of recognition contains certain elements of rationality inasmuch as it resembles the act of deduction.

2. It might seem that the second stage of sensory evolution resulting directly from the decomposition of complex groups and chains into separate links should be confronting whole groups with their separate links, as parts or attributes; these forms are found in children (as can be seen from their ability to draw landscapes at a very early age). But they are of lesser significance compared with the products of the analysis (decomposition again) of separate objects isolated from the group, thus, the distinguishing of parts and properties or attributes, as well as of the states of separate objects, should be regarded as the second stage of sensory evolution.

This is explained by the following. While large groups of external objects, for example, landscapes, have features characteristic of the entire combination, they have very few of the properties usually attributed to the separate objects. A landscape is too extensive as a group; it is, therefore, too variegated to speak, for example, about its form or colour. Besides, large groups act on us only from afar, with the result that numerous influences (tactile, olfactory, gustatory and partly even aural) do not reach the observer. Conversely, proximity enables us to get acquainted with the diverse properties of objects—to see them in full, or in part, to smell them and touch them, in a word, to bring all our senses into play. For this reason, analysis of the groups is reduced almost exclusively to the optical or visual decomposition of the picture, whereas in the case of a separate object we learn gradually to discern its form, colour, smell, taste, solidity, elasticity, roughness, etc. Nor should it be forgotten that the child's mobility brings it into constant contact with external objects in the vicinity; consequently, sensation at close proximity must of necessity predominate over distant sensation.

What are the means which enable the child to distinguish parts, properties or attributes, as well as states of separate objects, and how is this done?

3. The distinguishing of parts in isolated objects is accomplished mainly by the eye. It is true that in many cases touch helps vision, but in normal people (i.e., people who are not blind) touch is inferior to sight as regards the speed, volume and precision of the analysis; for this reason it is decisive only in exceptional cases (the touch of normal people has, of course, a specific sphere in which it has undivided rule, for example, in perceiving the solidity, elasticity and relief of objects, etc.). Therefore I shall speak here only of the visual decomposition of parts and, as a preliminary, make the following statement:

*the visual decomposition of isolated objects into parts is absolutely equivalent, both in content and in the nature of the process, to the decomposition of our former groups into isolated objects; the sole difference is in the conditions of vision. A group is disintegrated via distant vision, the isolated object—via immediate vision.*

When we look at a distant landscape, the range of our vision takes in such large groups as a town, a lake, a mountain chain;

as to separate parts which we discern in the picture, they are, even in the most favourable case, but large objects, such as a house, or a tree (of course, without the details). But when we approach the house or the tree, the images grow in size until the range of our vision is occupied by one object only, so much so that we are able to discern the details of the object. When we draw still closer to the given object, the range of vision is reduced to a part of the house or tree; as a result, it is possible to observe the details of the given part of the object. But this is not all. I have already mentioned that, compared with all other points of the retina which are likewise affected by the images observed in conditions of both distant and near vision, the yellow spot of the retina is the point of clearest vision. In both cases this structure helps to isolate some parts of the image from the whole with greater clarity; in this sense, it is the yellow spot which analyses the picture even when we look at a distant landscape. But while in this case it helps to isolate only the large objects, in the case of near vision it isolates the separate points from the parts of the object. The analysis is the same in both cases; the only difference is that in conditions of distant vision the images of towns, woods and lakes are impressed on the retina in a diminished size, whereas in conditions of near vision the entire retina previously filled with the vast picture is occupied by the image of a single tree. Consequently, as long as the whole external object and any of its parts—no matter how small—are optically separable, within the limits of the analytical power of the eye, they (i.e., the object and its parts) in respect of decomposition are equivalent to a group in the same sense as the landscape seen close at hand and not from afar.

When we look at a distant landscape, the optical axes of the eye, i.e., the straight lines connecting the centre of the yellow spot with the point observed by us, pass from one prominent feature of the picture to another; the same thing takes place in near vision. *In both cases the visual acts are interrupted* by motor reactions, and in both the muscular sense links up the points of the picture by means of spatial relations.

In short, from the point of view of the decomposition of impressions within the sensory limits, *the second stage of evolution is related to the preceding stage in respect of the decomposition of sensory objects, in exactly the same way as near vision is related to distant vision.*

In other words, *the sensory decomposition of the objects of vision is effected by means of the general factors of psychical evolution already known to us, namely, the inborn neuro-psychical organisation and repetition of the external influences in the form of definite groups, which, however, vary from case to case.*

Along with the optic discreteness of objects and the topographic relations between their parts, the eye also perceives the outline or the general planary form of the objects, their colour, position in relation to the observer, distance, size, volume and motion. These sensory forms are indispensable links *in the acts of differentiated vision, the sum of the visual attributes which characterise the object in any given impression.*

What is the nature of these attributes and what determines their discreteness?

The reader will find the answer to this question in any textbook on physiology. Here I shall confine myself to a few general remarks.

The outline of an object, i.e., the line dividing the object *from its surroundings, is one of the most distinct features of* every visual image. On the other hand, when we look at an object our eyes always move from one characteristic point to another; consequently, they move also along the entire outline of the object. Because of this, in all cases when the planary form of the object is definite, the trace left in the sphere of the muscular sense by the movement of the optic axes must likewise be definite.

*If the object under observation is on our right* we turn the eyes or head in its direction. Thus, to the optic sensation a muscular reaction of a definite direction is added; this reaction is repeated thousands of times throughout life and ultimately becomes for our consciousness a sign[61] *indicating the direction* in which the object is seen.

*The distance of the object is also determined by the exercised* muscular sense, which corresponds to the degree of the convergence of the optical axes.

The size of the object is determined by the same factor as the distance, and also by the angle of vision which, in its turn, is measured by the muscular movements.

The volume of the object is determined by a certain disparity of the images on the retinas of both eyes and possibly by their comparison, effected by means of very slight movements of the optical axes.

The movements of the object—both as regards direction and speed—are determined by the corresponding displacements of the optical axes (we follow the moving object with our eyes).

Lastly, the colour vision is equivalent to the vision of light in general, because there is no such thing as colourless light.

It is this sum of motor reactions, accompanied by varied but definite forms of muscular sense, which, in its totality, constitutes the so-called capacity to see—which is something the child learns long before it learns to walk. Constantly repeated throughout life, this complex of movements is gradually co-ordinated into a group which is as natural as the act of walking or any movement of the hand, and can be as easily reproduced. Muscular sense is exercised together with the movements which it accompanies. In its turn, it is co-ordinated into a regular system of signs which, added to the effects of the retinal excitation, determine all the spatial aspects of vision.

Thus, the optic attributes of an object are actually linked to an *association* between one and the same effect of the retinal excitation and the varied, but quite definite forms of the muscular sense, in other words, a definite effect of light is associated with the activity of various muscular groups, because the convergence of the optical axes on definite points and the movement of the converged axes from one point to another are accomplished with the participation of different muscular groups. From this it follows that

*the discreteness of the optic attributes of an object is based on the discreteness of the physiological reactions which participate in the perception of impressions.*

*The perception of the outline of an object, of its colour, size, distance, direction, volume and motion is a co-ordinated sensory group (or more precisely, a chain, because not all reactions are simultaneous), in the sense that phases of walking, or* *words spoken aloud, are co-ordinated groups of elements of motion.*

4. The laws governing the decomposition of objects into their attributes and the reunion of the latter into co-ordinated groups are manifested with greater force in those cases where the sensory chain includes the activity of various sense organs. The following example will illustrate this.

We perceive an orange as a round or spherical body of orange colour, specific smell and taste. In this complex impression the outline of the object and its colour are conveyed by the eye, the spherical form—predominantly by the hand with its muscular system (but also by the eye), and the two last-mentioned qualities—by the olfactory and gustatory mechanisms. The combination of the sensory signs can take place as a result of diverse encounters with the object, in parts or at once. The eye sees the orange; then the arm is extended, the hand picks up the orange and raises it to the nose and mouth; a few more movements, and there appears the sensation of smell and taste. Through repetition, the chain is registered in the memory; the separate motor reactions are effaced, but the forms of the muscular sense connected with them do not disappear, because the memory retains the size of the orange, its spherical form and even its position relative to the subject. The end result is an associated sensory group with links provided by the separate reactions of the visual, tactile, olfactory and gustatory mechanisms.

It is clear that the number of these groups is enormous; particularly numerous are those groups in which visual products are associated with tactile ones, because all terrestrial bodies without exception (except, perhaps, the air) are visible and tangible, though they are not bound to emit sounds or odours or to have the attribute of taste. It is also clear that the sensory image of an object is determined by the combination of all the properties or attributes accessible to the senses.

We could further examine the dependence of the attributes of objects on the discreteness of the physiological reactions of perception by confronting the properties of the receptor mechanisms known from the anatomy and physiology of the sense organs, with properties known to us from experience. However, I shall not do this because the matter has been sufficiently elucidated by a similar parallel between the properties of the visual mechanism and the optic attributes of objects.*

In brief, *all the attributes or properties of objects accessible to the senses are products of discrete physiological reactions of perception, the number of the former being strictly determined by the number of the latter.*

For the eye, there are *seven* known reactions and as many categories of attributes (colour, planary form, size, distance, direction, volume and motion). For touch, the number of reactions associated with the muscular sense of the arm and the body as a whole amounts at least to *nine*, and they correspond to the following attributes: temperature, planary form, size, distance, direction, volume, compressibility, weight and motion. For the ear the number of the principal reactions and attributes does not exceed *three* (duration, pitch and timbre). And lastly, for smell and taste there exist single forms of reactions. Thus, the greatest number of sensory attributes in an object is 21. But we should not forget that these 21 categories admit of multitudinous variations.

5. The acts of distinguishing the qualities or attributes of objects are undoubtedly inherent both in children and animals —the latter recognise objects by their separate attributes. The ability to do so is even more important for animals than it is for children, because the animals, ever in a state of war, are constantly surrounded by enemies; for this reason the ability to orientate in the external environment at the slightest indication is of vital importance to them.

* Confronting the physiological properties and sensory products of the higher and lower sense organs, such as vision with olfaction, audition with taste, is also instructive in this respect. The organisation of the human olfactory and gustatory mechanisms is primitive compared with that of vision, touch and hearing, hence the degree of differentiation of the gustatory and olfactory sensations is extremely low. This can be seen from the fact that we often resort to the names of odorous objects to define scents (violet, jasmine, cucumber, etc.) and distinguish only the intensity of the sensation as well as its pleasant or unpleasant aspect, whereas in sounds we are conscious, in addition to these aspects, of their duration, pitch, timbre and of the endless modifications of the principal properties when the sounds act in chains.

It is clear, moreover, that in many cases the ability to distinguish the attributes of objects is acquired by the animal too as a result of its experience, i.e., it is the outcome of repeated encounters with the objects. A dog will not jump out of a window from the third floor, will not poke its muzzle into the fire, nor will it fear its reflection in the mirror if it knows from experience the consequences of jumping and the properties of the fire and the mirror. On the other hand, there is no doubt that in many other cases knowledge of the properties of objects is innate in animals, i.e., inherited. Whereas in the past facts of this kind puzzled observers, creating an unbridgeable gulf between the psychical organisation of man and that of the animal, we now have some knowledge of the nature of the difference. Since, as we know, the acts of sensory perception in man also tend to co-ordinate into groups, similar to the acts of locomotion or to the habitual hand movements, there is nothing surprising in the sensory groups being innate to the same degree as locomotion. Moreover, when considering questions of this kind, it is necessary to take into account that the period of psychical development of animals is much briefer than that of man; the dog, for example, acquires in a few days as much as the child acquires in the space of months.

In any case, the act of distinguishing the properties of objects is in itself a process of object thinking, as Helmholtz has demonstrated. The child probably sees (i.e., perceives) the shape of objects, their size and distance as distinctly as the adult and can make use of the indications of differentiated sensation in its movements (it turns round when called and grasps objects with its hand correctly determining their direction and distance); but these actions are not products of reasoning—they are the habitual consequences of differentiated sensation, although they bear a resemblance to acts of deduction. It is this similarity that impelled Helmholtz to designate the separate acts of the child's spatial vision as "unconscious deductions" (*unbewusste Schlüsse*); indeed, *they contain the material indispensable to acts of deduction (see the conclusions given below); however, it would be wrong to think that the acts of children and animals follow from reasoning in the form of syllogisms.*

Let us imagine, for example, the following picture. A dog is sitting near a house; the house is on the left of the dog; on the right is a copse with an opening in it. Suddenly a hare appears in the opening and the dog rushes after it. Upon seeing this one might think that the psychical process taking place in the dog's mind assumes the following form if expressed in words: "I see in front of me a house, a copse, an opening in the copse and a hare; the hare is on my right, *consequently*, I must run at top speed to the right, *because the hare* is running swiftly." The actual process, however, is simpler: it takes only some fractions of a second to recognise the hare on the right and, provided the impression is impulsive enough, it immediately evokes a motor reaction in its direction. If the dog is hungry, the movement in all probability will be swifter still, and not because the old syllogisms are reinforced by new considerations about the hare as a dainty morsel, but merely because the impulse of the impression is intensified. The main thing, then, is the rapid recognition of the specific and spatial peculiarities of the object and the acquired capacity to adapt the body movements to them.

I repeat, at this stage of development the differentiated sensation, as a means of orientation in time and space and as a guide to purposeful movements, possesses all the external features of thinking; in reality, however, this is merely a phase of differentiated sensory chains co-ordinated with each other and with motor reactions into definite groups. This phase, the phase of *sensory automatic thinking*, is the limit beyond which the animal can hardly go, whereas in man it passes directly into so-called *concrete object thinking*.

6. From recognising objects by their attributes, an ability acquired during the preceding stage of development, the child passes directly to actual thinking in terms of external objects and their properties or attributes. First, a kind of separation *of the object from its attribute* takes place in the child's consciousness, this makes possible their mental confrontation from the point of view of their interrelation. When the child says "the horse is running", "the tree is green", "the stone is hard", "the snow is white", it is separating the object from its attributes and confronting them.

How is this done?

There was a time when the first of our problems—the act of *abstracting attributes from objects—played an essential part* in the theoretical views on man's mental life and was regarded as the corner-stone of philosophical systems; but in our days this process, having shed both its attraction and its aura of mystery, can be safely considered as one of the most elementary forms of psychical activity.

In order to comprehend it, we must revert to what we said earlier about the faculty to distinguish the optic attributes of objects. The reader will recall that the development of this faculty is associated with the development—through exercise —of the muscular sense accompanying the *motor reactions* of the eyes when focused on objects. But nothing was said about the initial forms of spatial vision in which the exercised eye differentiates the contours, size, distance, etc.; and such forms must exist, otherwise there would be nothing for the eye to differentiate.

In the retina of the new-born child external objects are reproduced in the same way as in the retina of the adult. In both cases visual impressions derive from the stimulation of the numerous points of the retina; consequently, the child perceives the planary images of objects, including their *outlines*, in the same or almost the same way as the adult. But at first the child lacks the ability to converge the optical axes of the eyes on a single point and afterwards to move the converged axes along the outline of the object, or generally from one point to another. That is why at *first there is no difference in the perception of the upper, lower, right* or *left* parts of the object, as well as of its size and distance. But when the child masters the art of concentrating the eyes on an object, it acquires a multitude of ready forms of ocular movement depending on the *location of the retinal excitation. And since the eyes every minute* perform upward and downward movements when passing from the upper parts of an object to the lower ones, or, which is *the same, from the lower to the upper parts of the image on* the retina (since the image on the retina is reversed), the latter ceases to be a passive mirror of the external pictures and is no longer indifferent whether the excitation is located in the upper, lower, right or left part of the eye. *Because of the exer-*

cised muscular sense an independent sense of location gradually develops in the retina and, as a result, any excitation of its lower part is directly objectivised upward (i.e., perceived as an optic influence coming from above); excitation of the upper part is projected downward, that of the right part—to the left, etc. Lastly, the retina of the exercised eye acquires the ability to take in instantaneously, without moving the eye, the contours of objects, their size, and direction (and less clearly—their distance and volume).*

Thanks to this, the child whose retinas are exercised *in localising* visual impressions sees each object successively in two different ways: at first glance it perceives the characteristic features of the planary image and in this way recognises the object; subsequently, when the optical axes fall on a certain part of the object, this part is seen more distinctly than the others. The first two acts are known to us: they are a reproduction of a co-ordinated group at a hint from one or a number of its elements. As we know, this is so rapid a process that its two parts are felt simultaneously and, of course, as a *whole object*, although it may be that the outline alone is quite distinct (that is why children and people at lower levels of development reproduce only the outlines of objects). But later, when a brightly coloured or peculiarly shaped part of the object strikes the mind in a particularly vivid way, we get a mental *confrontation of the whole object and one of its attributes*. Acts of vision are repeated in the child in this general form thousands of times; registered in its memory in the same way they are reproduced in the mind at the slightest hint.

From this it follows that

*mental abstraction of parts and attributes from an object as a whole is based on the discreteness of the physiological reactions of perception and the difference that exists between them; the first general effect of the external impulse corresponds to the object, while the particular reaction of detailed vision corresponds to the attribute of the object.*

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* This explains the capacity of the eyes to recognise objects when *illuminated for an instant by an electric spark* (see section III of this article).

7. Another, more general condition for abstracting attributes from objects is the variability of the external influences accompanying the repetition of uniform impressions and the modification of the *subjective conditions for their perception*. One and the same object observed under different conditions of illumination and from different points of view may change its colour and form, be warm or cold to the touch, look smaller when seen from a distance and larger when we approach it. The impressions produced by separate similar objects are, of course, still more varied. As we know, this results in the isolation of the more or less constant attributes in the sensory group (*corresponding to the object*). The first of these attributes are registered better in memory, form a more solid group and, within the limits of this group, are reproduced more easily; any of the variable attributes can be a hint for the reproduction of this group. In these conditions the *reproduced group, as the most constant part in the sensation and in the object, is the equivalent of the object as a whole, while the sensory hint, which engenders its reproduction, is an attribute of the object.*

Thus, the reader will appreciate that the whole thing boils down to what we have repeatedly said about the decomposition of large groups of objects into separate objects, and of separate objects into their attributes; *indeed, this is the beginning of the abstraction of parts from groups*, irrespective of whether we have in mind a large group of objects, or a single object considered as a group of attributes. The act of abstraction consists in the possibility of confronting the group with its part. In this respect, however, there is a difference between large groups and single objects. The former, being *combinations extremely variable in content, have a smaller chance of being memorised in groups*, and as a result of the repetition of impressions, they in the majority of cases disintegrate into their components, i.e., single objects; the latter, being infinitely smaller and more constant groups, are memorised and reproduced both in full and in parts (see what has been said previously about the *comparative difficulty experienced by the child in thinking in terms of groups of objects*). Thus, *while the general conditions for the decomposition of objects into their attributes are the same as for the decomposition of the large groups into single objects (variability of the objective and subjective conditions of perception), the products of the decomposition differ in both cases: the large group, being an extremely variable combination, is registered predominantly in parts, and only in exceptional cases as a unit, while the single object, as a smaller and more constant group, is registered both as a unit and in parts.*

*Reproduced in the last two forms along parallel lines, this group constitutes real object thinking, in which the object, its properties, its state and condition are the subjects.*

In this category of thought *the discreteness of the objects* corresponds to *the discreteness of the physiological reactions of perception and of their traces in the nervous organisation;* their *confrontation* corresponds to the *succession of the spreading of the nervous process in the acts of reproduction,* while the *connecting links* (the manner of the confrontation) correspond to a *partial similarity* between the successive reactions of perception and their traces in the memory.

Only this partial similarity between the initial general reaction, corresponding to *the object,* and the differentiated reaction corresponding to the *attribute,* can we explain the direct sensation of the close connection between them; it explains, moreover, the inaccuracy of the terms used when people speak of the object and its attribute as being equivalents, although the object is a sum, while the attribute is but one of the items. Another inaccuracy—the tendency to substitute one of the attributes of the object (frequently the outline) for the object as a whole—is likewise comprehensible in the light of what has been said above; this, undoubtedly, is due to the practical advantage of recognising and designating objects as quickly as possible by their attributes or signs.

8. I shall not dwell in detail on those cases of concrete object thinking in which the thinking instead of being about one object and its attribute, is about two or more. To do so would merely mean repeating what has been said. Indeed, when the exercised *eye of the child moves from one object to another,* a *series of* grouped sensory products are confronted in his mind exactly

in the same way as the object was previously confronted with an attribute; the only difference is that now the confrontation can be more varied: whereas previously it was possible only by similarity, it can now take place also in space and time. Each adjacent pair is thus associated in the mind by a definite relation; it is registered in the memory and can, given favourable conditions, be reproduced in the mind anew in the form of an object thought. Insofar as the successive reactions of perception are similar or different, it is the similarity or difference which *plays the role of the connecting link between the objects of thought; insofar as the motor reactions of the observer are* involved in passing from one object to another (such reactions invariably manifest themselves), the objects are connected by relationships in space and time. In brief, here, too

*the thought is simply the reproduction of a differentiated sensory group which consists of at least three discrete reactions of perception. The objects of thought usually correspond to the two extreme reactions, their connecting link to the intermediate reaction.*

How wide the sphere of application of this general formula is can be seen from the fact that we can confront in thought *any two external objects, no matter how different they may be: for example, a grain of sand with the sun, a man with a speck* of dust, a town with a chip of wood, etc., the sole condition being that they appear in the mind in succession. Given this condition, a certain relationship between the objects must inevitably manifest itself, because the human organs and processes of perception are the same for all objects.

Lastly, our formula is applicable to the so-called chains or series of thoughts, because they derive from the coupling of successive pairs when the observer passes successively from one object to another. These chains *in turn can be fully registered in the memory and, reproduced in verbal form, they are* what we usually designate as descriptions of places, scenes and events.

9. Here I want to say a few words in conclusion about the phase of concrete object thinking, or thinking in terms of actual external objects and their attributes.

At this stage of development which is of very brief duration (the cause of this will be dealt with later) the thoughts of the child, which hardly differ from actual impressions, are related to these impressions in the same way as recollections are related to things actually seen or heard. The content of the thought is confined to what the child is able to perceive by means of exercised vision, audition, touch and olfaction. The child, as it were, glides over the sensory surface of objects and phenomena, grasping only that which is directly accessible to sight, hearing and touch. Such thinking can at best lead to a slavish, photographic reproduction of reality, and, what is more, from its purely external aspect. The child does not apprehend the essential links between objects and their delicate interrelations which are used by the adult in his everyday life and which, being simultaneously the mainspring of external life, impart a definite sense and meaning to all vital phenomena. The sphere of the child's personal experience is probably confined during the first years of life to a few hundred encounters with external objects from which it could learn about these interrelations; but these encounters are, undoubtedly, mixed with thousands of others where the relations are unessential and casual. In everyday life, as in science, the relations of the first kind, revealed by experience, are seldom found on the surface of phenomena; they are as a rule marked by auxiliary, unessential phenomena. Besides, the personal experience of the infant is a matter merely of months, whereas many of the things taking place in the external world last for a number of years. The child lives almost exclusively in the present, whereas the adult to a considerable degree lives and acts with a look to the future.

If, therefore, we assume that the next phase of man's mental development consists in acquiring the capacity to distinguish the essential interconnections and interdependences between objects from the casual ones, and in learning the duration of the most common phenomena, this phase will be a long one indeed. The lifetime of an individual would not be long enough to attain even these two elementary aims, if he had to rely exclusively on his own personal experience and if no radical change occurred in his mental life. Fortunately, the children of civilised races are surrounded from the cradle not only by natural influences, but also by artificial combinations of objects and relations which have been created by culture and on which human thought has worked for centuries. From early childhood man acquires through verbal intercourse and practical activity ready-made forms of the experience of others, and this relieves him from the difficult task of learning everything from his own experience. But no matter how illustrative the primary education may be, the teacher cannot do without a system of certain symbols (i.e., words, drawings and graphic images in general); on the other hand, the pupil must be capable of perceiving and assimilating the symbolic images—otherwise the teaching would be fruitless. If there were no ground for perception and assimilation of the symbols, the latter would either not be perceived at all, as we see in the case of animals, or they would be perceived in isolation from the products of personal experience, as is always the case when the mental material is beyond the comprehension of a pupil of the given age.

For the pupil to be able to learn the symbolic representation of the facts of the external world, it is essential that the symbolism should correspond, both in content and degree, to the symbolisation of impressions which takes place in the child independently of education.

It is this mysterious process of transmuting sensory products into less and less sensory symbols, together with the innate capacity of speech, which enables man to combine the products of the experience of other people with his own (i.e., to assimilate what he is taught); it is, moreover, the most characteristic feature of his entire subsequent mental development.

It would seem that this stage of psychical evolution in the sphere of thought begins with a very considerable change in the child's mental activity (as we shall see later, this is not so): previously the child thought in terms of concrete sensations, but all of a sudden the objects of its thought cease to be copies of reality; they become reflections of this reality, which are at first very close to it, but gradually depart from their source so much so that all the links between the sign or symbol and its sensory root seem to be completely lost.

These signs or symbols are usually called *abstracts* or *mental abstractions* from the actual state of affairs; this is why the entire corresponding stage of development is called *abstract* or *symbolic thinking*. This stage begins in early childhood and lasts all our life without undergoing any sudden change.

10. From now on, our task will be to examine the conditions in which *abstract thinking* develops.

I shall first of all try to establish the limits and the plan of my research, since here the sphere of the phenomena is extremely varied, actually embracing all human knowledge.

1) We have said above that the characteristic feature of abstract thought is the greater or lesser symbolism of its objects. The closer the derivative product to its sensory source, the greater its likeness to reality, and vice versa. But when it deviates far from the source, the object loses its sensory form and turns into an extra-sensory sign.

My first task, then, is to examine the conditions that determine *the symbolisation of sensory impressions and their derivative forms* of the 1st, 2nd and subsequent orders.

2) With the gradual progress of mental development, man is no longer satisfied with the direct indications of his senses. Even children at the age of 2 or 3 begin to ask "how?", "why?" and "what for?". As we know, the process of finding answers to these questions, the so-called *interpretation of phenomena*, is a mental process of a seemingly active character (as distinct from the process by means of which man states or describes facts) which has always been as the decisive argument in favour of the existence in man of an active principle, namely, of the intellect as an instrument for interpreting facts. Elucidation of this form of psychical activity will be my second task.

3) My third task will be to explain the conditions in which thought is transferred from the sensory sphere to the extra-sensory, and to examine a few general cases of this transfer.

The examination of each of the three points must consist in finding an answer to the following questions: which of the already known innate qualities of the developing nervous organisation or what new qualities help us to explain the three *foregoing categories*, and is the form of the external influence the same for this phase of development, or are there new forms of this influence of which nothing has been said as yet? In others words, is it possible to explain the essential characteristics of abstract thought from the standpoint of Spencer's theory? Is abstract thought only a further stage of development identical with the preceding stages both in basic principles and type, or do new agents participate in it alongside the old?

Any reader more or less familiar with the essence of these problems will readily understand that it is far from my intention to give an exhaustive solution of them; to do so would be tantamount to expressing in terms of the neuro-psychical organisation and external influences the difference between animals and man (since, as we know, abstract thinking is inherent only in man) and, what is more, to expressing it at a time when we do not know what constitutes the essential anatomical and physiological difference between the organisation of the brain of man and that of animals, and when, generally speaking, our knowledge of the role of this organisation is far from being extensive. Consequently, the questions to be considered by us can be approached only in a very general way.

## VI

Thinking in symbols or abstractions.—Inner symbolisation of impressions or formation of concepts and notions—External symbolisation or expression of impressions, concepts and notions by means of conventional signs, i e, by elements of speech

1. Let us imagine for a moment that the world is filled with absolutely identical trees, lakes and mountains, or that all objects in general lack individual distinctions. In this case the job of memorising these objects would be a simple matter: once differentiated and memorised, the given concrete form would be ideal for all further life encounters. Man's memory, however, would be filled not with symbols but with reproductions of reality. All mountains would be known by one name, say "Mount *Kazbek*", and there would be no difference between this name and the word *mountain*.

Let us imagine, on the other hand, that there are distinctions between objects, and that it is man's misfortune to have to memorise all objects with all their particular traits. In this case he would have in his mind thousands of images for all, even the most ordinary, objects—tree, stone or horse—and his thinking in all probability would be confined to concrete objects. Fortunately, this is not so. By virtue of the law—already known to us—of the registration of impressions by similarity, all identical objects merge in man's memory into average standards. He thinks, for example, of an oak, birch or fir, though he has seen these objects thousands of times in a variety of forms. These average products are no longer exact reproductions of reality, because the impressions varied with every encounter; but in essence they are single sensory images or signs which replace the numerous uniform objects.

*These are symbols of the first order*, and they figure even in the thinking of the child, provided it has already seen dozens of birch-trees, dogs or horses.

From the average oak, fir or birch the child's thought is transferred to the "tree" as a single image or symbol for a multitude of similar (not uniform) objects. "The tree", even in the child's mind, is not only a verbal symbol, it is a highly differentiated image. When drawing a tree correctly, i.e., first the trunk, then the branches and, finally, the leaves, the child demonstrates its capacity not only to abstract the outline from the object, but also to distinguish its parts and to appreciate their topographic relationships. *These are symbols of the second order.*

At this stage of abstraction from the original sensory images (i.e., from the impressions produced by actual trees) all the less constant attributes are excluded (size, volume, direction of vision, colour of various parts); the remainder, i.e., the general image of the tree, which most people retain in their memory for life, becomes an *abbreviated symbol* or sign for a definite category of external objects.

It is hardly necessary to explain here the origin of these abbreviated symbols, which are, obviously, countless in man, because any landscape can be represented by means of contours and separate lines. Everything here depends, first, on the discreteness of the physiological reactions of perception and, second, on the intensification of the traces left in the organisation by the reactions repeated most frequently during the perception of similar impressions. In this sense, *every abbreviated* *symbol, like the one mentioned above, is in content a greater or smaller fraction of the entire object which it replaces; from the point of view of the process, it is a fraction of the sum of the reactions of perception* (or, to be more precise, a trace of these *fractional reactions*).

2. With the growth of the child, observable objects and phenomena increase and become more diversified; their combination into groups and chains is more varied, and the personal experience registered by the child in its memory becomes richer. On the other hand, with the gradual exercise of the sense organs and of the entire system of the adaptive motor reactions of the body, including locomotion and especially the movements performed by the hands when grasping objects and breaking them,* the acts of perception, while becoming more and more fragmentary, preserve their previous physiological discreteness. Accordingly, the child is able to isolate ever smaller parts and attributes from the objects, to differentiate them physically and mentally to an ever-increasing degree and to penetrate from the surface of the object into its interior. What an enormous number of separate sensory states must be caused by an analysis the limits of which are determined, on the one hand, by an entire landscape, and on the other, by a tiny grain of sand! And all these states, passing through the mind, become elements of thought! After dwelling on this fact one begins to wonder not at the variety of the objects, but at the ability of the mind to cope with this vast mass of material without collapsing under its weight. Fortunately, the explanation is simple and understandable. Along with the analytical process of multiplication of the objects of thought, there takes place a reverse synthetical process of combining the thousands and millions of identical traits into single terms or signs; the process of fragmentation is accompanied by selecting and grouping identical fragments and reconstituting first certain parts of the divided objects and then the objects themselves. That this is not just a phrase can be easily proved by the child's "tree". To really be an average term, the "tree"

* The moment the child has learnt to seize objects with its hands it begins to break them and tear them, at first unconsciously and afterwards deliberately.

must have an average trunk, average branches and leaves. Consequently, the "tree" is, in appearance at least, a product of numerous fragmentations, generalisations of parts and reconstruction and generalisation of the whole.

With regard to each object taken separately, this fragmentation or analysis is a means of disclosing all the properties of the object; with regard to the sum of objects, it is a means of classifying the objects themselves, as well as their attributes and relations.

In all these processes the analytical work of decomposing objects into parts or attributes and reuniting the identical fragments into average terms do not signify anything new to us. For example, the capacity of the eye to see each point of the object separately is the result of its organisation; our capacity to isolate the part from the whole is determined, as we know, by the discreteness of the acts of perception; lastly, the reuniting of the similar fragments into average terms is due to the act of memory registration by similarity. But what do we imply by the words "reconstituting a generalised whole from generalised parts"?

Previously, when discussing the abstraction of parts and attributes from whole objects, I pointed out that the latter, being constant groups of attributes, can be reproduced in full and in parts. This is what takes place, of course, throughout the lifetime of man, uninterruptedly; while the traces left both by whole objects (i.e., by the sum of the properties) and by their separate parts and attributes (i.e., by the items of the sum) undergo an apparently simultaneous metamorphosis and become average results. Consequently, at all stages of the transformation the linkage between the symbolic whole and the symbolic part remains unchanged. A generalised "tree" is a member of a "generalised forest" in the same way as an "actual oak" is a member of an "actual forest". Every time man encounters an object of the external world, the neuro-psychical process can take place in two directions—from the whole impression to its components, or vice versa. The first case corresponds to analysis, the second—to synthesis (reproduction of a whole group at a hint from one of its members) But, of course, decomposition and reconstitution of sensory products are but elementary lessons for man; as time goes on, he learns to decompose and reconstitute objects from parts not fictitiously, but actually.

3. *It is, of course, impossible to enumerate all the results of* the transformations described above; but if we bear in mind Spencer's idea that here, too, the only possible factors of evolution are the external influences and the variable ground of the neuro-psychical organisation which parallel to each other become increasingly complex, the consequences of these processes can be summed up as follows:

1) Multiplicity and growing diversity of encounters with uniform *objects (of the same species or variety—as the naturalist* would say—or at least of the same kind) lead to average results, which are usually termed *notions* of objects.

2) Multiplicity and growing diversity of encounters with dissimilar objects lead to average results of a still more general character—the so-called *concepts.*

3) Multiplicity and growing diversity of encounters associated with perfecting the means of observation and analysis lead to the *symbolisation of parts, attributes and relationships* which yield products belonging directly to the extra-sensory sphere.

4) All these results are obtained by way of analysis, synthesis and comparison or classification.

Let us consider these points in greater detail.

The *notion of an object differs from the differentiated sensory* image of a concrete object in two respects. The latter, being the result of the differentiated sensory perception of a definite single object, is the sum of the attributes directly accessible to the senses. As to the notion of the object, it is the average of the *separate differentiated perceptions—an abstraction from a* definite sum of uniform objects and, together with the external attributes, it includes those which cannot be revealed directly, but only by a detailed mental and physical analysis of objects and of their relationships to each other and to man. As a single *abstraction from many, the notion of an object is a symbol. As a combination of the properties* and relations *of the object to* other objects, including man, it is a mental form immeasurably richer in content than the preceding form (the differentiated sensory image); it is a synthetic form which combines everything *known* to man about the object. In this sense, the *complete* notion of an object embraces the entire natural history of the object and, equally, its full significance in the life of man. Complete notions of objects are, therefore, rare in the minds of people;* as to the formations encountered in everyday life under the same name, they are merely *fragments of the complete* notions possible at the given time; their content varies not only among people but even in one and the same person, depending on the circumstances of rèproduction (thinking).

Take, for example, the "notion of a chair". People see chairs probably millions of times during their lives; they see them in diverse forms and in different aspects (from the front, back and side) so much so that if the idea of the chair were simply a combination of separate images, the result would be an inconceivable confusion. But everyone knows that a chair consists of a horizontal seat, four vertical legs beneath it and a vertical back behind and above it. In this generalised form the product acquires a definite aspect in space (it can be drawn); at the same time it is the practical use of the chair as a seat which, clearly, has played the greatest role in its development. True, the joiner's notion of a chair is more complete than the one mentioned above, because it includes, naturally, the material of which the chair is made and the process of furniture-making. For San-Gally** the product will be different again, because here the material and the process of production differ from those of the joiner. The idea of a chair formed by a collector of antique furniture would differ from that, say, of a naturalist, if the latter were to take it into his head to write a history of the chair, as Faraday wrote the history of the candle.

But however incomplete our notions of objects may be in practical life, they are at any rate products of abstraction or symbols and they constitute the 3rd order of transformation of all primary sensory forms. The origin of the symbols known as *concepts can be best explained by means of a few simple* examples. in the child's mind the tree, the bush and the grass, being abstractions from groups of similar objects, are notions.

* Even here the completeness is relative, since knowledge progresses; hence, our notions of objects are partly extended and partly modified.

** A hardware shop in St. Petersburg.

The child is aware, of course, of the relationship between the tree and the bush, for he refers to the latter as "a small tree"; it is to be assumed, moreover, that the grass is likewise compared in the mind of the child with the tree and the bush, because the child correctly draws all three objects as forms varying in size and rising vertically from the ground. This means that the comparison of these objects (according to similarity of the reactions of perception), from the point of view of their size and their position relative to the horizon, has already taken place in his mind. Later, when the child learns from his own experience or from his mother or nurse to distinguish stalks and leaves in the grass, it is possible that he begins to be aware of the relationship of the latter to trees. But if the child is told that the tree and the grass are "plants", the meaning of the latter will be lost on it, because to the child it lacks a sensory form. The child may memorise this word and even use it properly, but for quite a long time it will merely be a *general name* for similar objects. The words "beast", "bird", "insect" and "animal" undergo the same transformations in the child's mind. The meaning of the first two words (beast as a quadruped) can be easily explained to the child; but the word "insect" requires special instruction, and many people do not use it properly; even the words "animal" and "plant", are used as mere names of objects by people unacquainted with the mysteries of zoology and botany.

The process of the formation of concepts and names is still more evident in the scientific systems of classification. The words "vertebrates", "Annelida", etc., correspond to definite concepts—to typical general attributes of definite groups of animals; as to the words "variety", "species", "genus", etc., they are conventional labels for groups of animals arranged in chains according to the varying degrees of similarity. Words of the first kind imply realities—certain things common to the structure of the organism, while words of the second kind are but symbols which can quite easily be replaced by other words. This is the essential difference between the name and the concept, a difference which, unfortunately, is often overlooked.

In scientific systems of classification abstracts are often obtained by comparing separate parts or attributes abstracted from whole objects. I shall cite some examples illustrating the comparison of inter-object relations.

When the infant has learned to use its eyes, it, clearly, perceives the external objects as things outside its body: while in the lap of its nurse, it reaches out for the brightly coloured objects before its eyes. Later, when it has learned to walk, it is able to appreciate the distance of the objects—it grasps the objects near at hand and walks towards the distant ones; in these actions it is guided by the already differentiated muscular sense which accompanies the adaptive reactions of the eye to near and distant vision. Soon the child learns also to appreciate the difference in the size of familiar external objects. For example, when drawing a man, it does not make the head bigger than the body or the feet bigger than the head. These drawings also clearly show that the sensory substrata that enable the adult to measure the planary dimensions of objects in height and width are beginning to take shape in the child's mind; in my view, the explanation is that the greatest dimensions of most objects surrounding the child are vertical (man, tree, grass, church, house), while the ground on which they stand is horizontal to the eye. Hence the habit of moving the eyes mainly in vertical and horizontal directions in order to determine the top, bottom and sides of objects.

Thus, the imperceptible sensory formations, which we designate by the words *spatial relations*, develop in the mind already in childhood. They are imperceptible because they are determined by the muscular sense of which we are unconscious and which accompanies the acts of looking in all directions: nearby, into the distance, upward, downward and sideways. These acts are the concomitants of the visual processes; repeated every minute of our life, they form, together with the latter, the so-called musculo-visual associations; on the other hand, breaking away from these associations (by virtue of the general laws of dissociation of impressions) and merging with one another by virtue of similarity, they lead to the formation of such concepts as *proximity*, *distance*, *top*, *bottom*, *size*, *remoteness*, etc. Thus, thinking in terms of forms, dimensions and movements corresponds in its essence to thinking in terms of the traces left by the motor reactions of the eyes and hands during the acts of vision and touch.

From these examples the reader will easily appreciate that the symbolisation of parts, attributes and relations abstracted from complete objects yields products which occupy an intermediate place between the notions of the objects and the mental forms directly exceeding the bounds of the sensory sphere. Notwithstanding the obvious existence of a sensory substratum, the abstractions of this category are so removed from their sources that their sensory origin can hardly be discerned. Consequently, replacing reality in our thinking, they often seem to be something more than *abbreviations*; to be precise, they appear as *conventional* signs, or symbols.

Let us now pass to the last point.

Classification of objects is usually regarded as the prerogative of scientists; however, this is not quite correct: the laymen and even children also classify objects, though, naturally, they confine themselves to closely related objects and, what is more, related by attributes directly accessible to the senses. A tree and a bush, a river, a stream and a brook, a mountain, a hill and a hillock are typical objects for comparison according to size. Objects with distinct outlines are undoubtedly compared according to these outlines (for example, a straight, hooked and snub nose), heavy objects—according to weight (for example, metals, and their antithesis—down), sounds—according to timbre, etc. In short, every outstanding feature in a chain of similar objects is in itself an indispensable condition for mental confrontation by virtue of the law of registration by similarity. Practical needs and everyday occupations also play their part in engineering such confrontations. As the mountaineer sees it, the mountain and the hillock are something more than mere visual forms; they are characterised also by the degree of fatigue associated with the ascent of each. The person who carries heavy loads on his head most likely keeps in mind something in the nature of a comparative table of the specific weights of diverse objects. We see, therefore, that in some cases classification is of no practical significance, while in others, on the contrary, it is of direct use.

As to the ability to classify all objects, or more exactly, to compare objects of the external world in groups of two, three.

etc., here again everything depends on the perceptual reactions which, with exercise, become increasingly differentiated at the same time retaining their distinctness. Thus, the planary form, colour, size, distance, direction of vision, etc., are the visual attributes of objects and of their parts at all stages of the exercised vision. Consequently, no matter whether we look at a group consisting of several grains of sand, or at a landscape, the visual reactions are the same, and this uniformity always corresponds to the similarity of attributes (because the discreteness of the attributes derives from the discreteness of the perceptual reactions). This enables us to compare, according to similarity, even those things which in everyday life are unjustly considered as having no resemblance to each other. There can be no absolute dissimilarity in the external world, because our instruments for perceiving sensory impressions are the same for all objects. That is why all objects of the external world are called *visible*, and that is why we attribute to all of them certain common properties without which no object is conceivable, such as extent, resistance to pressure and weight. But if any two objects have a degree of similarity, it is obvious that they can be compared and arranged in a chain according to this similarity. Previously, when speaking of the physiological aspect of the attributes or properties of objects directly accessible to the senses, we mentioned 21 such properties; the number of possible traits of similarity between objects, naturally, is bound to be the same. Almost all the visual and tactile attributes are, with few exceptions, innate in terrestrial bodies; consequently, even the most dissimilar objects can be compared with each other in 9 directions according to similarity And this applies only to the properties directly accessible to the senses, when the objects have not yet been physically decomposed and when the senses have not yet penetrated into the depth of the objects.

This shows, without further explanation, the vast number of thoughts of which man is capable when the sensory images of objects assume the form of notions and when the perceptual reactions have been differentiated to the utmost (it should be borne in mind that even then thinking is, in its content, a comparison of objects in a certain relation). There is not the slightest doubt that from the beginning of the world up to our times the man has not existed who could mentally accomplish all the possible comparisons between all the objects of the external world taken in pairs. Not only is the span of life too short for this, a series of processes of this kind would have no practical significance, it would be more like the raving of a madman. Yet every man is capable of making these comparisons, and the best proof is that, with the development of symbolisation, the sensory products of the primary stages can, increasingly, assume the form of thoughts or states of ideation. That is why the symbolisation of impressions is also rightfully called the *ideation* of impressions. The primary sensory product, after undergoing the above-mentioned transformations, loses the bright colours of reality, but gains in respect of ideation.

Thus, only the following processes can be definitely established in the internal symbolisation of the impressions produced by the objects and phenomena of the external world (or—what is the same thing—in the formation of abstractions of different orders): 1) a more and more detailed analysis of the sensory concretes, extended to an ever-increasing number of their groups; 2) classification of complete objects (i.e., of the natural sums of the traits), and of their parts, attributes, states and relations, into groups of a more and more general character. The first half of the processes corresponds to a more and more differentiated dissociation of the sensory groups and chains which is invariably connected with the exercise of the sense organs and with the increasing number of life encounters. Actually these are the same processes by means of which at the lower stages of evolution groups of objects are decomposed into their component parts and complete objects into attributes directly accessible to the senses. Consequently, in this respect the phase of abstract thinking is the natural continuation of the preceding phases. But the same can be said of the second half of the processes. Separate acts of classification, whatever their objects may be, consist either in comparing pairs of the objects subjected to classification, or in considering each object separately; in the latter case, the impressions produced by each object are mentally compared with the reproduced average trace left by all the preceding similar impressions. In both cases the comparison leads to the merging of the similar aspects of the new and old impressions.

and to the formation in the common trace of particular combinations of similar attributes corresponding to those of the species or genus. Thus, here again we find nothing new with regard to the basic law of the registration of impressions by similarity.

Consequently, *in general, the whole cycle of inner transformations of the sensory products into more and more symbolic forms, which begins with the notions of objects and ends with passing directly into the extra-sensory sphere, can be explained by Spencer's hypothesis to the same extent, or almost to the same extent, as the phenomena of evolution at the preceding stages of development.*

The one aspect of the human organisation that baffles comprehension is that even the child manifests an instinctive interest in a detailed analysis of objects which bear no direct relation to its orientation in space and time. According to the structure of the sensory mechanisms (at any rate, of the peripheral ends of these mechanisms), the higher animals should be capable also of a very detailed analysis (but to a lesser degree than man who is provided with such a delicate analytical instrument as the hand with its wonderful tactile surface); however, in their analysis, as well as in the generalisation of impressions, animals for some reason or other do not go beyond the limits of the practical requirements of orientation. The animal remains all its life a narrow utilitarian, while man acts as a theoretician already in childhood. It is clear, however, that in the mental acts of man this feature plays only the role of an indefinite stimulus or motive, like hunger, for example, which makes the animal look for food, but never exerts any influence on the development of thought as such.

*A thought formed of symbols of any degree of generalisation remains a differentiated sensory group or the sensory expression of a nervous process proceeding along an isolated group of differentiated pathways*

4. Passing now to the question of the external symbolisation of sensory acts, let me say in advance that its extreme complexity* exceeds by far the limits of my competence, and I touch

* Actually the external symbols by means of which man expresses his emotional states include the natural gestures of the body (including the

on this question only because it has an aspect which cannot be disregarded by any investigator in the sphere of thought.

Man's ability to express his emotional states by means of conventional external symbols serves him not only as a medium for mental intercourse with others, but also as an auxiliary or even as an instrument of his own thought. Thanks to education, thought begins to assume the form of words already in childhood and little by little man learns to think in three patterns: 1) a more or less fragmentary and abbreviated reproduction of actual experience, without transmuting the sensory elements into conventional symbols; 2) the same abbreviated reproductions with their elements expressed in words; and lastly, 3) words only. The stronger the sensory elements of the impression, the greater the chances of its reproduction in the first of the above-mentioned forms. And conversely, the more symbolic the sensory elements of the given moment, the greater the chances for their expression in the more habitual symbolic (abbreviated) forms. For the vast majority of people the word is the habitual form. But when thought passes from the sensory into the extra-sensory sphere, speech, as a system of conventional symbols, developing simultaneously with thought and conformably to it, becomes a necessity. Without it, the elements of extra-sensory thought, deprived of image and form, could not be retained in the consciousness. Speech imparts to them an objective character, a kind of reality (fictitious, of course) and it is, therefore, the basic condition of extra-sensory thought.

These facts are well known, and there is no need to dwell on them; but they give rise to some questions which cannot be ignored.

If we bear in mind that the bulk of the knowledge acquired by almost every person derives from the experience of other people transmitted in oral or written form, the thought naturally arises that man's ability to speak and to write probably plays a more important role in his mental development than the so-called personal experience of which we have spoken up to now (and

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voice); the conventional gestures (mainly, imitative) of the deaf-and-dumb; speech and written characters; abbreviated graphic diagrams or drawings, and the system of mathematical symbols.

which is understood as sensory forms becoming more and more differentiated and generalised with the ever-increasing modification of the objective and subjective conditions of perception). If this is the case, then clearly the main determinant of mental development is not *Spencer*'s general factors whose interaction creates personal experience (the developing innate nervous organisation and the external influences), but the great mental changes which take place in the pupil when learning the art of speaking, reading and writing. It can be assumed, therefore, that the basic factors of thought as a mental process undergo profound changes with the introduction of such conventional symbols as words.

5. To clarify this question, the first thing to do is to make the acquaintance of the structure of the neuro-muscular apparatus of speech and afterwards to examine the process of teaching words to the child.

Man can whisper in two ways: either by slightly inhaling air or by slightly exhaling it. In both cases the air, when passing through the oral cavity, produces a slight sound which, owing to the movements of the uvula, tongue and lips, is articulated into words. Consequently, the whole mechanism of speech actually consists of diverse combinations of the work of the muscles which govern the movements of the afore-mentioned organs. The site in the brain which dispatches variously combined impulses to the muscles of the tongue, lips and uvula, has long been known. In this respect, however, the organ of speech in no way differs from the neuro-muscular mechanisms of the other organs, for example, of the hand, because the co-ordinated movements of the latter are no less varied (the hand in addition to writing all the words of speech, can play musical instruments and do all kinds of work); moreover, the nervous centres of its movements are located in the same area of the brain as the speech centres. Lastly, a definite facial expression, as we know, corresponds to the emotional character of speech, and powerful emotions, while paralysing speech, simultaneously stop the movements of all other parts of the body. Consequently, there are definite pathways leading from the sensory spheres to the speech centres. But the organ of speech is characterised, in addition, at least in early childhood, by the following feature: it is stimulated by acoustic influences. Like some birds (for example, the starling and the parrot), the child instinctively imitates sounds. For a long time the sounds "moo-moo" and "twit-twit" evoke *in the child the images of a cow and a bird. It is precisely this peculiarity of the neuro-psychical organisation* which paves the way to the learning of words. We cannot explain this innate tendency to imitate sounds, just as we cannot explain the innate capacity of our eyes to project impressions outwardly; what we do know is that it is involuntary, that it is much the same as the corresponding ability of the parrot, and this is sufficient for our present purpose. We know that *the innate neuro-psychical organisation of the child is one of the factors determining the development of the verbal symbolisation of impressions; this accords with Spencer's theory.*

Let us pass now to the learning of verbal symbols.

I have repeatedly said that thinking is simply a consecutive chain of sensory signs, parallel to the passage of the nervous process along definite pathways—a series of signs indicating a number of separate acts of perception. For instance, when I see "a yellow, round, spherical body possessing a certain smell and taste", *the sign-chain passing through my mind is as follows:*

*yellow, round, spherical, smell* and *taste,* which corresponds to the following series of separate physiological reactions: *purely optical, musculo-visual, musculo-tactile, olfactory,* and *gustatory.*

But when I am being taught to designate objects by corresponding words, the sound group *orange* and the corresponding *aural reaction* are added to this series of sensory signs.

*When the child learns to pronounce a word, the reaction in* its mind becomes *musculo-aural.*

Is there any need to demonstrate that the new members differ from the old only in form? All the impressions derived from external objects and their relations, including such concrete objects as a dog or a tree, are but sensory signs of the external objects and of their relationships. *Consequently, nothing alien is introduced into sensation by words.* So it is that the optic signals of the object perceived by the eye and the word spoken by the mother perceived by the ear are associated into a group according to the law of contiguity, and in this way the object acquires a name. A long time must pass, I believe, before the child begins consciously to distinguish between the name of the object and its natural properties. Even adults sometimes commit the sin of confusing the names of objects with reality. In any case, so long as the process of teaching words signifies for the child's consciousness the action of definite external influences on the organ of hearing plus the influences exerted on other organs,

*the second factor of the verbal symbolisation of impressions is, in keeping with Spencer's theory, a complex of varied external influences.*

Such are the child's first steps in this new sphere of impressions. The second step in the verbal symbolisation of impressions consists in distinguishing the name of the object as such from the names given to its properties; this step corresponds to abstraction of the attributes from the object. Later, when the child itself, independently of any teaching, begins to differentiate and classify objects and their abstracted parts, attributes and relationships, the need for new designations arises; this need finds ready satisfaction in speech which down the centuries has been developing parallel with the development of thought and in conformity with it. Alongside the classification of objects according to similarity, there appear names for the kind, species and genus Differentiation is accompanied by the appearance of names for complete objects and for their parts. When the thinking passes from the objects to their properties and relationships, i.e., when it is their attributes, states and interrelations and not the objects as such which constitute the subjects of thought, the language is ready to turn adjectives and verbs into nouns, etc. Man learns this in practice as well as in theory, i.e., through application of the things learnt. And so, gradually the elements of speech cease to be acoustic labels attached to the separate elements of thought; words begin to symbolise personal experience and, like the latter, are combined into definitely coordinated sensory groups. When this takes place it no longer makes any difference to man whether he thinks in terms of direct symbols or in the form of conventional symbols.

The way is cleared for this last step in the evolution of external symbolisation, i.e., the complete separation of the name from the object designated, by the gradual process of separating the acoustic members from the sensory groups with which they are associated. As elements of the association, equivalent to all the other elements, the names, obviously, share the same fate as all the elements of the group. They can serve as hints for the mental reproduction of the whole group; they can be reproduced themselves at a hint from another member of the group and, lastly, they, like all the other attributes, can be abstracted.

In short, no matter from which point of view we consider the question, it turns out that the introduction of verbal symbols into thought is either an addition of new sensory signs to an already existing series, or a replacement of some signs by others which are physiologically equivalent. It is clear that the nature of thought is not, and cannot be, changed by this.

*Even metaphysical thought, as a process, remains a series of sensory signs parallel to the movement of excitation along definite pathways.*

## VII

Active forms of thinking.—Self-sensations.—Self-consciousness.—Deductions in general and deductions in particular.—From *action to cause*

1. Turning now to an examination of a new and vast range of phenomena which impart to man's mental activity a pronounced active character, I shall endeavour, first, to define the limits of this problem.

When applying Spencer's scheme to the development of the various forms of object thinking from complex impressions, we were obliged of necessity to portray man as a passive carrier of the changes which take place in his neuro-psychical make-up. Instead of man, with his capacity for the most varied mental initiative, we posed his innate neuro-psychical organisation with its likewise innate capacity to develop in a definite way under the influence of external factors; and in all cases without exception we looked on this organisation as something passive, affected solely by the external environment. To an appreciable degree the mental development of man takes place in this way, inasmuch as he reproduces and acquires the elements of his own experience and of the experience of others. But everybody knows that the person who has learnt to think is able not only to assimilate the elements of experience, but also to make use of them, to apply them in practice. As a thinker, he observes and analyses facts, compares them, draws conclusions, generalises the results of the analysis and comparison and, ultimately, discovers the causes of phenomena. And since in all these cases, man is the active agent, the entire complex of phenomena is known as *active thinking*.

Let us now examine all the phenomena pertaining to active thinking.

2. When the child has learnt to express itself in words, we know from what it says that it is always conscious of its *initiative* in the matter of thought and action. The child's talk is every bit as impregnated with the pronoun *I* as the speech of the adult, if not more so; its *Ego* feels, thinks, wants, runs, sulks, cries, laughs and, generally speaking, does all the things in which the mind takes part alone or with the participation of the hands and feet. It is obvious that in these circumstances the use of the word *I* is based on certain sensory states, otherwise the child would never acquire this mode of expression.

It is easy to see that the expressions used by the child are, in substance, confined to the things it has seen, smelled, touched, to the *things* it has felt in general, and to *how* it acted; as recollections, they are reproduced acts, but with the addition of a new element—the word *I*—which imparts an active character to the thought. Consequently, the whole thing lies in the sensory essence of this word.

Along with perceptions from the external world, we continuously receive impressions from our own body. Some of these are perceived in the usual way (one's own voice—hearing, the forms of the body—sight and touch); others emerge, so to speak, from within the body and appear in the consciousness in the shape of indistinct, vague sensations. The latter accompany the processes taking place in the main anatomical systems of the body (hunger, thirst, state of satisfaction, fatigue, etc.) and are rightly called systemic senses. Since these processes take place in the body continuously, the systemic senses must always fill the mind, and if we are not always conscious of their presence, this is because they are extremely indistinct compared with the products of the activity of the higher sense organs. But the moment the strength of one of the systemic sensations rises above the usual level, it begins to prevail in the mind, or at least becomes an equal member of the associated chain passing through the mind at the given moment.

For this reason man cannot have any object sensation of his own without some kind of admixture of a systemic sense. One part of this mixture or association, provided by the activity of the higher sense organs, has its equivalent in an object of the external world, while the other part has no such equivalent. The first part of the sensation bears, so to speak, an objective character, whereas the second is purely subjective. The first corresponds to the objects of the external world, the second—to the sensory states of the body itself, to *self-sensations*.

When for one reason or another man becomes conscious of this sensory element, the latter, always associated with simultaneous impressions from external objects, imparts a subjective character to the sensory state. Since, however, the systemic sensations of the normal person are always obscure, indistinct and non-differentiated, it is seldom possible to distinguish the separate components of the subjective appendage. This is proved by the fact that when, in the course of dissociation of the group, the subjective factor becomes isolated into a separate link (the dissociation takes place, of course, according to general laws), no appropriate terms are found for it in the human language (if we exclude the cases when it is designated by a human name, for example, Peter or John) and it is indicated even in childhood by the generic symbol *I*.

Because of the extremely frequent formation of these associations, which, for the sake of brevity, I shall call *personal sensory chains*, any sensation in general, no matter how fragmentary, can manifest itself both in the consciousness and in speech in two forms—with and without the addition of the *I*. In the first case the sensation or thought expressed in words always bears the character of an objective description of what has been experienced: "the tree lies on the ground", "the dog is running", "the sparrow is chirping", "the flower emits a scent". In the second case, the same acts acquire the character of a description of definite personal sensations: "I see a tree lying on the ground", "I see the dog running", "I hear the sparrow chirping", "I smell the flower". The difference in the two cases consists solely in the addition of the two subjective members "I see", and "I hear"; but what a difference, both in form and content! In one case we describe phenomena taking place outside us; in the other we describe the same phenomena as our sensory acts.*

True, man becomes fully conscious of this difference not in childhood, but later, when all the reactions of perception have not only been completely differentiated, but have combined into groups according to the degree of similarity and to the sense organs to which they belong. At this stage all the members of the typical personal chains, usually expressed in speech by verbs, acquire a definite meaning in the mind. The effects of the stimulation of the sense organs by light, sound, smell, etc., abstracted from everything else and symbolised, become *sight, hearing, touch* and *smell* (in the Russian language there is no corresponding term for the sensation of taste) as species of the genus "sensation"; the motor reactions of perception become *looking, listening, smelling* and *tasting* as active aspects of the same processes (which, properly speaking, is incorrect, because the passive forms correspond to the effects of nerve stimulation by light, sound, etc., whereas the active category consists of the muscular reactions that take place during the act of perceiving impressions), as well as species of the genus "action". Since their connection with the sensory element *I* remains uninterrupted, it is clear that in the end there is bound to be two forms of *I*—passive and active—"I feel" and "I act".

And so the *self-sensation* of the child develops into the *self-consciousness* of the adult; this enables man to approach the acts of his consciousness critically, i.e., to separate *all his internal factors* from the external factors, to analyse the former and compare them with the latter and to study the acts of his consciousness. Although such introspection is a simple phenomenon, it is often interpreted in a strange way. This can be illustrated by a simple example.

From childhood man is told what he may desire and what he may not, what is good and what evil, is warned of the likely consequences of bad actions. So that when the child associates an action with these admonitions, the latter enter the reproduced picture as indispensable elements imparting a definite colouring to the motive of the action, to the action itself and to its consequence. Is not this self-analysis and even self-judgement? And is not this true of corresponding examples in the life of the adult? In both cases the decisive factor is the *recollection* of the action, which is differentiated into motive, action and result, with a definite appreciation of all the three members of the chain as conforming to a definite moral code. Yet for many people this phenomenon is a mystery; they say that man, as it were, becomes a dual personality—able to act and, simultaneously, to judge his actions. This incorrect approach is due to our habit of separating man from his thoughts and actions, forgetting that this is a purely mental and by no means a real separation.

I shall not dwell any longer on self-consciousness, because this would mean going beyond the limits of our task and examining the logical aspect of thought. I shall, therefore, revert to what was said at the beginning of this chapter concerning man's ability to observe, analyse, compare, draw conclusions and discover the causes of phenomena.

3. If we abstract ourselves from what is tó us the incomprehensible innate tendency of man for observation, we shall not find in the powers of observation anything other than the ability to make skilful use of the sense organs and so discern the exceedingly delicate nuances in their indications. As to *comparison* regarded as an active form of passive *confrontation*, it is simply an expression of the latter in the form of personal action; the same can be said about *generalisation*, i.e., the combining of similarities into groups of a more general character. *The decisive thing in both cases is that the similarities and the differences are ascertained independently of our will and reasoning.* The matter is quite different—seemingly at least—with deduction, which has always been regarded as a conscious act of the intellect. This point requires a more detailed explanation.

In everyday life, as well as in the textbooks on logic, the term "deduction" signifies the final act of the intellect which is always preceded by a mental confrontation of objects or by a series of confrontations. A deduction is always the result of analysis, the comparison of a series of analyses, or, finally, of a series of comparisons. In its simplest form the deduction does not contain anything that has not been given by the preceding confrontation, because, as we know, the latter always contains all three elements of thought, i.e., the objects compared and their relationships; hence, the deduction can only be thought. Actually in all cases the mind which *makes* the deduction does not accomplish any work: the man merely repeats the preceding act and, for the most part, in verbal form.

But often, and even more often, the deduction does not fully coincide in content with the preceding confrontation (in these cases the logicians refer to the latter as *a premise*). Thus, in practice (in the sphere of concrete, symbolic and mixed thinking) the deduction can be inferred: from the part to the whole, and vice versa; from the attribute, property or state of the object to the object itself, and vice versa; from a given case to cases of varying degrees of similarity (and vice versa), or, what is virtually the same, from the particular to the general; from a phenomenon or fact of the given moment to an anticipated or absent fact; from the present to the future; from the effect to the cause, and vice versa; and lastly, from the sensory to the truly extra-sensory.

In all these cases (for the sake of convenience, I ask the reader to exclude for the time being deductions which proceed from the effect to the cause and from the sensory to the extra-sensory, since they will be dealt with later) the mind making the deduction actually does some work, because of the absence of the elements of the deduction, and the deduction is reached by passing from the present to the absent. But what kind of work does the mind perform? To answer this question one has only to bear in mind that if man is able to draw deductions about the subject under consideration this is solely because he bases himself on the knowledge acquired from previous experience. Without this experience, deduction is impossible. Consequently, in these cases the reproduced element of the previous experience takes the place of the absent member, thus making deduction possible. Experience alone enables us to draw conclusions concerning complete objects by their fragments (reproduction of the whole by part). Similarly, from the specific mobility of an object seen for the first time, we can conclude that we are dealing with an animal (reproduction of the attribute of a class by the particular attribute of a concrete object). For the same reason, when we see lightning during a storm, we anticipate thunder (reproduction of a corresponding previous experience with a complete number of members). All this is known to us from what has been said earlier, so much so that further explanation would be superfluous, had I not mentioned among the deductions those which proceed from the present to the past and future. Since nothing has been said about their composition from the point of view of sensations and ideas, I deem it necessary to dwell on these two forms.

In the sphere of sensory thinking, the *past* in relation to the *present* is mostly recollection of things actually experienced. Generally speaking, we can distinguish a sensation of the past from one of the present because of the big difference in their content (vividness) and in the conditions in which they originated (the real impression necessitates a real substratum, the recollection does not). But when past sensations relating to different periods of time are simultaneously reproduced in the consciousness, the conditions by means of which we distinguish them are no longer the same; the conditions derive from the auxiliary circumstances which accompanied the acts compared and which were associated with them. To the extent that these auxiliary circumstances differ, often in a purely casual way, we are able to distinguish the remoteness of the acts themselves. Without these auxiliary circumstances we would not be able to distinguish between similar sensations relating to different periods of time.

In other words, in the sensory sphere the *past* in itself contains no characteristic features. Later, when man has gained knowledge of the *chains* or of phenomena in their natural sequence, when he has learnt to differentiate them in time at every new encounter with a familiar chain, there are moments of awareness that a certain link in the chain was present and then disappeared, that another is still present and that a third is anticipated. It goes without saying that the sensations which correspond to the moment of disappearance, especially if the latter is abrupt, are not perceived in the same way as the subsequent ones; and as a real sensation, it, in its turn, differs from the anticipated one which is a reproduction. Consequently, during encounters with phenomena or chains of phenomena man gradually learns to distinguish the important moments which correspond to the appearance, duration and disappearance of the links of which the chain is composed. On the other hand, from encounters with the fragments of the chains man learns to compare the intermediate links with the extremities, and vice versa (reproduction of the whole by a part); naturally, in these comparisons the preceding link appears in the consciousness with the attribute of disappearance in relation to the subsequent link, while the latter appears with the attribute of anticipation. Still later, when man enters the period of classification and generalisation of the differentiated chains, these sensory attributes become symbols—preceding and subsequent, *beginning, continuation* and *end, past, present* and *future*. Here, the past is what has disappeared; the present is what is taking place, and the future is what is anticipated.

From this brief outline the reader will gather without any further explanations that man arrives at the concept of *present, past* and *future* exactly in the same way as he arrives at the concept of space. In the first case, the analysed and classified elements are in their initial form the sensory chain with a varying succession of its links in time, whereas in the second case, it is a group with varying combinations of the links in space.

It follows, then, that deductions effected from the present to the past and future can contain nothing except that which is already known from previous experience.

Hence, *whatever the relation of the deduction to the premises may be, we cannot find in it anything that is not contained in the premises or in the elements of previous experience corresponding to these premises.*

Were it not for the obstacle in the shape of the active form of the process of "drawing conclusions", I would even go so far as to say:

*From the psycho-genetic point of view, the deduction* (or conclusive statement) *is simply a previous experience reproduced by premises in all cases when the acts of thinking assume the* *form of syllogisms**; but the afore-mentioned obstacle, too, will soon be eliminated.

The question of the sensory sources of the processes of deduction was first elucidated by Helmholtz. In his famous work, *Physiological Optics*, he examined the conditions of development of spatial vision and came to the conclusion that when it has been formed in the child, the sensory acts corresponding to the different aspects of spatial vision assume the form of processes of deduction; this is because all the motor reactions of the child exhibit at this period a kind of *reasoning* concerning the distance, direction, size and other spatial attributes of the visible objects. This reasoning is so pronounced in the sensory acts that Helmholtz did not hesitate to call them *conclusions*, although spatial vision exists even at this early period of life when there can be no talk about the child being able to *reason consciously*. Helmholtz, however, finds a way out of the contradiction by designating these conclusions as *unconscious*[62] (*unbewusste Schlüsse.*)**

* I think that nowadays no one believes in the possibility of making a deduction *from the known to the unknown*. Even in those cases when a really new confrontation arises in the mind of a person and he, as it were, has an insight into its result, the latter is still a member of the confrontation, in the same way as a relation linking the objects of thought is an indispensable third member of the thought. *The only really new thing is* the confrontation of objects never before confronted by anyone, or the confrontation of objects by some of their new aspects which have been revealed as a result of some fresh analysis or which simply escaped the attention of others. It is clear that here, too, the merit of the discovery *is to be ascribed to the premises and not to the deduction, which merely* states in verbal form what has already been done.

** Helmholtz's idea can be explained by the following simple example Suppose that a child which has learnt to walk sees an object on its right; it turns towards the object, approaches *it, stops, stretches out its hand and grasps* the object. Upon seeing this, the observer might think that the child reasons thus· "I see an object on my right; hence, I must turn to the right and walk towards it since the object is a good bit away from me. I am now alongside the object and there is no need to walk farther; I must *stop and extend my hand.*" *Indeed the actions of the child, directed by* spatial vision, bear the character of reasoning; but in reality they are based solely on the capacity to distinguish spatial relations or to analyse spatial groups. The explanation is that at first nothing is seen in the acts *performed by the child except elements of spatial differentiation; but the* moment this differentiation is seen as a deliberate act on the part of the child, one involuntarily begins to believe that the child *reasons*

All that has been said above can now be summarised.

Self-sensation, or the association of all the external impressions with the sensations emanating from our own body, lies at the bedrock of all phenomena. Even the child mentally separates itself from its thoughts, desires and actions; consequently, personal chains become differentiated already in childhood. At a more mature age self-sensation turns into self-consciousness. The adult, to a still greater degree, separates himself from what is taking place within him; hence—his self-analysis, self-judgement, and in general the feeling that he is active in the sphere of thought. As such, he analyses, compares and generalises the facts (i.e., combines similarities into groups which become increasingly general), passes from the general to the particular, from the particular to the general, and draws conclusions. Moreover, all that in his previous life had assumed passive forms of thought (analysis, comparison, etc.), is now repeated in the form of deliberate action. The form changes, the substance does not.

*There is, then, nothing in this sphere of phenomena which does not fit in with Spencer's general scheme of evolution.*

We turn now to the next logical form of thought.

4. In the sphere of logic there is hardly another question so much in need of a sound psychological elucidation as that of "cause" and "causality" or dependence. These words, together with the aphorism "there can be no effect without a cause", have been repeated so often that one would think that the concepts designated by them should have been established long ago; yet the confusion in this respect is astonishing.

For the sake of brevity and clarity, I deem it necessary to give here a brief summary of the viewpoints on this subject:

1) the concepts *cause* and *causality* are applicable only to *phenomena* and *chains*, both objective (i.e., phenomena of the external world) and subjective (i.e., phenomena of the inner world of man)—to successions, but not to coexistences;

2) the cause is the agent or active principle of the phenomenon, while causality is its relation to the secondary factors of the phenomenon; but this relation is of a specific character: it is neither spatial nor qualitative, neither a similarity nor a relation in time;

3) the causal relationship between the factors of the phenomena is not directly accessible to the senses; it is disclosed by the mind in the course of cognition;

4) the causal relationship is, moreover, the first natural step in the direction of interpreting the phenomena, being

5) a form of apprehending the relationships and dependences between objects which, together with apprehension of their similarity and contiguity in space and time, is an innate faculty of the human mind.

These points can be explained by means of a few examples.

A stone falling to the ground is, for the senses, merely a picture; but the mind goes on to interpret this phenomenon in the following way: the active principle or the cause of the fall is the earth's power of attraction, with the stone playing but a passive and secondary role.

After heavy rains a river breaches a dyke. This is another picture which, when interpreted, shows that the active agent here is the pressure of the water.

The same is true of all disasters *caused* by what we call the destructive forces of nature.

These are examples of the causal explanation of external natural phenomena. Here are a few more, this time relating to the inner world of man.

Man's passions are often the cause of his misfortunes.

The judge tries to find the cause of the crime in the so-called criminal will of the accused, in the traits of his character, in the conditions of his life and even in his pathological state.

Here, of course, the connections differ from those in the external phenomena; still, they have a common feature—the offence results from the criminal will or some other circumstances as inevitably as a conflagration is caused by a spark.

It is quite clear from this that in the sphere of thought causal dependence is a new form of confrontation of the objects of thought, along with coexistence, succession and similarity. The last three forms, as we know, are related to the innate neuro-psychical organisation; this, naturally, suggests that the new form, too, is rooted in the neuro-psychical organisation. Let us see if this is so.

[illegible] the child's consciousness decomposes (analyses) [illegible] into groups and chains, and the latter into [illegible] links, which in their turn are decomposed into their [illegible] (this, as we know, is due to the registration of im[illegible] according to their similarity and contiguity in space [illegible]), the child's mind is filled only with the pictures of [illegible], the latter are merely registered, not explained. But [illegible] moment the child has learnt to speak, it begins to develop [illegible], baffling to us, in objects of the external world, [illegible] about things which impels it to ask mother "Why doesn't the table walk?", "How can the sun move without legs, and where does it go at night-time?", "Why does the wind [illegible]?", etc. True, the questioning may be inspired by the stories which the child has heard from its mother; but one thing is certain, they reflect the desire to know and understand the things seen and heard. This desire, naturally, concerns mainly the things repeated in the same way, because only these things get fixed in the child's mind, and become familiar.

Consequently, our habit of establishing the causal relationships between objects and phenomena is actually based on the innate property, an extremely valuable one, of man's neuro[illegible] organisation which, already in the child, is expressed by the unconscious desire to understand the surroundings. But this is a vague desire and, as we shall see later, it can be satisfied in various ways. In this respect, there is quite a big difference between the causal dependence and all other forms of mental confrontation of objects and phenomena already known to us, namely, coexistence, succession and similarity. The elements of impressions are combined into groups and chains, and the similarities and differences between objects are distinguished spontaneously, without any instruction, whereas the desire to understand is satisfied by explanations given by other people.

[illegible] The moment the child begins to ask how and why, these questions, naturally, are associated with the corresponding answers or explanations by the mother or nurse. Whatever the [illegible] and scientific value of these explanations may be, many of them conform to the scheme of cause, effect and their interconnection. I shall not be exaggerating when I say that in explanations of this kind the cause often appears in the form of an active agent which more or less resembles man with his capacity to act. This very ordinary and striking form of explanation is accessible to everyone irrespective of the level of his intellectual development. In this way, the seed is sown, and it is now the job of the soil to yield the corresponding fruit. And the soil, let it be said, proves to be most fertile.

When the child has learnt to walk, speak and use its hands, it lives in constant activity and play. It is active every minute, introducing changes into the objects of the external world; and, of course, it is conscious of its ability to do so. In other words, sensory chains pass through the child's consciousness every minute (for the sake of simplicity, we might call them *chains of personal action*); these chains, confronted with each other, are differentiated according to the general principles (i.e., the laws of similarity) and, lastly, decomposed into elements which, in their abstract form, correspond to the concepts of the animate agent endowed with the desire and the ability to act, to the action itself and its effect. All this is repeated hundreds and even thousands of times; as a result, the type of animate agent producing the phenomena or making changes in the objects of the external world is so familiar to the child that it becomes the standard for explaining both the phenomena and the changes.

Not only children, but even adults use this standard in explaining things done by the animate agent (another person, or an animal). Not without reason, it is said that man judges the actions of other people and animals according to his own measure. As long as the child's mind cannot explain the physical causes of physical phenomena it applies the same standard to these phenomena too. For this reason, of all the explanations offered to the child by its mother or nurse according to the scheme of causal connection, it understands best those where the cause is attributed to an animate agent, especially in those cases where there are no tangible objects or visible images which could be regarded as the causes of the phenomena.

There is no doubt that this accounts for the emergence in the minds of culturally backward people of myths or spiritualistic causes, by which they try to explain things. By taking the superficial view of the mental processes which take place in the minds of such people, we could mistake them for deductions from the known to the unknown, which, of course, is psychologically impossible. But if we assume that the animate agent is the result of comparison with chains of personal action, the thing becomes comprehensible: the process is a deduction from one chain of experiences, in which a greater or lesser number of links are absent, to another similar chain (which in most cases is actually dissimilar) in which all the links are present.

The concept of cause as an active principle is developed in exactly the same way. The only difference is that here the animate agent is replaced by one of its properties, namely, the capacity to act. The idea of cause as a *force* arose precisely in this way, man's muscular strength, apparently, serving as a standard. In this form, the cause has persisted until recently even in physics, being used to explain mainly those cases where observation reveals or indicates the presence of attraction or repulsion. Nowadays it is rejected by naturalists who no longer regard it as the basic agent in the phenomenon, but as an ordinary factor. Thus, when the stone falls to the ground, the earth is not the only active agent; the stone, too, acts in this role, because it in turn attracts the earth when falling. For the physicist this is a particular case of the interaction of two free masses of different size. Similarly, the cause of the conflagration is not simply fire itself, since only combustibles can burn. The dyke is broken not by the pressure of the water alone, but because its resistibility is insufficient, etc.

How, then, should we understand the concepts "cause" and "causality"? These terms are still used not only in everyday life, but also in scientific literature.

*These concepts, as applied to the facts of the external and internal world, are the first steps in explaining that aspect of the given phenomenon as a result of which the preceding links of the phenomenon are inevitably connected with the subsequent ones.* It is easy to see, however, that this is not an explanation of the phenomenon, but simply a statement of the inevitable succession of its members and their inevitable linkage. The phenomena are decomposed into their component parts in the usual way; but since the human mind has for these cases a ready-made standard of connection between the parts, in the form of an agent (animate or inanimate) and an action, the connection is measured by this standard; the result is that that which precedes becomes the cause and that which follows becomes the effect.

It is obvious that *in the development of the concepts examined above there is nothing incompatible with the theory of Herbert Spencer.**

## VIII

Extra-sensory thinking.—General characteristics of extra-sensory products.—Four categories of the extra-sensory.—The preparatory ground.—Examples.—The sensory roots and the evolution of extra-sensory thinking.—Conclusion

Before passing to an examination of extra-sensory thinking as the highest stage of development of human mentality, I wish to point out that it is not my intention to discuss problems of faith, i.e., the problems of the super-sensory.

Here again our task is to solve the following general question: Does a pronounced change take place in thinking when it passes from products with traces of the sensory to extra-sensory objects, or does the evolution proceed in the usual way, in accordance with Spencer's theory?

For this purpose, we shall dwell first on the preparatory ground on which the extra-sensory appears and then, by means of a few typical examples, trace its development. In order to

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* Many years ago I happened to be present at a lesson when a child was first taught to read. The teacher (my sister) was upset when I, jokingly, told the pupil that *b-a* should be pronounced not "*ba*", as he was being taught, but "*beeay*", since the letter on the left is pronounced "*bee*" and the one on the right—"*ay*". Fortunately, the boy, an apt pupil, quickly grasped that the sound "*bee*" was but the name of a letter which, when it stands before *a*, *e*, *o* and *u*, is pronounced *b*; hence, the combinations of this letter with *a*, *e*, *o* and *u* should be pronounced *ba*, *be*, *bo* and *bu*.

There is no doubt that my first explanation seemed correct to the boy. However, it left the "chain" *b-a* without a connection between the links, whereas the *second explanation joined the links into a comprehensible whole*. After this all went well with the lesson, because a standard had been created in the child's mind.

bring together all the extra-sensory elements, we shall group them into the four categories:

1) external realities and the realities of man's inner world which are inaccessible to the sense organs;

2) possible realities;

3) logical constructions, conditionally applicable to reality, and

4) logical constructions not connected with reality.

1. The general ground for the appearance of the extra-sensory is prepared by the almost uninterrupted observations which enable man to draw conclusions about the presence or existence of an object although at the given moment it is invisible, inaudible and intangible. A familiar hillock or wood obscuring the house from view does not prevent us from knowing that the house, though it cannot be seen at the moment, is there nevertheless. In a familiar place, we are aware not only of the objects that we see in front of us, but also with those behind us. There is nothing sensory in a familiar room which is absolutely dark and silent; but when we enter this room we know exactly where the table, sofa and chairs are situated and we can walk about the room without stumbling against the furniture. A vast category of anticipations is of similar significance: the child's mind is filled with them when walking and performing various experiments. The anticipated is the aim of all of its actions; invisible and intangible at the moment, it exists only in the mind. This thought transition from the actually experienced to the corresponding non-existent reality is repeated unendingly and, little by little, accustoms man to the idea that realities are possible even beyond the senses.

2. Man, with all the processes taking place in his body and mind, is as conscious of his real existence as he is of the reality of what he has seen and felt. Yet the acts of consciousness are not accessible to the sense organs. Consequently, all the acts of consciousness, irrespective of their character, should be assigned to the first mentioned category of realities inaccessible to the sense organs.

Also assigned to this category are the external realities revealed through the medium of simple and scientific experiments.

The concept *remoteness* is accessible to the senses only to a very limited extent—the limit of the range of vision. Everything beyond this limit, even though it is real, is comprehended by thought alone and acquires a definite designation only in the conventional form of measure and number (the number of versts, kilometres, miles, etc.). The same is true of the concept of *smallness*. A speck of dust is the limit of human vision; beyond it are the extra-sensory realities which only the microscope can disclose. The limit of human sensation with respect to everything which lasts in time is still smaller. We are conscious of the continuity of things, because in a transient thing we can distinguish the beginning, the middle and the end. But there is not a man in the world who could distinguish directly, through his senses, the continuity of phenomena of more than a few seconds duration; nonetheless we think in terms not only of minutes, but also of years and centuries, and of course, again in a way that has nothing whatever to do with sensation. We do not have a special sense organ for perceiving electricity, yet "electricity" as a special kind of energy, was perceived by man in a purely sensory way—by its indirect manifestations via the senses. We are not conscious of the movement of the earth round its axis and round the sun, but it is a fact.

The second category includes all the extra-sensory deductions of the experimental sciences (physics and chemistry); all current concepts concerning man's basic mental capacities can, likewise, be included in this category, though with some reservation.

As long as the chemist studies the composition (and other properties) of bodies, by disintegrating them into their elements, reconstituting them and, having done so, classifies all the material in a variety of ways (i.e., according to similarity in this or that respect), he is acting within the sensory sphere and all his actions are a striking example of *involuntary** use of the methods known as the logical methods of thought—analysis, synthesis and comparison. But when the chemist reasons about the structure of bodies and employs the concepts

* My point is that the chemist, when he acts in this way, may not be conscious that he is following the rules of logical thought.

*molecule, atom* and *valency* he is thinking in terms of extra-sensory objects. The molecule and the atom of the chemist are not actual realities; they are possible realities because they are deduced from experiments. The waves produced by water, the periodic swinging of the pendulum and the acoustic vibrations, all accessible to the senses, preceded the theory of light waves. The waves of light and ether are extra-sensory concepts, but they stand on the threshold of reality, i.e., they are possible realities.

In these examples the extra-sensory nature of the objects is immediately understandable because experience has taught us to delineate the boundaries beyond which it begins. But can we say what is real in the psychical sphere? In the past, when it was believed that the participation of the sense organs in man's mental life is confined to the modest role of transmitting the sensations of light, heat, sound, etc., to the spirit, the answer was to hand: the sense organs furnish the raw material to the spirit, while the transmutation of this material into ideas is accomplished by such psychical factors as memory, judgement, sense, intellect and will which to this day are commonly considered as the basic faculties of the spirit. We have become so familiar with these concepts and so used to explaining our own psychical manifestations and those of other people and sometimes even of animals (ascribing to the latter a degree of sense and intellect and even will) that they are accepted by most people. It is not difficult to understand, however, that all the so-called *special faculties of this spirit* are at best hypotheses invoked to explain definite cycles of phenomena, i.e., they are possible realities.

I must stop here to answer the question: How are the extra-sensory objects of the two categories created, *what factors* give rise to them?

The reality of the acts of consciousness, when accompanied by any kind of pleasant or unpleasant sensation, is *felt* directly even by the child. At a mature age, when the personal chains have become differentiated in various ways (thought and desire), man compares them with the phenomena of the external world; at this stage the acts of consciousness *appear to the mind as phenomena* of definite duration taking place inside us. It follows, then, that our ideas of these processes are based on self-observation, analysis and comparison, i.e., on *experience in the broad sense of this word.* The role played by experience in forming our ideas of external extra-sensory realities can be seen from the following example.

Without navigation the savages inhabiting a tiny island somewhere in the ocean would hardly have any idea of the distances beyond the limits of vision. And even among them one could be found capable of thinking beyond these limits. Proceeding from everyday experience, which shows that realities (visible objects) are often concealed from the eye by other objects and regarding the sky as a kind of a curtain descending to the sea he might admit the existence of realities beyond the curtain. In his mind, this imagined reality would be a *possible* reality, the logical result of his premises. But if our savage were enabled to travel away beyond the horizon, he would regard as actual realities the distances concealed by the limit of vision. Generally speaking, the external realities lying beyond the limits of the senses and arising as a result of the data provided by experience, become, for the mind, actual realities only through further experience.

The same is true of the role played by experience in the theoretic construction of the experimental sciences and psychology. These sciences deal with cases where the phenomena are interpreted in the absence of one or several real factors. The mind, so to speak, perceives the indispensability of these factors in the phenomenon and creates them not haphazardly, but in accordance with the facts which are explained. In this sense, the hypotheses always bear the character of logical constructions or deductions from definite premises. The intellect, for instance, *is created according to the causal scheme of things, as an active principle explaining the definite cycles of phenomena used as premises; the oscillations of ether have the same significance for the phenomena of light, etc.*

The third and fourth categories include mental mathematical constructions. I shall dwell in detail on examples from this classical sphere of extra-sensory thought in order to elucidate the general conditions of the applicability of mathematical knowledge to realities and the reasons for its complete divorce from reality.

and is possible only if the symbols are arranged in a definite order. It is impossible, for example, to count at sight even 10 grains of sand placed at different points on the ground without moving the eyes according to a previously accepted system and without mentally noting the periodic fixation of the eyes by means of the words: one, two, three, etc. It will be easier to count the grains by touching them and moving them one by one, though this too will be hardly possible without mental calculation. Why? Simply because the act of counting by moving eyes or fingers, being monotonously repeated periods of a more or less long chain, cannot be registered in the memory separately and, by virtue of similarity, they become merged. The matter is different when each subsequent movement is registered in the mind by a new symbol, for example, an acoustic one; then the memorising takes place without difficulty, because each symbol sums up the material already counted.

Many who have never given thought to the sensory origin of the act of counting might now suppose that numbers have developed from purposeless acts like those of counting objects by means of the eyes or fingers. At first, they may have appeared to the mind undifferentiated either as symbols indicating particular periods of the movements of the eyes or fingers, or again in the form of variable groups of objects isolated in the process of counting from multiplicity*; and only gradually did numbers, with their strictly definite character, begin to develop from this sensory complex, approximately in the same way as thinking develops from an integrated complex sensation.

It is not my purpose, of course, to write a history of the gradual development of numbers; but, as a researcher who has advanced the thesis of the empirical origin of the extra-sensory, I am obliged to indicate those elements of consciousness in which numbers had their origin.

I shall show, moreover, that the various sensory aspects of the act of walking—one of the commonest acts—contains elements not only for the construction of numbers with their

* For example, if from a bundle of rods we draw one rod after another and place them side by side, the first three groups will resemble the first three Roman numerals.

strictly definite character, but also for measuring length and brief intervals of time.

But before doing so, let me say a few words about the capacity of the ear to assess the duration of time.

Sound and time appear in the mind as having a certain duration; in this sense the continuous sounds of the external environment are in all probability the sensory prototypes of time. What is more, the ear distinguishes in the most delicate way the varying degrees of the duration of brief sounds and the intervals or pauses between them. The protracted character of the acoustic impressions and the varying degrees of the duration of the sounds are explained by the structure of the organ of hearing. But how do we explain the capacity to gauge the length of the pauses?

This capacity, clearly, cannot be the result exclusively of aural training, because in each case the pause corresponds to the period of almost complete inactivity of the organ of hearing. Things would be different if the intervals between the sounds were, by virtue of the special structure of the aural apparatus, filled with elements of the muscular sense with their innate tendency to be of long duration in the mind; in this case we would have a definite sensory measure of each pause. But so far no elements of this kind have been discovered in the ear; it is my belief, therefore, that the capacity to assess the brief time intervals is engendered by the primary periodic movements of the body and chiefly by the act of walking. Developing here, it subsequently inculcated the sense of hearing.

Everyone knows from personal experience that man can distinguish directly, i.e., exclusively by means of the protracted muscular sense, the highly variegated degrees of duration and rapidity of the bodily movements, beginning with the *moment* by which people usually indicate the rapidity and the briefest possible duration of an action. It will be appreciated, however, that the sense of rapidity and duration develops easier and acquires a definite character in association with the movements performed with frequency and with a more or less automatic regularity. Such are the *periodical flexions and extensions of the limbs*, i.e., arms and legs (which are the *simplest* and the *commonest* body movements), and above all the acts of walking. In my view awareness of the overall difference between "slow and fast walking" comes even in early childhood. Later, the decomposition of the sensory locomotor chain leads to the isolation of the separate moments of walking when each foot touches the ground, *i.e., when standing on one leg is accompanied by the movement of the other.* As a result, *the duration of standing on the right foot is measured by the protracted muscular sense* called for by the movement of the left foot, and vice versa. No harm is done by this shifting of the sensory measure from right to left and from left to right, for the reason that, when walking with an average step, the two acts, i.e., standing on one leg and the movement of the other, almost coincide in time; moreover, owing to the structure of the hip-joint (see textbooks on physiology) the acts of walking are, of necessity, performed with automatic regularity. When the decomposition reaches a certain degree, the *step* (i.e., the interval between the moments when both feet successively touch the ground) is isolated as a continuously repeated element of *locomotion and as a continuously repeated element of duration.* But since each application of the foot to the ground is accompanied by a sound, the different speeds of the walking appear to the mind as a periodical chain of short sounds where the intervals are filled with protracted elements of the muscular sense. This is how the sense of hearing learns to distinguish the varying lengths of the intervals associated with accelerating or slowing down the rate of walking.

With this conclusion we can now return to the matter in hand.

*Man is aware of the process of walking simply as a regular periodical chain of sounds produced by the feet when they* touch the ground, with regular empty intervals in-between, just as he is aware of the beating of his heart at night. If we were to indicate three successive periods in a chain of this kind by different graphical signs and then look at them a day later, what would they remind us of? The first would flash through the mind in the shape of a single movement (the step has a visual image), the second sign as a twofold movement, etc. But let us *introduce into this picture the acoustic regularity of the pe-*

riods or the *acoustic equality* of the pauses and the signs will become equivalent in meaning to the figures 1, 2, 3. What engenders this *sense of equality*? Basically the educators of the sense of hearing—the elements of the muscular sense which accompany each step; since to our mind these are *the most uniform* of all body sensations, they are perceived as *absolutely identical ones*. And, if walking does contain certain elements which to us seem to be alike, in the same way as man is like himself, then of course they are the elements of muscular sense which accompany each step. That is why walking can have for the mind a form in which the sensory elements are replaced by *empty, but equal* intervals. *When similarity reaches this degree, it corresponds to the degree of equality which transforms numbers into uniform units strictly definite in their interrelations.** Consequently, definite numbers can really arise from the elements of walking.

Walking can be also felt as the periodical application of our steps along the visible line traced by man in space, in the same way as, for example, we alternatively displace the right and left legs of the dividers along the length of a line we are measuring. To the eye, the way traversed appears as an entire stretch (as the distance of the object towards which we are moving) and acquires the significance of a measured length; as to the step, perceived as a continuously repeated element of the way, it acquires the significance of a measure. This significance of the step becomes still clearer when the feet leave traces on the ground. In this case the way is divided into equal parts by the steps. And since the steps can be counted, it is only natural that man should do so in order to measure the distance. This, in all probability, is the origin of the pedal measure of length, and of the ells and spans (probably of late appearance) for measuring height.

Finally, walking can be felt as an acoustic chain characterised by *constancy* of the empty intervals and persisting through-

* Equality can be practical, or sensory, and mathematical. This division is fully justified, since the former expresses an approximation, and the latter—the limit. In practice, however, the equality of numbers (and, consequently, their definite character) is for millions simply the likeness of an object to itself.

out the time man is covering a certain distance. In this case, the process is seen by the mind in exactly the same way as in the case when the duration of a phenomenon, having a definite beginning and ending in time, is measured by means of an acoustic computer (for example, a metronome). The constancy of the steps corresponds in essence to the periods of the time-measuring instrument, while the act of walking, as a chain, corresponds to the instrument itself.

The example of walking is of importance not only because it is a single standard from which numbers, measures of length and time developed, but also because it reduces the source of all three to one and the same agent—the muscular sense, and by doing so makes it possible to determine them physiologically.

*As a computer of equal periods, muscular sense supplies, by means of definite symbols, a series of numbers.*

*As a computer of periodically marked equal lengths, it supplies, by means of the same symbols, definite distances in space.*

*As a computer of periodically repeated equal durations, it supplies, again by means of the same symbols, definite intervals of time.*

The fact that all three products have their source in the muscular sense is of great theoretic significance. In the first part of this work, muscular sense was described as the factor which determines the relations between objects in space and time. The proximity or remoteness of objects, their height, direction and speed of their motion, were all defined as products of muscular sense. Now we see that this same muscular sense, divisible in the course of periodical movements, becomes *a differentiating analyser or an instrument for measuring space and time.*[63]

It is far from my intention to claim that numbers and measures of length and time have developed exclusively from walking. On the contrary, I am well aware that the fractional measures of time in use had their origin in the division of long daily periods into equal parts, and are not due to the reduction of the latter to short conventional units deduced from the duration of our steps. My aim is to show in as simple and comprehensible form as possible that all three products developed originally from some regular periodical movements of the body accompanied by the muscular sense; but precisely what these particular movements were is of secondary importance. I can add to what has already been said this last argument, which proves the origin of numbers from some regular periodical movements.

It is commonly known that from the ancient times to our days only groups of uniform objects have been counted. We count, for instance, the trees in the forest, the sheep of the flock, the windows and chimneys of the house; but I am sure that very few people could say offhand the number of outstanding features to be seen in a man's head. Everyone knows for sure that a man has two eyes, one nose, one mouth and two ears; but many people (I am judging by myself) have never realised that the total number is six. The reason for this, clearly, is not in the practical purposes of counting but much deeper; if man had counted all the features of objects indiscriminately from generation to generation, very important results could have been obtained. The real reason is that the greater the difference between the objects examined in turn by the eye or by the hand, the more the attention is deflected from number to quality and the more difficult the counting becomes. On the other hand, the more monotonous the influences of the external environment on man, the more regular are the periodical movements of his hands, feet and even respiration; but the moment a certain impression exceeds the average level, the harmony of the periodical movements is violated. Does not this show that counting as a harmonious chain developed and could develop only from an equally harmonious movement.

Now the reader will understand without any further explanations that similarity plays an outstanding role in transforming connections in space and time into qualitative relations. This transformation is, as we have just seen, accomplished by means of number and measure; as to the formation of the latter, this is a result of the analysis of regular periodical chains the links of which are similar to such a degree that they are wholly identical.

B

Now let us see if we can find in mathematics other repercussions of reality which make possible the practical application of this science.

Mathematics, which occupies a special place among all the branches of human knowledge, has this remarkable peculiarity: elaborating its extra-sensory material by the usual methods of research—analysis, synthesis and comparison—it, unlike the experimental sciences, deduces infallible conclusions; mathematics obtains absolute truths, while the truths of experimental sciences are relative.

The first indication of the infallibility of mathematical thinking is that all the reasoning and actions of this science depart from axioms. Since most of these axioms are self-evident to educated people, i.e., are understood at once, without any reasoning and explanation, they were supposed to be non-experimental (or, what is the same thing, extra-sensory), while the method of their perception or apprehension was regarded as being direct or intuitive.

To avoid a long discussion of this subject, I will direct the attention of the reader to the following. All self-evident truths are elementary and appear to be highly generalised conclusions applied at every step not only in science, but also in practical life. This applicability of axioms *in practice*, along with the fact that small children do not understand many of them, engenders grave doubts as to their *non-experimental origin*, although, *of course, it does not refute this idea entirely. The following argument, however, does refute it. Everyone acknowledges that intuition is equivalent to a conclusion deduced without a premise.* On this ground, Lewes[64] aptly characterised it in these words: *intuition is organised reasoning;* in saying this, Lewes wanted to point out its similarity with a very habitual movement which has become automatic and in which the mechanism of its assimilation is imperceptible owing to the rapidity and easiness of the action. On my part, I can refer to a still better analogy, namely, to the *unbewusste Schlüsse*[65] *of Helmholtz* in the perception of spatial relations by children at the age when they have just learnt to walk and are as yet incapable of reasoning. The analogy between these acts and intuition is so complete that I can affirm without any hesitation that the intuitive comprehension, say, of the axiom "the part is always smaller than the whole" is psychologically equivalent to the comprehension of the statement: "in order to see an object located on the right it is necessary to turn the head or the eyes to the right". Who can doubt that the second of these truths, which is as *self-evident*, *general* and *necessary* as the first, has a sensory origin? The geometrical axiom "a straight line is the shortest distance between two points", which need not be proved, is undoubtedly also of sensory origin. When looking at surrounding objects, we are quite conscious of the difference (from the point of view of position) between those *directly* in front of us and all the others. We are accustomed to relate the position of visible objects, including even a grain of sand, to the front of our body and to the position of the imaginary cyclopic eye on the bridge of the nose (since it appears to us that we see not with two eyes, but only with one, placed between them). By the words "right in front of me" we imply a straight line; this is implied also in the act of walking. If the given locality does not present any obstacles, we move towards the desired object along a straight line; in doing so we are guided not by geometrical considerations but in accordance with the existing co-ordination of the leg movements with the front of the body and with the direction of our vision along the optical axis of the cyclopic eye. As a result of this practical experience, even the uneducated person considers the following truth as self-evident: "if it were possible to walk straight to the given object it would be quite near, but unfortunately, it is necessary to go in a round-about way". The idea that one and the same action, when applied to identical units produces identical results, and when applied to similar units produces similar results, etc., is another absolute truth constantly invoked by the mathematician in his operations. If the shoe-maker were not absolutely convinced from experience that by using one kind of last it is possible to make shoes of the same size and by using different kinds to make shoes differing in size, he would give up his trade.

The second and most important sign of the infallibility of mathematical thought (for the time being I ask the reader to bear in mind only numbers and arithmetical operations with numbers)* is the ideal uniformity, simplicity and natural unchangeability of the material of which mathematical values are constructed. Thanks to these properties of the material, all the operations to which it is subjected (essentially the same as those we previously attributed to the chemist), namely, analysis, synthesis and comparison, achieve ideal simplicity and produce absolutely correct results. Thus, the statement "twice two is four" is more reliable than the conviction that today will be followed by tomorrow, because the first is an absolute truth, while the second derives from the aeons of human experience with the hypothetical "tomorrow". For the same reasons, the degrees of similarity and dissimilarity in mathematics, from identity to contrast, are quite definite. Of all the many contrasts there are in this world the greatest and yet the simplest are the mathematical concepts of the "positive" and the "negative".

It would appear that all the foregoing properties of mathematical values, expressed in the words *uniformity, natural invariability under the influence of diverse actions, definiteness of operations and results, definiteness of similarities and dissimilarities*, have been borrowed from reality; the only difference is that in mathematical values these properties reach, so to speak, the ideal, whereas in real objects they but approximate to it. Moreover, when characterising quantity, I proceeded from numbers and arithmetical operations carried out with numbers; arithmetic, however, is assimilated in early youth, i.e., by a soil fed solely on realities.

But mathematical thought does not stop at this primary stage of development: from the finite it passes to the infinite, from the invariable to the variable.

If we draw a line with pencil or pen on a piece of paper and examine it under a microscope with adequate magnifying power, we shall see that the line far from being smooth is slightly indented. The explanation is simple. The first contact of the pen or pencil with the paper yields a dot of certain dimensions; consequently the movement of the pen or pencil

* It should not be forgotten, however, that at subsequent stages of the development of mathematical thought only the form of the quantity changes, one common sign—a letter—replaces the signs and numbers.

along the paper produces a continuous chain of dots, and the bigger the dot and the slower its movement, the more granular the chain. The line would be still more irregular, if the gradual movement of the dot were associated with the rotation of a writing instrument around its axis and if the dimensions of the dot were not equal in all directions. But let us imagine a dot with no dimensions; this dot could move with any speed and rotation, and yet its path would show a line uniform in length and without any dimension in width. It would be a mathematical point and the path of its movement—a mathematical line. Both the mathematical point and the line are more than extrasensory, they are what we call fiction, an absolute impossibility; on the other hand, the spatial relations between the point and the line would be strictly defined. This example shows how, by simple reasoning and experiments, it is possible to arrive at fictions where the simplest relations are concerned. On the other hand, it is easy to show that the two fictions can be applied to realities, which is further proof that they originate from realities. For example, the centre of gravity of a body is a concept on the borderline of reality, but this centre can only be a mathematical point. Another example: when a joiner uses a thread to measure the dimensions of an article he is making, he is quite sure that it is the length of the thread that matters, not its width. The notion of the outline of the object is the equivalent also of a mathematical line: the eye sees the outline as the borderline between the object and the surrounding uniform background; but whither pertains this border as a line: to the substance of the object or to the surrounding background? Only the mathematical line possessing no breadth enables us to get out of the difficulty.

To illustrate the development of the finite into the infinite, let us take the following simple example.

We can obtain 2 by adding to 1 a countless number of infinitesimal fractions.

On paper this looks like being a simple matter, but in reality it involves a number of quite important notions: 1) an apparently infinite divisibility of values which do not, however, reach zero, 2) zero as the limit of divisibility—a fiction essentially equivalent to the mathematical point—only the latter is applied to space and the former—to quantity; 3) an infinite increase of values towards the fictitious limit—"infinity" with its symbol $\infty$. These concepts are the starting-points of the higher mathematical analysis; however abstract they may be, they still reflect reality. Thus, to our mind world space is boundless; the absolute zero of temperature is a possible reality; the zero of pressure in the vacuum of the barometer is an actual reality.

Here is another example of mathematical dependence which is equivalent to what we commonly call causal dependence.

If $x$ denotes an unknown quantity connected in one way or another with the known quantity $a$, the two together give us the new unknown quantity $y$:

$$a+x=y$$

If known values expressed in the form of letters or numbers are substituted for $x$, i.e., if $x$ is, so to speak, a variable quantity, then each definite variation of $x$ leads to a corresponding definite variation of the whole sum, i.e., $y$. We say, therefore, that in the given equation $x$ is an independent and $y$ a dependent variable. The first, apparently, plays the role of the cause, the second—the role of the effect, the more so, since here, too, there is the same inevitable relationship as between cause and effect. This is the starting-point of the theory of functions; the roots of which, evidently, lie in arithmetic, and its further elaboration boils down to the study of the relationships between the independent and dependent variables when the latter are continuously changing at varying speed. Moreover, the fact of this *continuous change* indicates that it is the momentary forms of the transmutation, i.e., values approaching zero, which are to be studied. This idea, a self-evident truth, also lies at the base of higher analysis; its origins, evidently, derive from such sensory observations as running water, or any other visible motion, and from simple experiments like the following. A series of dots closely situated but separated from each other from a distance gives the impression of being a solid line. *Consequently, the movement of the pen that produced this line consisted of a number of separate short phases; the result, however, is the same as if the pen movement were continuous.* The difference, therefore, between mathematical and sensory continuity is that the latter, owing to the limited character of our senses, can be only apparent, whereas the former is absolute.

All that has been said above is, so to speak, the background to mathematical thought. Along with constructions that are more or less clear reflections of reality, or that can be conditionally applied to realities (as an ideal standard to a corresponding approximation), we encounter at every step on this background a complete divorce from reality. The products of three multipliers, values of the third power and functions with two independent variables correspond to abstractions from realities—to volumes; but above these limits mathematical expressions of the same order have no connection with reality. Negative values can be conditionally applied to realities, while the so-called imaginary quantities $\sqrt{-a}$ are quantitative impossibilities, i.e., they are not values, but forms. However, in analysis these constructions are equal to all other members, and when the mathematician applies his usual methods to them, he obtains correct results.

In essence, these constructions are products of the usual mathematical operations with symbols of quantity, i.e., with forms, irrespective of their content. When dealing with abstractions, the mathematician thinks in terms of the forms or external expressions of the abstract objects. The infallibility of his conclusions is determined by the fact that in mathematics (as distinct from any other science) form *fully* corresponds to content. Thus, in algebra a simple symbol frequently expresses the value itself, the operation conducted with it and the result; if the result cannot be expressed by a short symbol, it is expressed by a formula.

It is clear, then, that the reason for the divorce of mathematics from reality is, generally speaking, the multiplication of forms by analogy and generalisation.

I have included these mathematical constructions in the fourth category of extra-sensory objects under the heading of logical constructions without a real basis.

How are we to assess these manifestations of the mind? Can we say that they are the peak of thinking, yielding products that lie beyond the limits of experience, and do they entitle us to believe that *human thought is able* in general (i.e., not only in the sphere of quantitative relations) *to overstep with impunity these* limits by means of logic, or, as we often say, by way of speculation? The negative answer to the first question is clear and simple: all transcendental mathematical constructions (i.e., those *which are beyond the reach of experience) are effected, as stated* above, by means of the usual logical operations and symbols; consequently, they do not reveal anything new in man's thinking. As to the second question, the best answer is provided by the *history of development (namely, in the progress) of experimental* sciences, since it is here that the creative capacity of the mind has manifested itself with particular force during the past century.

*The advance of the experimental sciences opens up new hori*zons, raises new problems which follow from experimentation but lie beyond its limits. Fortunately, the human mind does not stop at experimentation, but advances farther into the domain *of enigmas. Some of these enigmas can be solved only partly* or conditionally; others are solved at once and completely with the means at the disposal of a particularly skilful researcher; still others cannot be experimentally solved at the moment, *though they are perfectly clear to the mind.* Thus, Leverrier[66] discovered Neptune not by means of the telescope, but by way of logical deduction based on the available astronomic data. The idea of the role of the medium in the so-called "action at a distance" had taken shape in Faraday's[67] mind as a logical deduction from his experiments long before it was acknowledged by others, and became an indispensable element of the *explanation of experimental facts. Maxwell*[68] *arrived at the idea* of the analogy between light and electricity before it had been proved by the experiments of Hertz.[69]. As a matter of fact, cases of this kind are encountered practically at every step in the *sphere of discoveries, because discoveries are always pre*ceded by certain considerations arising from the new, experimentally still unverified confrontations of known facts (for example, the ideas of Robert Mayer[70] which gave rise to the theory of the conservation of energy). It is only the public that thinks that an unexpected discovery emerges directly from the brain of the inventor, without any pre-history of development, like *deus-ex-machina; but for the inventor himself and for all* those who are equal to him in knowledge, the discovery is simply a new aspect of something already known.

It is, therefore, possible to arrive at truths (positive knowledge) by means of purely logical deductions, but *only on the condition that the truths are based on the known facts, the premises for the deductions.* Is not this the same process that takes place in the mind of the mathematician when he arrives at new transcendental principles? For here, too, the deduction is based on a new confrontation of data already known to the mathematician as a result of his accumulated mathematical experience.

The same is true of the conditional solution of experimental enigmas, i.e., of the formation of hypotheses in the experimental sciences. As we know, the only hypotheses considered trustworthy are those which stand at the threshold of the positive facts waiting to be explained, and where the additional hypothetical elements have a real form, being logical deductions from definite premises, i.e., not actual but possible realities.

Consequently, in the domain of knowledge true progress is always determined by what is possible for the given time, just as in everyday life there opens up beyond the boundaries of the accumulated *experience a sphere of possibilities* for human thought, and man's actions yield valuable results only when his efforts are directed towards these possibilities. Unfortunately, both in everyday life and in the domain of knowledge there are not only real but also seeming possibilities. Thus, in the domain of knowledge human thought has been *accustomed from* antiquity to go far beyond the boundaries of experience and to regard as solvable even such problems as the unification of the sum of human knowledge or the discovery of the origin, purpose and ultimate cause of all things in the universe.

It goes without saying that the attempts of thought to penetrate into these remote spheres are, at best, a wandering among the enigmas without the possibility of proving the validity of the conclusions reached, because scientific experiment alone can provide reliable criteria for distinguishing the real from the seeming possibilities; but in this domain such experimentation is impossible.

Let us stop here to summarise what has been said about the development of the extra-sensory products from experimental data.

Man, by differentiating subjective and objective chains according to the conditions of sensation and action, becomes accustomed to consider as real not only that which is directly accessible to his senses. In his everyday language he even has a special generic name—*possibility*—for these extra-sensory products. The sum of all the experimental possibilities is for any man the bedrock on which he constructs the extra-sensory.

Through the continued decomposition of external bodies man obtains the products that are inaccessible to his senses. His conviction that the invisible speck of dust has a separate existence is based on the empirical knowledge (a conclusion drawn from the confrontation of similar chains) that as the process of decomposition proceeds, the separate parts become smaller and smaller.

Through the continued combination of external objects into groups, man arrives at the knowledge (again a conclusion drawn from the confrontation of similar chains) that as the process of combining goes on the number of the parts grouped grows and the size of the group increases. Some people even begin to imagine (as a consequence of continuous combination) dimensions which exceed the perceptual possibilities of the sense organs; but this imagination is as vague as any unexperienced possibility.

It may well be that the same process of continuous combining of external objects, and also the analysis of the periodical acts of walking, or in any case the analysis of some of the regular periodical movements of the body, are the sources of *numbers* and *measures*. Sooner or later, the numbers are arranged into a system and assume the form of graphic symbols, while measures take the form of standards.

When this results in the formation of the concept of equal parts of the whole, the numbers and measures can be diminished or augmented infinitely; and since the initial values are definite, the derivative measures, too, are definite.

Now the extra-sensory products of the decomposition and combination of the external objects become perfectly *definite* (though conditional), i.e., *comprehensible* to the mind. Thus, the symbols 1/2 mm, 1/100 mm and 1/1,000,000 mm are equally comprehensible, although *the first corresponds to a dimension* visible to the naked eye, the second (1/100 mm)—to a dimension visible only with the microscope, while the third (1/1,000,000)—is inaccessible even to the microscope. The first value is sensory for everybody; the second is extra-sensory for the ordinary man, but can be explained by adducing the size of a millimetre; the third is at the moment extra-sensory to all, but may become sensory, say, in a hundred years. The terrestrial globe, an interval of 30 sec., and the more so of one hour, one day, a week, etc., cannot be imagined as something sensory; but the symbols "a globe of a diameter of one thousand million versts" (which, of course, is larger than the terrestrial globe), or "a period of one thousand million years" are every bit as comprehensible as the symbols "a billiard ball" and "one minute".

Such is the power of the precision of numbers and measures when applied to experimental possibilities resulting from continuous disintegration and synthesis. By their means, modern physics has extended the limits of possible realities to such a degree that no numbers can designate them. For example, on the basis of experimental data the physicist finds about $10^{26}$ or 100,000,000,000,000,000,000,000,000 molecules in one drop of water!

The role played by numbers and measures in classification and generalisation is greater still, though perhaps less striking, and the results are even more important.

The beginning of their application in this respect was shown above when we spoke about the transmutation or generalisation of number and extent in space and time into quantity. These three short words imply a countless multitude of combinations and successions, groups, chains, forms and images. Extent alone includes every conceivable form of curved lines, surfaces, areas with the most diverse outlines and volumes. The great generalising power of numbers and measures is clearly seen from the fact that man could elaborate definite norms *which make it possible to reduce all this material to the formula of quantity.*

The generalising power of numbers and measures is felt at every step in such experimental sciences as physics and chemistry. In these spheres measurement is not only an instrument for the quantitative analysis of facts, it is also a means for classifying them; it is, moreover, a means of a very general character, thanks to which the two sciences arrive at their most general conclusions and theories.

Thus, *the transition of thought from the sphere of experience to the extra-sensory sphere is effected by way of continued analysis, continued synthesis and continued generalisation.*

In this sense *it is the natural continuation of the preceding phase of development which does not differ from the latter in methods nor, consequently, in the processes of thought.*

*But it differs essentially in content. Whereas the preceding phase symbolised reality, this phase symbolises real, but, alas, often fictitious, possibility.*

## THE THEORY OF NON-FREEDOM OF WILL CONSIDERED FROM THE PRACTICAL ASPECT[71]

In view of the close connection between the problems of psychology and real life and the lack of psychological education even among the intellectual circles of our society, it will not be out of place to accompany the theoretical elaboration of psychological questions with a complete and clear elucidation of the practical consequences which ensue from all the propositions advanced. Otherwise the readers will draw their own conclusions and, should these be wrong, the theoretical work will be blamed for disseminating delusions. This article, then, should be regarded as a practical addition to those theoretical problems elaborated by me previously. It is true that the publication of this article is somewhat belated, but for this I am not to blame.

We shall examine here the practical consequences of the theory of non-freedom of will.

At first glance the consequences are innumerable, because this theory, which radically changes man's approach to the actions of others, as well as to his own, concerns all the private and social relations which rest directly or indirectly on recognition of free will. Moreover, a superficial acquaintance with this theory could create the impression that the changes which it has wrought in the views of human relations are highly pernicious. I shall illustrate this by a few examples.

Previously every human action presupposed a free man behind it, a man fighting against evil temptations and remaining free even in his moral degradation. Now, behind each human action there is a slave who is obedient to his own character, tastes, inclinations, desires, passions, etc., and who is driven, willy-nilly, in the direction prompted by his own spiritual make-up. The free man enjoyed the merit of struggle in the event of victory and bore the burden of guilt in the event of degradation; the slave, of course, cannot be held responsible in either case. *Hence the conclusion:* the new theory shelves all the crimes and good deeds and, together with them, all the precious qualities which we are accustomed to deduce from strong will, such as perseverance, courage, loyalty, etc., i.e., exemplary qualities of tremendous educational significance.

In the light of the old theory any agreement between a community and one of its members, or between some of its members, was guaranteed by the freedom of action of the parties concerned; now there is no such guarantee. How can the person who is not free to act assume any commitment? *Hence the conclusion*: the new theory undermines one of the principles of social intercourse and thus threatens the very foundations of society as a whole.

No less pernicious are the consequences resulting from this change in man's views on his own actions. As soon as he is convinced that he does not bear responsibility for any action, whatever it may be, he is no longer interested in perfecting himself morally and intellectually, especially if he has no liking for the task. *Hence the conclusion*: the idea of non-freedom of will is likely to engender immorality, the limits of which cannot be foreseen.

Clearly a theory which involves such dreadful consequences deserves the appellation of an "accursed" theory. Fortunately, however, *it is easy* to see that not a single one of these horrors is really engendered by this theory; it is easy, because in practice—as I shall try to prove—private and social relations are based not on metaphysical fictions, such as the philosophical freedom of will not subject to any earthly law, but on facts (of course, generalised) elaborated as a result of individual and social experience. The sole exception to this is the prevailing opinion about the significance of "punishment"; but even here, as we shall see later, practice is always at loggerheads with the current theory.

In order to present my case in a more striking manner, I shall analyse, side by side, the theory of freedom of will and that of non-freedom of will.

*According to the freedom theory:*

All the mental and moral qualities of man and, in equal measure all the external conditions preceding an action*, play the role of incentives to the action in one way or other. The choice of the latter is ascribed to will, as the supreme factor which, being outside the arena of the conflicting motives, is, in essence, free.

*According to the non-freedom theory:*

All the mental and moral qualities of man and, in equal measure, all the external conditions preceding an action, play the role of both incentives to the action and its *determinants*. Actually, however, in each particular case the role of determinant is played by the dominant motive. The moment dominant position is established, the nature of the action is determined.

Theoretically, the difference between the two points of view is enormous: one recognises the existence in man of an extremely important and special mental faculty, the other completely denies that this is so. But let us proceed.

*According to the freedom theory:*

All the mental and moral promptings to an action, the interplay of which fills *man's consciousness*, while but a part of his spiritual make-up are, nevertheless, quite a considerable part, because none will deny the influence which his spiritual make-up in its *entirety* exerts on his actions. The other part, the part which completes the personality, is will.

*According to the non-freedom theory:*

All the mental and moral promptings *to an action, the interplay* of which fills man's consciousness, can be regarded as the *sum total* of his mental and moral personality at a *particular moment*, because, according to this theory, any spiritual movement, no matter how elementary, is the result *of all the past and present development* of man.

Consequently, whereas in one case the action is attributed to the influence exerted by the sum of the spiritual forces of man, in the second it can with equal justice be attributed to the sum of his personality.

* Strictly speaking, the external conditions cannot be separated from the moral and mental qualities of man, because they act exclusively through the medium of the latter.

| *According to the freedom theory:* | *According to the non-freedom theory:* |
|---|---|
| The conflicting motives have their origin mainly in emotions, moral sense and reason. Man is conscious of this conflict; and since will chooses one or another of the directions suggested by the motives, the choice is always a deliberate act. | The motives have their origin in the same basic sources, consequently here, too, both conscience and reason have their say in the conflict. And here again man is aware of all the phases of this conflict; he knows, therefore, that action is caused by the motive which predominates over all others, he is, likewise, conscious of his attitude to the voice of conscience and reason in the course of the conflict. |

Thus, according to both theories action is a conscious thing, and conscience and reason take part in it, i.e., in both cases *in equal measure action can be ascribed to man as a moral and rational being.*

From the point of view of theory, the difference between the two cases is the same, because of the addition of free will, but in practice this addition loses its significance. In reality in the case of freedom of will action is regarded as being good or bad depending on whether will *accords* with the dictates of conscience and reason, but in the case of non-freedom of will it depends on whether the action is the *result* of these dictates. But in practice this is obviously the same.

Moreover, the foregoing confrontation shows that man, being *conscious of the motive responsible for his decision,* is bound to know whether his action will be a good or a bad one, and what its likely consequences will be. If he is not lost completely to moral sense, any evil decision is bound to evoke protest on the part of his conscience and reason; the latter become accusers, and man himself becomes, as it were, the accused. Qualms of conscience and reason, depending solely on the presence or absence of the latter, are, of course, equally innate in the freedom of will theorist and in his adversary. Consequently, the latter,

*as a moral and rational being is responsible also to his conscience and reason.*

Further, the *confrontation shows* that man, observing the conflict of motives which takes place in his mind before he reaches a decision, *cannot* but know that it is *possible* for him to act in a whole variety of ways in identical conditions, i.e., to act prudently or imprudently, wisely or foolishly, properly or improperly, etc. Naturally, he attributes this possibility to others as well. Given the preconceived idea of freedom of will, this possibility is interpreted as the result of such freedom, and is expressed in the words "freedom of choice". But if there is *no preconceived idea, then, without theoretically interpreting* the correctly arranged and correctly generalised observation, it is deduced from the variety of motives taking part in the decision, in exactly the same way as the diversity of the forms of a phenomenon is reduced by the naturalist to the diversity of the factors engendering it.

Applied to questions of practical life, a generalised observation which has not been interpreted theoretically retains its significance, irrespective of whether or not we recognise freedom of will—

*in both cases the possibility of acting differently under certain conditions, i.e., properly or improperly, is a priori ascribed to every human being.*

But if the theoretical interpretation is taken into account, the difference between the champions of free will and their adversaries will be very great even in practice.

Free will presupposes not only the possibility of man acting in a variety of ways, but also the *absolute* possibility of his acting in a certain direction, in a strictly definite way and in no other, because of his innate *absolute* freedom of choice.

The general possibility of acting in all kinds of ways is, according to the opponents of free will, the limit which cannot be overstepped, one can only suppose that in all probability the good man will do good works, while the bad man will do evil.

This is the only case in which the two theories lead in practice to contradictory views on human actions; I will return to this later on.

So much for the general data. Now I shall proceed to examine the critical attacks, mentioned earlier, on the *theory of non-freedom of will.*

When an agreement is concluded between a community and one of its members or between two individuals, neither party can be absolutely sure that the agreement will be implemented, because this is a matter for the future; what is essential is that the parties should have mutual confidence in the *possibility* of fulfilling the agreement. The same can be said about a man deprived of free will, as far as he remains a moral and rational being; this is because the possibility of acting differently in particular cases is determined not by the presence or absence of free will, but by the sum of the incentives to action which, in turn, depends on mental, moral and sensory factors. It is true that *freedom of action* of the contracting parties is regarded as one of the conditions guaranteeing realisation of the agreement; but everybody knows that these words imply practical freedom, man's dependence solely on himself, so that his actions are not subordinated to the will of others, but certainly not philosophical freedom. The latter would be more of a hindrance to concluding agreements since it would introduce into the prevision a factor unrestrained by any conditions; on the contrary, the dependence of human actions on mental and moral factors communicates a definite stability to the prevision; it is well known that loyalty to an agreement is best guaranteed by the honesty of the two sides, that is, by their conscience.

Hence the fate of agreements in no way depends on the presence or absence of free will; everything depends on moral sense, conscience and reason. So long as these faculties are not deadened or distorted, agreement, whatever the viewpoints on will, is equally possible and, its execution is equally probable, all the moral and mental factors being the same.

But perhaps the conscience and reason of the champions of non-freedom of will differ from those of their opponents. Perhaps it is this theory that deadens and distorts man's conscience and reason. In this case, the afore-mentioned arguments will, of course, be of no avail, since they are based on the equality of conscience and reason, irrespective of the particular view on will.

It goes without saying that what is implied here is the corroding influence of the teaching on conscience, because conscience is the basic factor for honest observance of agreements. Moreover, as we know, reason is infinitely less susceptible to extraneous influences than conscience.

This brings us to the heart of the matter—to an examination of the influence exerted by the theory of non-freedom of will on man's moral sense.

As to the place occupied by moral sense among other psychical manifestations, the psychologists are in agreement. As a sense (*Sentiment, Gefühl*), it belongs to the category of those non-decomposable mental states which accompany highly diverse acts (from an elementary sensation to an abstract thought and from a simple movement to a complex action) and which are expressed in the consciousness by varying degrees of pleasure or disgust. The moral sense proper is a complex of corresponding mental states engendered by human intercourse. Love, respect and confidence, the principal manifestations of the moral sense are, simultaneously, the precious bonds which unite the family and society; love of the good and of truth, adherence to duty and kindness to neighbours—these are the main tokens of man's morality, no matter how and where he lives and acts. From these examples the reader will appreciate that the moral sense is the basis and the regulator of social life.

But how does this moral sense develop? Although psychologists disagree about this as far as particulars are concerned, the latter are of no importance in our case, because all psychologists agree on the essential point. To express my idea as simply as possible, I shall formulate it as follows: the law of development of the moral sense is the same as the law of development of tastes in general, and of the taste for the beautiful in particular. According to the evolutionists (i.e., according to the theory of the gradual mental development of the human race), among all peoples living for centuries in society and on the principles of developing morality, spiritual education derives from the innate instincts of good and evil, which are inherited together with the social instincts. As is clearly evident from the identical conditions of the development of the moral and aesthetic senses and as proved by pedagogical practice long ago, education necessitates demonstrative instruction based on graphic examples and practical exercises. Just as in the sphere of aesthetics the practical aim boils down to inculcating a taste for external beauty, in the sphere of morality the sole ultimate goal of education is inculcating a taste for man's inner beauty, in particular for beauty of behaviour expressed by such words as courage, loyalty, tenderness, kindness, etc. If the educator succeeds in inculcating in his pupil a taste for good and respect for courage and truth (and not merely an understanding of these concepts, because understanding alone does not yet determine man's morality), this means that he has associated in the pupil's mind the idea of these qualities with the ardent feeling of joy or satisfaction which arises in any moral person when somebody performs a good, just and courageous deed, or when he himself performs such a deed. The moment this taste has been inculcated in a person, it stimulates him to do good works, which become a source of satisfaction. And once this taste has been inculcated in a person, it will be an extremely difficult thing to eradicate it.

But how, it may be asked, can the idea of non-freedom of will exert influence on the taste for morality, i.e., for moral actions?

*Clearly there can be no such influence, for the moral value of an action is determined by its aims, by its relationship to the particular individual and to society, by the perceptible conditions in which it is performed and certainly not by its psychogenetic aspect which is concealed from us. Hence the motives prompting a particular action and the processes in which it originates can but determine our attitude to the person performing the action, i.e., whether to regard it as being to his credit or to condemn it. Generous and noble actions can be prompted by vanity, by cold and egoistic calculation and even by fraudulent purposes; but this does not mean that the action loses its generous and noble character. Only if the moral aspect of human actions, expressed by the words good, bad, kind, wicked, generous, mean, etc., depended, in so much as a fraction, on its inner origin in free will, the theory of non-freedom of will would, of course, be destructive to morality.*

*I can foresee the following objection to this theoretical reasoning about tastes being incommensurable with abstract con-*

clusions and, consequently, the impossibility of their exerting any reciprocal influence:

"By depriving man of free will, you make him an automaton and, at the same time, affirm that this in no way affects the attitude to human actions. But, having disfigured his entire spiritual make-up by your theoretical operation, you change the attitude not only to particular manifestations of his personality but to man as a whole."

However weighty this objection may seem at first glance, it is based on a number of misconceptions.

The idea of freedom of will, widespread though it is, is simply a theoretical explanation of a certain aspect of phenomena, a so-called scientific truth or hypothesis, depending on whether the explanation is absolutely sound or not. If the presence of free will in man were as evident, say, as that of the eyes and ears, there would be no argument about it. But since the argument exists, it follows that that aspect of the phenomena to which free will is applied as an explanation can be explained also without it. In other words, neither the content, nor the character of these phenomena display any special signs of free will, otherwise it would be a case similar to that of the ears and the eyes.

Hence, the theory disfigures neither the content nor the character of the facts from which free will is deduced; these facts are, predominantly, human actions, i.e., precisely those manifestations of the personality which arouse our sympathy or antipathy. So that from this point of view the idea of non-freedom of will does not cause any change in the taste for human actions.

Nor does it change the essence of the inner struggle which precedes the action, because the role of free will is taken over by the predominant motive. An iron will, scorning the danger of death, becomes a powerful moral sense which triumphs over the fear of death; will without a moral backing becomes a rooted instinct or emotion, etc.

And that aspect of human activity which distinguishes man most of all from an automaton, namely, the variety of actions performed under seemingly identical conditions, is not changed one iota, because both with free will and without it man can perform the same variety of actions in any given case.

Lastly, the theory does not eliminate the sense of freedom of action which is innate in man, because far from subordinating the individual to the will of others, it makes him dependent on himself, i.e., on his own desires and interests.

It is true that our theory deprives man of the appendage theoretically imposed on him, but this appendage is not indispensable to the performing of an action and makes man independent of earthly laws, i.e., it places him outside the medium in which he acts.

Thus, the idea of non-freedom of will cannot exert any depraving influence on morality; hence, even without free will man remains legally capable of entering into agreements and of assuming obligations, i.e., is a legally capable member of society.

Now for human actions from the standpoint of their merits and demerits.

If a person has done something beneficial to another person or to society as a whole, we usually say that he has done somebody a good turn or rendered a service to society. In this case there is no need to peer into his soul in order to find out the motives which prompted his action, or the process which engendered it; the usual thing is to thank the person or even to reward him the moment the beneficial consequence of his action and the difficulties under which it was performed have been ascertained. Thus, by means of gratitude and reward we recognise the value of the action, irrespective of the nature of its inner origins, and we confirm that it has been performed by the particular person and by no one else. This kind of service, clearly, is invariable, no matter whether man has freedom of will or not.

But there are other cases when the innermost motives of the action are taken into account; if it is found that the action, being highly noble by itself, had its source in pure and sincere motives, its moral qualities are attributed to the person who performed it, and the latter is rewarded by gaining our sympathy. In this case we regard the action as a personal merit, and the reward, i.e., our sympathy, is directly associated not only with the quality of the action but also with its inner genesis.

The degree of the sympathy generated by the quality of the action depends, of course, on the personal moral taste of the individual, and the same is true of the other half, associated with the concept of the inner genesis. Some people value selfless courage above all; they measure the degree of valour mainly by the difficulties accompanying the effort which presuppose determination and iron will. Others prefer the resolute and calm courage of the man who never hesitates or wavers, i.e., stability of motive which determines the action and puts all other motives in the shade. For some people freedom of will is sometimes the decisive factor which elevates the value of the action, as well as the value of personality, especially in those cases when it is said that the man could have acted with less valour without risking honour and reputation. Nor do those who deny freedom of will disregard this aspect; they, too, see in these actions a particular merit, an indication of very strong moral principles. In a word, when we accept an action with sympathy or antipathy, we are guided by our personal moral tastes which cannot be influenced by the theory of non-freedom of will. It follows, then, that the appraisal of the merits of an action remains unaffected.

The only change that follows from the theory of non-freedom of will concerns the views on crime, guilt and punishment.

Fortunately, in this very delicate matter I can base myself on the authority of our famous criminologist, my friend N. S. Tagantsev[72] who holds a place in Russian literature for his critical assessment of the theory of crime and guilt from the standpoint of recognition and denial of freedom of will.* Here is Tagantsev's basic conclusion**:

"All human actions, the good, and the bad, the useful and the harmful, and, consequently, crimes in particular, are, undoubtedly, like all other phenomena on earth, subject to the law of causality. We cannot affirm that a certain crime could

* Course of Russian Criminal Law by N S Tagantsev, Vol. I, St. Petersburg, 1874.

** Ibid., p. 67

or could not have taken place: it was found to be committed because the sum total of the reasons and conditions which engendered it was to hand. . . ."

I shall avail myself of this conclusion to develop our problem by means of an example. By the word "punishment" I do not imply the broad concept current among the criminologists who regard it as a special means of combatting crime, both its social consequences and its source, i.e., the person committing it, but simply the sum of the practical actions or measures taken against the criminal.

If a wild beast appears in the neighbourhood of a village jeopardising the life of individual members of the community, or killing their livestock, the elimination of this evil is a matter of interest and duty of the community as a whole. The beast is not a criminal, but this does not make things easier for the inhabitants, because the ravenous instincts of the beast are dangerous. These instincts, being innate, cannot be eliminated; consequently, the beast must be destroyed without further ado.

Let us now suppose that one of the members of the community, a certain X., has caused material damage to his neighbour, just as the beast did in the first case. In this case, too, elimination of the evil is a matter of interest and of duty to the community as a whole. But this is a more complicated case, and it will be considered from different aspects, depending on whether freedom of will is recognised in man or not.

*In the case of free will the general line of the reasoning will be:*

X. has violated the agreement. As a conscious and rational person, he was aware of the significance of the agreement; as a moral person, he could distinguish between good and evil, and lastly, *being free in the choice of his actions*, he could abstain from doing wrong irrespective of the reasons which impelled him in this direction.

Consequently, X. is a criminal.

*In the case of non-freedom of will the general line of the reasoning will be:*

X. has violated the agreement. As a conscious and rational person, he was aware of the significance of the agreement; as a moral person, he could distinguish between good and evil, but, not being free in the choice of his actions, he could not but act as *he did in the given external and internal conditions.*

Consequently, X. is not a criminal.

As a result of this reasoning, X., endowed with freedom of will, is taken into custody; this is followed by a verification (i.e., investigation and trial) aimed at establishing whether X. can be classified as a criminal and, first, whether he acted deliberately, i.e., was in his right mind when committing the deed. After this the circumstances in which the deed was committed are examined and the details of X.'s life are appraised in order to reveal, as much as possible, the psycho-genesis of his action. The second part of the examination must elucidate two points: for the jury—the degree of imputability (innocence, guilt with and without extenuating circumstances), and for the judges who pass the sentence—the degree of criminality of the defendant's will.

The first part of the examination fully corresponds to the above-mentioned general line of reasoning, the second part, only in the case of X. being held to be innocent (for example, if the deed was unpremeditated, or committed as an extreme means of self-defence), or found guilty without extenuating circumstances. But if X. is found guilty and at the same time deserving of clemency, and if the judges mitigate the punishment in accordance with this addition to the verdict, *their practical decision will directly conflict with the above-mentioned formula* For if X. is guilty, it means that he acted deliberately, while in his right mind; he knew that he was about to break the law although he was *free* not to do so. Why, in these circumstances, should clemency be shown to him? Clemency, as everybody knows, emanates from a very noble source —from the words of the gospel, to the effect that he who is free from sin should throw the first stone; it emanates also from tolerance which the person endowed with lofty moral qualities displays for the weaknesses and frailties of others. In all cases when a court investigation establishes in a person accused of a criminal offence not so much moral deficiency as a lack of character or an unfortunate coincidence of tempting circumstances—which even an inherently good man finds difficulty in resisting—the severe formula of crime ensuing from the theory of freedom of will is rejected by the social conscience and is not, as is usually believed, mitigated, because the premise of "free will" necessarily leads to the only possible verunable to make proper use of the rights offered by a free and uncontrolled life (it goes without saying that the words "free" and "uncontrolled" are used here in their everyday sense), only one conclusion is possible: such persons can no longer be members of society and enjoy the rights of a free and uncontrolled life, no matter whether their will is free or not. But is not justice violated by acting in this way? It is only those who are guilty that can be penalised, while those without free will cannot be considered guilty. The question is easily answered. In the absence of free will society must of necessity regard the defects of its members as products of a hereditary predisposition, ignorance, uncouth manners, bad upbringing, lack of brains, poverty, idleness, laziness, etc.; consequently, it is not entitled *to treat its vicious members in a spiteful way, and all the more* so to punish them for their misdeeds. But society is obliged to isolate such defaulters and to try to reform them, just as it is obliged to take care of those who are mad or sick. If it were possible to leave such persons free and uncontrolled without infringing on the interests of society, and by so doing ensure a speedier reformation of them than by way of prison and compulsory labour, and if the public could preserve their former attitude of love, of respect and confidence in these abnormal persons, society would, by committing them to prison and compelling them to perform tasks, be acting contrary to its interests and contrary to the principles of justice. But as far as I know there has never been, nor can there be, a case of a criminal being left at liberty, without surveillance. The public will always avoid a person who is known to be vicious; they will never trust him and certainly they will never love or respect him. From the standpoint of punishment the criminal, if left in his former environment, amid general hostility and mistrust, would suffer a more horrible punishment than prison or penal servitude; it could lead to his suicide or make him a pathological case and, as a result, cause him to sink deeper into crime. Instead of being reformed, the vicious person would become even more vicious. Consequently, the external aspect of the actions by which society protects itself from its vicious members remains invariable, no matter whether free will is recognised or not. The only change is in the sense of the actions—retribution is replaced by reforming the criminal.

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It may well be that upon reading these notes many will say: "These are the utopian ideas of a man cut off from life, who does not know how abstract doctrines are applied to social life, and who does not understand or does not want to understand that the application of the very best of theories is accompanied by misconceptions, one-sided comprehension and even deliberate misinterpretation and that the results of any theory are determined not only by its essence, but also by the soil on which it falls." For greater clarity, these readers will probably refer to the important historical example of the Inquisition which, so it was alleged, was practised in the interests of the doctrine of love and mercy.

But as far as the reader will gather, I know this aspect of the question if not from practice then from what I have heard, and I am only too well aware of the importance of studying it from this standpoint. Unfortunately, a systematic examination of the matter presents insuperable difficulties. For one thing it is absolutely impossible to enumerate all the conceivable consequences of cases when, on the one hand, a theory is misunderstood and misinterpreted, and on the other hand, the soil on which it falls—the mind, character and morality—undergoes certain change. The aim could be achieved only by means of a general formula establishing the relationship between the theory and the soil, but this, of course, is impossible. Nevertheless, I consider it my duty to share with the readers the fragmentary conclusions which I have deduced from my study of the subject and which I consider valid.

1) No matter how much the theory of non-freedom of will may be misinterpreted, the misinterpretation cannot go beyond the idea that man is responsible for his actions neither to society, nor to his own conscience. A subject with this conviction does not recognise the right of society to punish him for

whatever he may commit, because of the logical impossibility of making him responsible for his actions (at the same time he overlooks the point that society is justified in not tolerating vicious people in its midst and in depriving them of liberty); moreover he believes that he is free from any obligations since it is useless to go against one's own nature (he disregards the conclusion following from the theory that as far as the future is concerned, each has the *opportunity* to perform any actions, in particular, the *opportunity* to perform good actions, provided he tries to educate his mind and his heart).

2) Even in this wording, which may be the result exclusively of extreme thoughtlessness, the theory, while it may facilitate the committing of evil deeds, cannot originate them. This can be proved quite easily. Evil deeds can be caused only by such motives as self-interest, hatred, animosity, personal vengeance, etc., i.e., emotions or extremely emotional ideas which becloud the mind and suppress the moral sense. The emotional character of such ideas turn a man into a fanatic, and make him run the risk of committing any criminal action. But this theory has nothing to do with emotions and fanatical ideas, because who would run the risk of committing a criminal action merely to demonstrate his irresponsibility to society and his own conscience?

3) In its distorted form the theory facilitates the committing of criminal actions in three ways: as an argument against the value of public opinion, as an argument against the pricks of conscience, and as indulgence towards certain passive qualities of the character.

4) The pernicious effects of the first argument, as far as it results from the misinterpreted theory, can be highly varied, depending on the temperament of the individual, on his emotional nature, and proneness to anger and hatred. Indeed, the conviction that society is not entitled to punish offences and the knowledge that, despite this, it will punish them cannot but engender a hostile attitude towards society, a feeling of alienation from society and indifference to its interests. But in some offenders this hostility will be neutralised by the idea (deriving directly from the concept of personal irresponsibility, *mutatis mutandis*) that the punishing society, even though it punishes

unjustly, cannot be held responsible for its actions. In others, who are less prone to anger, the resentment will not be so pronounced, while in still others who are inclined to hatred it will be more marked. It is not my purpose to say to what extent these varying degrees of hostility facilitate the accomplishment of a criminal act, but one thing is certain: if the offence has its source in an indifference to society plus contempt for its judgement and interests, especially if the offence originated in a feeling of hatred for society, then the hostility engendered by this theory is but a tiny fraction of the contempt and hatred. A hatred provoked by an anticipated unjust punishment cannot, of course, be compared with a hatred that is already effective.

5) The appeasing action of the distorted theory on the conscience seems at first glance to be terrible from the point of view of its possible consequences, especially when the theory falls on an amoral soil. But this is an erroneous view. Where there is no conscience there can be no appeasement—the person who is equally indifferent to good and evil does not need to excuse himself in his own eyes for the offence he is about to commit. Persons of this kind are truly terrible, but only because they are immoral. Where the moral sense is not yet completely lulled the appeasing argument of the distorted theory is likely to finish it off altogether; here everything depends on whether the vestiges of conscience are substantial or insignificant. In the first case the theory will encourage the offence to a greater degree than in the second case; I am not saying that the encouragement will be strong or weak because the underlying motive in wrongdoing (by virtue of point 1) is emotion, and not the theory the degree of participation of which cannot be determined.

6) Twinges of conscience, as everybody knows, brought on by wrongdoing, are described as shame and remorse. The latter, in contrast to perverseness and impenitence, are regarded as manifestations of the awakening conscience, that is, if they are sincere and are not the result of egoistic calculation, and, what is more, aimed to the detriment of others. Clearly the relationship of the distorted theory to these mental states will be the same as to the protests of conscience before the evil act is,

committed. The theory will harden the perverseness and impenitence and prevent the awakening conscience from manifesting itself. But, of course, the stronger the conscience, the lesser the practical significance of the inhibiting factor, and vice versa.

7) By virtue of its general character, the theory is more likely to subdue a man than to arouse his pride; hence in its distorted form it may favour the development of passive rather than active traits in man, i.e., apathy, laziness, idleness, indecision, etc. In my view, and I base this on the indubitable applicability of the general laws of harmony to the perception of impressions, that the theory is assimilated mainly by those who are passive by nature. This aspect of the influence likely to be exerted by the theory in its distorted form is, in my opinion, very harmful from the point of view of its educational influence on character, but its role in the predisposition to evil actions is insignificant because laziness, apathy and indecision have very little to do with these.

It would be appropriate now to dwell on the question of the soil on which the theory falls, and to examine it from the mental and moral aspect, but everything of importance in this respect has already been said in the foregoing seven paragraphs. Indeed, the extreme misinterpretation of the theory, compatible only with a very high degree of thoughtlessness, has been demonstrated in paragraph 1; the next five paragraphs prove that wrongdoing is directly related not to the distortion of the theory—in all cases the theory has been regarded as being utterly distorted—but to the abnormal soil on which it falls.

By proving the dependence of human actions on the conditions of the external and internal environment, the theory teaches: toleration towards our neighbours, and meekness in ourselves; immutability of virtue in the really good people and the possibility of reforming the wicked, i.e., faith in the good and the reformation of evil.

By reinforcing confidence in man in general, the theory transposes man's assessment of his own powers to a more positive ground, i.e., reinforces confidence in himself within the limits of this assessment.

By affirming the dependence of man's actions on his mental and moral development, the theory acts as an incentive to mental and moral perfection. Granting free will, it is possible to believe that it may help us out of trouble.

But with non-freedom of will, this "may" disappears: as the soil is so the actions will be.

What can be done to make sure that this theory falls on soil without being distorted?

Society must be solicitous for the moral education of its members; it should teach them to be good, truthful and industrious, and it should do this by way of example, because the moral sense, like the aesthetic sense, indispensably requires demonstrative instruction.

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## IMPRESSIONS AND REALITY*[73]

§1. The subject which I shall examine in this brief essay is, in my opinion, of interest not only to scientists but to intellectuals generally. After all it would be interesting to know whether there is any similarity between the objects and phenomena of the external world, on the one hand, and the impressions of them in the human consciousness, on the other, and what kind of similarity it is. For example, are the outlines, colours, lights and shadows of a mountain landscape real, do they exist, or are they simply sensory mirages created by our neuro-psychical organisation under the influence of external factors the specific nature of which cannot be cognised by us? In other words, can we regard the consciousness as a kind of mirror reflecting the surrounding reality and to what extent? If we put the last question, so to say, point-blank, i.e., if we hold that the external source is the cause and that the impression is the effect, then the problem will be insoluble. For at bedrock of every impression emanating from the external world is a form of sensation which so far is absolutely not subject to decomposition—the so-called sensations of light, taste, smell, etc., and although this particular form depends undoubtedly both on the structure of the receptor organ and on the external source, the latter disappears without leaving any trace in the sensation. The sensation of pain, for instance, does not directly indicate the cause of the pain. We are still baffled as to the origin of the sensation of sweetness or bitterness in substances. In what way oscillations, i.e., movements, engender the sensation of light, is

* Although this is a popular exposition of the subject, the article deals with the solution of an important scientific problem.

another and as yet insoluble mystery. In a word, throughout the sensory sphere there is no transitional bridge between the sensation and its external source. Many think that there is no such bridge, since sensation and the external material processes which produce it are not commensurable.* That is why it is said that we receive via our sense organs only a series of conventional signals from the objects of the external world.

§2. But how is it possible to reconcile this apparently conventional cognition of the external world with the achievements of natural science, thanks to which man is acquiring more and more power over the forces of nature? How is it that natural science, which deals only with conventional sensory signals emanating from the inaccessible reality, creates an increasingly harmonious system of knowledge, knowledge which is most effective, being constantly justified by its brilliant application —by its success in the sphere of technology?

This pronounced difference or even contradiction between the fundamental inaccessibility of the external world to human knowledge and the practical achievements of natural science has long been recognised by thinkers, and the following compromise has been established to reconcile the contradiction: our knowledge of the external world may not be conventional if the spiritual laws on which the science of it is based had the same roots as those which govern everything that exists and takes place outside us, or at least if these laws were strictly in harmony. Since the first point still remains to be proved, it is only the second which is accepted and is regarded as being beyond doubt. I shall avail myself of this circumstance and draw two conclusions.

The following propositions are the corner-stone of the compromise. *The identity of the sensory signals emanating from external objects must correspond to the identity of reality; the similarity of the signals—to the similarity of the reality, and the difference in the signals—to the difference in reality.*

* This argument, though false from the point of view of logic, is regarded as being convincing; only those objects which are known to us can be regarded as being incommensurable, the external is regarded as being unknown.

Further, by assuming that the laws of the imagined and of the real are in strict conformity, we admit *the possibility of partial similarity between the imagined and the real*, as the simplest case of the conformity.

§3. The latter conclusion leads, naturally, to the following considerations. Does not the idea of the inaccessibility of reality derive from the fact that when comparing the external source of an impression with the impression itself, we usually confront the external causes with forms of sensation that cannot be decomposed, such as the sensations of light, sound, bitterness, pain, etc., or from the fact that we confront only the extreme members of a long causal series without paying attention to the intermediate links connecting them? It is even possible that in some cases of complex decomposed impressions these links have been found, and that only because of the pressure of an established dogma nobody has up to now paid attention to them as to factors determining the complete or partial similarity between the source of the impression and the impression itself. From this to an attempt to reconsider from this aspect all the available physiological data concerning the sensory sphere is but a step.

But where and how are we to look for the *indubitable* conditions which determine the similarity of reality and impression? Presumably in the activities of those sense organs which are constructed like physical apparatuses and produce forms of sensation which can be decomposed and where the connection between these forms and the structure of the organ has been more or less elucidated. As to the question of how to look for the conditions of similarity it can be best answered by means of examples of physical combinations in which the initial cause and the final effect are similar and, being joined by connecting links, form together with the latter a so-called causal series.

Why does a string tuned to a definite tone easily respond (resonate) to a tone of the same pitch, even if the source of the latter, the sound-producing body, is separated from the string by a considerable layer of air? Because the source of the phenomenon, i.e., the vibrating body, the intervening medium, i.e., the oscillating air, and the final element, i.e., the string which perceives these oscillations, are interconnected links of a system highly conforming to each other as regards their capacity to vibrate with the same frequency. If the sound-producing body were a clarinet and the resonating body—a string, the cause and effect would be similar; but if there were strings on both sides of the chain, the cause and effect would be identical.

Let us take another, more complex example—the telephone. In essence the matter here is the same as in the previous example: at one end of the chain the sounds of the voice cause the plate of the receiver to vibrate; at the other end, similar vibrations are produced in a second plate and caught by the ear in the form of speech. The only difference between this example and the previous one is in the intervening medium: in the first case, this was air with its almost ideal elasticity and extreme compressibility of its particles, thanks to which it can oscillate in unison with the most extraordinary vibrations of the sounding body; in the second case, this is an electromagnetic combination distorted at both ends. However, in both cases the function of the intervening media is similar: they transmit the characteristic features of the vibration without any change. It is this that guarantees the similarity between the extreme members of causal series. Let us imagine, say, a physicist listening on the telephone to an unknown person several versts away. To the physicist the voice of the speaking person, as the first member of the causal series, is an unknown X; but, aware of the properties of the telephone as a connecting link, he knows that the voice he hears resembles the actual voice which is concealed from him.

Thus, the similarity between the extreme members of the causal series is beyond any doubt, if we know that it is based on a similar activity of the extreme members, which is not violated by the connecting link, or, if we deduce this similarity from the form of the connection between the beginning and the end of the phenomenon. In the latter case, one of the extreme members of the series, for example, the initial, may even be concealed from us (like the voice of the person speaking from a distance of several versts), on condition that there is a connecting link (telephone) which determines the form of the connection. Then, the concealed initial link of the chain is found approximately in the same way as the unknown member of a geometrical proportion: the unknown external is related to the connecting link as the latter is related to the final effect.

§4. Guided by these considerations in our examination of the physiological facts relating to sensation, we naturally arrive at the conclusion that the solution of the question should be sought in the sphere of the visual acts. To say nothing of the fact that in this sphere the connection between the forms of the sensation and the structure of the sense organ has been elucidated more completely than in other spheres, the developed impression here is of a pronounced objective character: we do not feel the process taking place in our eyes during the act of vision; we *directly* perceive the objects seen as existing outside us. This externalisation of impressions—a kind of materialisation of sensations—can be compared with the reflection of an object in a flat mirror; the only difference is that the physical mirror reproduces the images of objects behind itself, while the mirror of the consciousness projects them in front of itself. Because of this, the *image seen*, i.e., the sensory sign of the external object and at the same time the final member of the visual causal series, is accessible to observation in the same way as any material object;* this eliminates at once the incommensurability of the impression (as the sensory act) with its external source (as the material object), which led many to think that comparison of these two factors was fundamentally impossible. Moreover, *in a visual causal series there is always an intermediate member between the two extreme ones*, and this intermediate member is of great significance to us.

§5. When a person receives a visual impression, it is the image of the external object in the fundus of the eye, on the so-called retina, which acts as the connecting link between the external object (the appearance of which is unknown to the person) and the image of the object in his consciousness. And this intermediate link is the transitional bridge that we have been looking for. Its connection with the external object (the unknown!)

* In everyday life the visible image of an object is taken for the object itself; but this, of course, is wrong.

*is purely physical and fully corresponds to the reproduction of* an object on a screen by means of a double convex lens, because the image of an object on the retina of the eye is produced (chiefly) by the so-called crystalline lens, which has the form of a double convex lens. Moreover, the physicist claims that the external object and its image produced by a lens are identical; *by analogy, the physiologist claims the same for the external* object and its image on the retina. At first sight, this seems strange: both assert the similarity of two unknown things—the external object and its image on a screen or on the retina; and yet both are right. Observing an external object and its image (on a screen or on the retina) both receive from them *similar sensory signs* and, *according to the law of strict conformity* between the impression and reality, this likeness must correspond to the real similarity. Consequently, the similarity between the unknown external object and its image on the retina is beyond doubt. But according to physiology, between the image *on the retina and the image formed in the consciousness* (i.e., the impression!) there is also a similarity. Thus, the retina images of a triangle, a circle, the crescent of the moon, a window frame, etc., are perceived by the consciousness as a triangle, a circle, the crescent of the moon, etc. A diffuse image on *the retina leads to a vague image in consciousness.* An immovable point is perceived as motionless, a bird on the wing as moving, a dimly illuminated spot of the image—as a shaded one, a brilliant spot—as a luminous one, etc. In a word, the consciousness mirrors the retinal images as faithfuly as the retina and the refracting media of the eye mirror the external objects. *If the first member of the series is similar to the second*, the second to the third, then the third must be similar to the first. Consequently, *the unknown external object, or the object itself, is similar to its optical image in the consciousness.*

§6. But can we affirm with the same degree of certainty that all the features of an optical image—figure, colour, light and shadow—have this similarity? On a screen and on the retina the image is always flat, whereas the external object is usually *three-dimensional and is reproduced in the consciousness* precisely in this form. Consequently, the similarity between the connecting link and the extreme members of the series is incomplete and at best corresponds to the similarity between an object and its pictorial reproduction on paper or canvas. Moreover, the lenticular form of the principal refracting medium of the eye with its capacity to reproduce correctly the linear outline of the object plays an essential role in our arguments; however, in the reproduction of colours, light and shadows the form of the crystalline lens is of no importance whatever.

Let me say straightway that the correct reproduction of reality by the eye is probable only for those aspects of the visual image which can be presented in linear form on paper, i.e., for the outline of the object and the separate lines which express prominences, hollows, edges, cracks, etc., on the surface of the object. But it is impossible to prove the similarity of the image on the retina with reality as far as colours, light and shadows are concerned. We cannot, for example, affirm that people perceive one and the same colour similarly. Since childhood I have been taught to designate by the word "blue" the colours of all objects that are blue, and all my life I have applied this word to the corresponding sensation. But this does not mean that *my sensation of blue* is similar to that of another person, because the latter also names the colours by force of habit which he has acquired by learning. But a circle or a square of a regular form are seen similarly by all people with normal sight, because since the time of Euclid not a single student of geometry has perceived the image of a circle or a square in contradiction with the geometrical properties of these two figures.

§7. How, then, shall we understand the conclusion we have just reached? It has been said that the eye reproduces correctly the outlines of objects; at the same time we cannot know whether our terrestrial globe is filled with light. But since the visual outline of an object indispensably presupposes light, this aspect of the visible image is, perhaps, also nothing but a product of the neuro-psychical organisation and has nothing in common with reality.

When examining this question, I shall, for the sake of simplicity, have in mind a certain flat object, say, an irregular cardboard figure.

The outline of this object can be determined not only by sight, but also by touch, *in the absence of light*. The handicraft of blind people who have mastered their trade without assistance is proof of this; at the same time it shows that *generally speaking tactile determination of the forms of objects differs very* little from visual determination.* This may seem strange, since visual and tactile sensations are absolutely different; but it is easily explained. To perceive the outline of an object, it is necessary to distinguish the two different media which come in contact with each other and to have definite instruments for determining the form of the demarcation line between them. The so-called optical heterogeneity of substances corresponds to the difference of the media perceived by the eye, and the different degrees of the consistence of substances, or, to be precise, of their resistance to pressure, correspond to the difference determined by touch. As to the form of the demarcation line, physiology teaches that in both cases it is determined by *the movement of the sense organ—the eye or the hand*. Precisely the same movement which the hand performs when drawing the outline of an object on paper is performed by the eye when we are looking at an object, or by the hand of a blind man when he is feeling the shape of an object. This shows that one and the same object can be determined in two different *ways and that it is possible to verify the visible outline of an* object by touching it, provided of course that it is within reach. This is done in the following way. The eyes are fixed on a certain point on the outline of the object; at the same time a finger is brought to this point. At the moment the eye sees the contact of the finger and the outline of the object, the finger receives *a tactile sensation; this coincidence is invariably repeated* in all points of the outline of the object. In other words, the observer, like a student of geometry, superimposes the visual and tactile images one upon the other and thus establishes that their outlines coincide.

*Nobody will venture to affirm that the visual outline is per-*

* In my native village there lived, and perhaps still lives, a man who was born blind. This man made a fiddle with his own hands and without any help; the fiddle did not differ in appearance from other instruments of its kind.

haps a fiction without any real basis. As a concept, the outline is, undoubtedly, an abstraction, but as a sensory sign it is a border-line between two realities, because by virtue of the conformity between impression and reality, the perceived difference between the media corresponds to an actual difference between them. Indeed, it suffices to replace the border-line by a system of demarcation points of one of the material media, and we shall obtain the real outline.

After this, it is easy to understand that if we attach to the surface of a cardboard figure placed before our eyes some prominences and edges, or if we make cracks in it, etc., the verification by touch of our visual perception will show also for these details in the outline of the figure a coincidence of the visual and tactile sensations of form; actually what we have here are the stroke by which the unevenness of the surface of objects is usually expressed in sketches.*

§8. Up to now we have concerned ourselves with single objects only; let us now take a group of objects and arrange them not on one plane, but on several (as in landscapes), leaving empty spaces between them. If the group is situated at a distance from the observer, he can reproduce its image on a screen by means of a lens, and the image will be similar to that obtained by the eye. In both cases, i.e., for the lens and for the eye, the group of objects with empty spaces between them is equivalent to a single object of heterogeneous parts separated from each other by cracks; consequently, this case does not differ from the one examined above. But if the group is situated near the lens, it will be impossible to obtain a clear image of all the objects on the screen; however, here again the eye successfully copes with the task. We clearly see not only all the components of the group and the spaces between them, but we also see that the objects are not disposed on the same

* Since the analogy between the refracting media of the eye and the double-convex lens is the most essential argument in the system of our proofs, and since this lens has the faculty of producing images geometrically similar to objects, the presence of lenticular bodies in the eyes of all vertebrates and even insects, naturally leads to the idea that for the latter there is also a geometrical similarity between the visible and the real.

plane, that one object is nearer, another is farther, etc.; in a word, we see the picture *in depth*.

*To master this form of vision, man unconsciously and involuntarily* uses the methods of topographers or land-surveyors when they plot points situated at various distances from them, for example, points *a*, *b*, *c*, *d* and *e* (Fig. 1). For this purpose, *they choose another two points A and B from which all the* points to be marked on the plan are clearly visible and the dis-

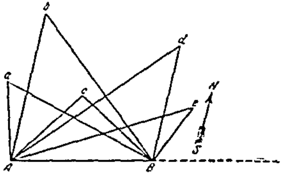


Fig. 1

tance between which can be measured in a straight line, for example, by means of a chain. Then from point *A* they determine with the help of a theodolite the angles *aAB*, *bAB*, *cAB*, etc. *Similarly they determine from point B the angles aBA*, *bBA*, *cBA*, etc. When the length of *AB* and the dimensions of all angles from *A* and *B* are known, it remains only to determine the direction of *AB* relative to the four cardinal points; this is done *by measuring the angle between AB and the NS direction* of the compass needle. Having obtained these data, the topographer plots *NS* and *AB* (the latter on a reduced scale) on a sheet of paper, and then, without changing his position, he can exactly define the location of points *a*, *b*, *c*... on his plan. For this purpose, it is sufficient to mark off from *A* and *B* the angles already measured; then the intersection of the lines *Aa* and *Ba* will give point *a*, the intersection of *aB* and *Bb* will give point *b*, etc. Consequently, the important thing is to know the angles *aAB* and *aBA*, *bAB* and *bBA*, etc., at the ends of the line *AB*, *the length of the latter being definite and invariable*.

Now, instead of the topographer, let us imagine simply a man who is looking alternately at points *a*, *b*, *c*, *d* and *e*, and let us take *AB* as a straight line connecting the centres of his eyes. Then in points *A* and *B* the role of the theodolites will be played by the eyes which are capable of turning from temple to nose and back; if both eyes are looking at point *a*, the line *Aa* will become the optical axis of the left eye, and the line *Ba*—the optical axis of the right eye. The man, like the topographer, measures the angles *aAB* and *aBA* (convergence of the optical axes); but this measurement is done not in degrees, it is accomplished by the sensation caused by the movements of the eyes. Since this measuring instrument is not so precise as the one mentioned above, the visual determination of the distance of points *a*, *b*, *c*... from *AB* is only approximately correct. But when the same operations are repeated at all points, one after the other, the comparative difference in their distance will be very clearly perceived.

Thus, the method applied by man for the visual determination of the position of objects in space is actually a geometrical method, which, however, is accomplished by means of a less precise instrument for measuring angles than that used in topography. Everyone who believes in the soundness of the results of geometrical construction will have to agree that in relation to the matter which has just been considered the eye reproduces reality with a considerable approximation.

§9. I anticipate the following objection: the surrounding objects are seen not as they are really disposed in space, but in perspective; we know that as a result not only the dimensions of objects lying along different planes are changed, but also their real distance from each other, so that parallel lines seem to converge, circular outlines to become elliptical, etc. Is not this a distortion of reality produced by the sense organ? The answer is simple. As we know, any given group of objects in space can be sketched in perspective also with the help of foolproof geometrical constructions only if we know the position of the observer's eye. Consequently, if it can be proved that when a man is looking at surrounding objects with both eyes he sees them as if the beam of vision were issuing from one point of his body, then it follows that *vision in perspective is likewise based exclusively on the participation of geometrical factors.*

Indeed, physiology teaches that in binocular vision man relates every point of space to the point on the bridge of the nose which is located exactly in the middle between the eyes. Straight lines from this point to the points in space give the direction of the objects in relation to the observer, while their distance from the observer is measured by the degree of convergence of the optical axes (goniometrically). The following experiment easily proves the existence of this imaginary point on the bridge of the nose. Stand before a window at a distance of some two feet and mark with ink point C on the window-pane (Fig. 2). Then fix your eyes *A* and *B* on this point and simultaneously bring your forefingers E and E slowly together by moving them towards each other from both sides, in the space between the eyes and the window. The moment the tips of the fingers meet the optical axes *AC* and *BC*, you will have the impression that some kind of semi-transparent extremities *F* and *F* have grown at the tips of both fingers, meeting precisely at the line CD. No matter at which point of the space between the eyes and the window you bring your fingers together, the result will always be the same. What does this mean? It means that every point located along the path of the converged optical axes is transferred from these lines to the line *CD*, one end of which, *D*, coincides with the middle of the bridge of the nose *AB*, and the other end with point C, which is under observation. Indeed, when we are looking at an object with both eyes, we do not see the bridge of the nose, and it always seems to us that we are looking with one eye located between the real eyes. Point D is the centre of this imaginary cyclopic eye—the *visual* "Ego" of man when he feels that one of the objects observed is nearer to him, another one—farther, or

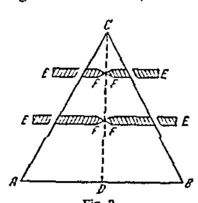

Fig. 2

that one object is on the left, another on the right, a third—above, etc. In all cases point $D$ is a substitute for the actual observer.

§10. Now that we know how the visual determination of the direction of objects and of their distance from the observer is effected, it is not difficult to show how the eyes measure the size of objects, or, more precisely, their height and width.*

For this purpose, let us imagine that before the cyclopic eye $M$ (Fig. 3) of a person three objects $AB$, $CD$ and $EF$ are located one after another on the same plane and that they are visible from the same angle EMF. These objects will obviously be unequal—the height will be proportionate to the distance from the eye, i.e.,

$$AB:CD:EF=MN:MP:MQ$$

In other words, for the eyes the dimensions of objects are relative values which depend on the distance of the given object from the observing eye. From this it follows that when we compare the dimensions of objects we should observe them from the same distance. Then one of the factors—the distance of the objects from the eye is, so to say, excluded, and the difference in the dimension of the objects is determined by the difference in the corresponding angles of vision $EMF$, $CMD$ and $AMB$ (Fig 4). The converged optical axes, repeatedly moving up and down along the height of the object and transversally along its width, actually perform the same movements as the legs of a compass in the hands of the student of geometry when he is measuring angles according to the length of the arcs.

Consequently, *the visual method of comparative determination of the size of objects is also a geometrical method.*

It has been said above that for the eyes the apparent dimensions of an object are relative values which depend on the distance of the object from the observing eye. This is proved by certain optical errors (which seem very strange but which can be easily explained), when something diverts the attention of the observer from the object he is looking at. For example, I

* These dimensions can be measured without changing the position of the object, thickness being determined as the width of the object after the latter has been turned.

have been told by a hunter of wild fowl that should a fly cut swiftly through the air a few inches before his eyes at the moment his dog is making a point and all his attention is concentrated on the actions of the dog, he takes the fly for a bird. This is explained by the fact that the hunter relates the image of the fly not to a distance of several inches as it should be, but

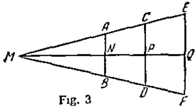


Fig. 3

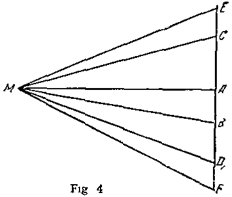


Fig 4

to a distance of several yards in the direction of the dog; at this distance, the image of the bird on the retina corresponds in size to that of a fly seen at a distance of inches; hence, the fly is taken for a bird. Thus, together with knowledge of the forms of objects and their distribution in space, the eye (and in blind people—the sense of touch) provides *more or less correct information about the comparative size of objects.*

However, the parallel between motionless objects and their images as we see them cannot be carried any further. I shall, therefore, conclude by a general argument in favour of what has been proved above in parts. Although this argument is not very important in itself, it is convincing when taken in conjunction with the foregoing arguments. Everyone knows that when men and animals move among the objects surrounding them, they are guided by the indications of their eyes; these indications are particularly valuable because of their rapidity and exactness, since it is vision that enables men and animals to move successfully, even rapidly, among the numerous obstacles (for example, in a forest). The information provided by the eyes would hardly be so rapid and exact if the images of the external world reproduced by the eyes did not conform to reality. It is true that our judgement of the result may be correct even if it has been obtained by means of an imperfect instrument; errors of observation can be rectified by reasoning, and once this habit has been formed, the imperfect instrument will serve faithfully. In our case, however, the whole cycle of optical errors, as far as locomotion is concerned, and all efforts to rectify these errors by reasoning, would apply to the period of childhood and would not escape observation; however, there are no observations of this kind.

Let us now pass from motionless to moving objects.

§11 If we regard a phenomenon as a perceptible change in the state or position of bodies, then a perceptible movement must be the simplest of all phenomena. The eye is the chief instrument by means of which we perceive this phenomenon; to the surprise of any intelligent person, this instrument is so perfect in this respect that it permits even the uneducated people to apprehend at once those aspects of motion by which the latter is characterised in such an exact science as mechanics. I have in mind the direction of the motion and its speed.

But how is this achieved?*

Everyday experience shows that when a person follows with his eyes a moving body, he fixes his converged optical axes on it and moves them simultaneously with the body along the whole path of its displacement. In this case the eyes act precisely in the same way as when they follow the outline of a motionless object by their crossed optical axes; the only differ-

* I shall examine here only the main initial case when man determines the movement of bodies, while he himself is motionless.

ence is that here the optical axes must often become considerably longer or shorter. In this respect, they can be compared to a pair of very long antennae which become many yards longer or shorter *depending on whether the moving body approaches* the observer or recedes from him. These antennae reproduce not only the entire path of the object, but also all the changes which take place in the speed of its motion along its path. The point is that the movement of the optical axes, which is connected with the movement of the eyeballs, is effected by the muscles of the eyes; and everyone knows from the movements of his hands, for example, that muscles can contract with varying speed. That is why the eyes can distinguish simultaneously the two characteristic features of motion—direction and speed (and, of course, all the changes which take place in direction and speed).

This is of great significance, because it is the only case in *man's organisation* where *the external object perceived*, i.e., *the moving object, and the instrument of perception*, i.e., the sense organ which moves along the same path as the object, *coincide in their activities* in the same way as two strings vibrating in unison, or as the transmitting and receiving plates of the telephone coincide in their physical combinations.

*It is clear, therefore, that in respect of movements* which can be perceived by the eye *the impression and the reality coincide.*

This, I think, is the main reason why motion appears to be the simplest and most comprehensible of all the phenomena in the world, why the science of the external world strives to reduce all phenomena to motion, and why the physicist, when he has *the opportunity to do so in a particular case*, believes that he has elucidated the given phenomenon even if the motion, which helps explain it, is inaccessible to our senses because of its rapidity. This is because the extra-sensory movements of which the physicists speak are simply qualitative modifications of the forms accessible to our senses; and knowledge of the latter is not conventional, but direct and fundamental.

It goes without saying that all my arguments are based on the absolute conviction, common to all, that the external world exists, a conviction which is as firm, and even firmer than the certainty that one day is always followed by another.

## OBJECT THINKING AND REALITY[74]

1. In the article "*Impressions and Reality*" I examined the question of whether there is a similarity between the impressions we receive from the external world and reality; I tried to show that this similarity can be proved only for some aspects of the visual and tactile impressions, namely, for the *linear configuration, disposition and displacement* of objects in space. In other words, similarity was established only for some of the features isolated from the impression as a whole. It is now my purpose to develop this question, to speak in a general way about the particular connections or relations between the links (or phases) of an integral impression which determine its inner sense, and owing to which the integral impression is transformed into a sensory thought and, if expressed in words, gives the well-known three-member sentence consisting of subject, predicate and copula. The point is this: whether we distinguish one object from another or discern a certain quality in an object, whether we detect a certain change in it, whether we see one object at rest and another in motion, one object on the right and another on the left, etc.—all are complex impressions equivalent to thought, because each can be expressed by a sentence consisting of three parts. The subject and the predicate express either two objects, or an object and its quality, or, lastly, two qualities, while the copula always expresses the relationship of the two objects confronted (i.e., subject and predicate). Consequently, our task is to ascertain the relationship between all three elements of thought—the objects, their attributes and their interrelations—and reality. The first two elements appear in the consciousness so distinctly that none can

doubt the existence of "something" real corresponding to these elements; but the links and relationships which unite the objects into thought are often so elusive and immaterial that many regard them as products of the mind.

For this reason our question will take the following form: *in what way do the links and relationships between the external objects perceived by us reflect reality, and in what way are they products of our sensory organisation and ascribed by the mind to the external world?*

The answer to this question will, undoubtedly, be of profound interest to any educated person, because, as we shall see later, the answer is associated with the role of the mind in cognising the external world.

But how to approach so broad a task? How is it possible to cover in a brief essay the sum of object relationships in object thinking? Covered, however, they must be, because the question is a very general one. Fortunately, the difficulties associated with this first step were surmounted long ago; so all I have to do is to put the results before you in the simplest and most comprehensible way.

No matter where man finds himself, he is always surrounded by objects! Some of the objects are immobile, others are sometimes in motion, still others, though motionless, manifest more or less protracted changes, etc. At the same time man can distinguish the separateness of objects; the ability to do so is described as the faculty *of isolating objects in space*, and his ability to distinguish changes in the position and state of objects as the faculty *of isolating phenomena in space and time*. These two faculties are acquired in infancy, and this acquisition marks the beginning of man's conscious acquaintance with the external world.

Then follows his ability to single out in objects all the attributes accessible to the senses, including the *constant* and *characteristic* attributes that enable us *to recognise objects and the way in which they differ. When a child draws a tree, a house* with a smoking chimney, a dog, etc., these objects are not only isolated from each other in its consciousness, they are registered in the memory in the form of characteristic outlines. When a child of this age is shown an oak, a birch, a willow, etc., and told to draw them on paper, it will draw one and the same form and will say this is a "tree". Hence, in the child's mind there has already taken place *a comparison of objects by similarity.*

Lastly, everyone knows that even very young children are eager to know the how and why of the things seen by them or described by others.

In everyday life this is taken as a sign of development of the child's mind, but to those acquainted with the development of object thinking from impressions, this sign already contains all the elements of object thinking, i.e., all the categories of links and relationships between objects which can only be conceived by man. This is easily proved. It suffices to compare, point by point, the foregoing elementary mental acts of the child with the mental methods of natural science in studying the external world and the links and relationships between objects.

Since this science studies the structure, composition and properties of bodies, and defines the factors of phenomena, it actually repeats the same mental operations as performed by the child when distinguishing the attributes of objects and phenomena. The sole difference is in the way the study is conducted; whereas the child is content with the direct indications of its natural senses, the scientist will use an arsenal of artificial means of analysis.

Further, in classifying objects into groups or systems, the descriptive sciences repeat the same mental operations by means of which the mind of the child relates the birch, aspen and oak to the group of "trees".

Lastly, as everybody knows, the study of nature boils down ultimately to the study of the interaction of its component factors. But there is nothing novel about this category of mental comparisons, because it answers the questions "how?" and "why?" which arise in the child's mind.

And so, notwithstanding its brevity, our enumeration does embrace all the general cases of the origin of conceivable links and relationships between the objects of the external world. If we accept this, our task boils down to the following.

For each of the foregoing acts—isolating objects, distinguishing their attributes, recognising them by their characteristics, their comparison by similarity and determination of their causal interdependence—it is necessary to ascertain the role of both variable factors in the development (decomposition) of complex impressions and in their conversion into object thinking, i.e., the role of the variable external influence as well as of the receptor organ or sense organ which develops as a result of exercise. If it turns out that at all stages of the development of the impression into a sensory thought the receptor organ does not create but merely borrows from reality the elements of complex impressions designated by the verbal image "copula", then our task will be solved.

Let us, then, begin with the *acts of isolating immobile objects in space*.

2. As we know, *this isolation presupposes a fixed limit for* any terrestrial body accessible to the senses. For sensation this is really the sole criterion of separateness. No one designates the sea as "an object"; only scientists regard air as a "body"; light, smell and sound are held to be only properties of bodies. Conversely, a grain of sand, a cloud and the sun appear as separate objects even in the consciousness of uneducated people.

But, as we have seen from the article "Impressions and Reality", the limits of bodies can be ascertained only by vision and touch; hence, *the spatial isolation of terrestrial bodies is the result solely of visual or tactile acts* (or of both together), and *insofar as the latter express the real outlines of the objects* (see the article "Impressions and Reality"), *the sensory isolation corresponds to reality*.

In other words, *the separateness of objects in space, as felt and conceived by us, is imposed upon the mind from without.*

As to the isolation of phenomena (modifications of the state and position of bodies) in space and time, I shall examine two typical cases—motion and sound.

The article "Impressions and Reality" has acquainted the reader with perception of the movements of objects. We know that the receptor organ, when following the moving body, reproduces and perceives motion with all its attributes (direction and speed) so accurately that the real and the perceived generally coincide. To what degree the eye is accustomed to discern not only the direction of movement but also its speed, is best shown by the visual illusions which baffle all reasoning. When we examine under the microscope the flow of blood along the smallest blood-vessels of a living animal, the displacement of the corpuscles, seemingly, is very rapid, whereas it is really very slow; the distance of displacement of a blood corpuscle in one second is smaller than the width of a pinhead. The illusion is due to the fact that the microscope greatly enlarges the pathway of the displacement without altering the time.

But if a movement which we perceive is always engendered by a real movement*—which is the case—and if both are similar, then *all the displacements of objects in space perceived by us are real and all the attributes of movement are imposed on the mind from without.*

In all cases the path of the displacement and its duration are measured by the exercised muscular sense which accompanies the movements of the eyes.** But man possesses another instrument for measuring time—the sense of hearing. True, for measuring long intervals of time, this sense is not suitable, but it can measure short intervals with remarkable precision. To be able to dance in time with music or to maintain a definite tempo in singing or playing a musical instrument, one must, so to say, have a good ear; and this is correct in the sense that the movements of dancing, singing and playing musical instruments are learned and performed under control of the sense of hearing. Anyone "with a good ear" and who has had anything to do with a metronome knows how delicately the ear assesses the precision of rhythm, i.e., the equality of the minute intervals of time. Moreover, scientific experiments have shown that the possible errors of the ear do not exceed several hundredths of a second. And if we add that the ear is highly sensitive to the oscillations of the intensity and pitch of sound, it will become quite clear that the organ of hearing is an appara-

* It is true that there are fictitious displacements of objects, but since they occur under highly distorted conditions of vision they do not refute, but, on the contrary, confirm the foregoing proposition.

** That is why in everyday life the shortest interval of time is designated by the expression "the twinkling of an eye" (in German by the word *Augenblick*) tus adopted mainly to the perception of acoustic phenomena varying in intensity, pitch and duration in brief intervals of time. Should the surrounding world be filled with invariable sounds of many hours' duration, the ear with its actual structure would be an imperfect organ. But this, as we know, is not the case. Even in the wail of the storm, in the rustle of the forest and in the roar of the sea, to say nothing of the sounds made by animals, the ear discerns more or less rapid oscillations and modulations. Hence to the ear *an isolated acoustic phenomenon is that acoustic minimum which characterises the* sound of the given object—the hissing of the serpent, the buzzing of the insect, the rumble of the mill-wheels, the cry of a bird, the peal of thunder, the noise of the sea, the articulated sounds of human speech, etc., etc.

Nobody, I believe, will argue against this definition, but everyone will say: such isolation really exists, but in all probability only in the psychical sphere, because to the deaf-and-dumb the external world is mute. It follows then, that the separateness of the external causes of acoustic phenomena must not necessarily correspond to the perceived separateness of the sounds. It is possible that the acoustic movements in the environment really last for hours without variation, and that the transitions and oscillations of sounds perceived by us are products of the organisation of the ear.

With the invention of the telephone and the phonograph this question has been answered once and for all. These instruments show that the plates vibrate, so to say, in time with the most complex acoustic movements, including human speech. On the other hand, we know that the ear has a similar plate, and that this plate vibrates under the action of sounds and reproduces external movements in the form of sounds much better than Edison's phonograph. And no matter how this brilliant inventor tries to improve his phonograph, the tympanic membrane of the human ear with its ossicles will still be for him an unattainable ideal. Patti's singing, recorded and reproduced by the phonograph, is remarkable; yet it is inferior to the singing heard directly by the ear.

Thus, although we know the way in which an acoustic sensation is originated by movement, strictly scientific experiments show that any perceived oscillation of a sound or variation of its intensity, pitch and duration corresponds to a strictly definite modification of an actual acoustic movement. Light and sound, as sensations, are products of the human organisation; but the sources of the forms and movements which we see, as well as of the acoustic modulations which we hear, lie outside us in reality. In the matter of forms and movements the eye plays the role of the photographic plate which clearly perceives not only immobile, but also moving images; because of this, the similarity between the perceived and the real is here as appreciable as between the person's face and his photo. As to the similarity between a sound and the external movement causing it, though it concerns all the aspects of the latter as a periodic oscillation, namely, the duration of the movement and the intensity and frequency of the oscillations, this is not similarity in the strict sense of the word; it is merely *parallelism* or *conformity*. A sound heard can be similar only to another sound, but not to a movement, whereas in the visual sphere a form seen is similar to a form which really exists.

In any case although the ear is a conventional reproducer of certain external movements (transforming these movements into sounds), it is more delicate and more faithful than all the instruments so far invented by man for recording acoustic oscillations. True, the sphere of acoustic movements in nature is much more extensive than the sphere of the sounds heard by man,* it follows that the *transmission of the reality by the ear* is far from being complete; but this restricts only the sphere of application of this apparatus and by no means the delicacy and precision of its reproduction of reality. The eye, too, does not see microscopic objects, but this does not prevent it from being, within the limits of its action, the most delicate recorder of forms.

Thus, the real separateness corresponds to the perceived separateness of the sounds. The source of all that we designate

* The limits of audibility for musical tones are between 16 and 40,000 oscillations per second Moreover, the microphone shows that we *do not* hear a multitude of faint noises (for example, the noise made by a creeping fly) of which we had no idea prior to the invention of this "aural microscope"

as modulation of sounds is external to us, and sensation develops parallel to the external movement. The beginning of a sound coincides with the beginning of a movement, its end with the end of the movement, and the variation of sounds according to their pitch, intensity and duration—with the frequency, amplitude and duration of the acoustic movement.

3. The examination of the question of the discernment of attributes in objects can be best started with an example. Externally, an orange is characterised by the following attributes: a spheric form, a furrowed surface, an orange colour, a certain size, a certain weight and, lastly, a certain aroma. The *discrete character* of these attributes is due to the *discrete character* of the reactions of the receptor organs—the eye (form, colour, size and properties of the surface), the touching hand (form, size and properties of the surface), the muscular sense (weight) and the olfactory organ. But this is not all. If the discrete character of all the perceptive reactions were felt by us as distinctly as that of the attributes, the question would have been solved long ago even for the layman; in reality, however, this is not so. Distinguishing between attributes is regarded as their *mental separation*, or, in any case, as a psychical process. This explanation is true in the same measure as the explanation based on the discrete character of the reactions; but there is nothing mental in the psychical process of separation: this process develops in the unconscious recesses of memory. The point is this. If all the objects in the world were transformed into oranges, it is more than likely that man would never learn to distinguish all the attributes of this fruit. But since he has to deal with spherical forms of highly diverse colours, sizes and weights, as well as with the odours of objects of other forms and colours, and since in the recesses of his memory the impressions—no matter how different—are always compared by similarity (or, what is the same, by similar reactions of perception), it is these comparisons that result in the separation *from each other of the forms, colours, sizes, odours, etc.*

No matter what explanation we may choose (actually they are identical), it will prove that the organisation of the sensory mechanisms plays an essential role in separating the attributes. That is why it is impossible to affirm in general that something really discrete corresponds to a discrete sensation and that the two are always parallel. The only exceptions are those attributes the discernment of which is possible owing to the displacements of the receptor organ during the perceptive reaction; they are: the outlines of the object, its size, the topography of its components and its displacement in space. These attributes are as discrete in reality as in sensation, both types of discretion being parallel. To make sure that this is really so, let the reader ask himself whether he discerns by sensation different movements of his arm, or similar movements of his right and left arms, and whether he believes in the real separateness of his arms with their movements upwards, downwards, etc. The modulations of sound constitute, as we have seen, another exception. Knowing the physical basis of the sound, we can isolate in each object the cause of the sound, whereas, for example, in sugar we know neither the factors which connect, nor those which separate the real source of its white colour and sweet taste.

Thus, *so long as the distinguishing of attributes concerns the analysis of objects and phenomena in space and time, the indications of the sense organs* (vision, touch and hearing) *are parallel to reality*. Beyond these limits the parallelism is of a very general character, and, moreover, always conventional. Thus, given identical external influences, certain distinctions of an unknown nature, but perfectly real nevertheless, correspond to the yellow, green and red colours of the objects; if the colouration is constant, then its real basis is likewise an indispensable attribute to the object; if a certain dark object suddenly begins to glitter, the change in the sensation corresponds to an actual change in the state of the object; a difference in the taste of two substances, for example, between bitter and sweet ones, corresponds to a real difference, etc. In a word, the relation between the object and its attribute as a conventional sign is here the same as between the object and its name. Assigned to the object once and for all, the name even substitutes the object itself.

4. Before proceeding with our subject, I shall show with the help of two examples how object thinking arises from the separation of attributes in an object. Visual separation of the topographical peculiarities of complex objects, such as a land-

scape and the human body, is, perhaps, the simplest and clearest example.

How are the features of a landscape actually described?

*To the left* of the observer there is a mountain; a stream winds its way *at the foot* of the mountain; a bridge is seen *in the distance; near* the bridge, *to the right* of the river cattle are grazing; still *farther to the right* a village and a church are seen, and a *little way off* a building with a *high* column, probably a smoke stack, since smoke is wreathing *over* it.

What are the topographical features of a human image?

The *upper part* is formed by the head with its forehead, eyes, nose and mouth; *then follow* the neck, the arms, the trunk, the legs, and *below*—the feet.

That is how an adult would describe the two pictures, adding to the topography now and again such figurative expressions as "*the winding stream*", "*the bridge thrown over the stream*", etc. The child, too, can correctly assess the topography of objects since it is able to take in their outlines with the eyes and has learnt to distinguish by sensation the movements of the eyes *upwards, downwards, to the right and to the left.*

But how are these movements effected?

They have their source in the special structure of the retina which impels us to move the eyes so as to take in not only the general outlines of the objects but also their separate details.

If you open a book and fix both eyes on the middle of a word consisting say, of ten letters, you will be able to see distinctly and to read not more than five letters; this is because their image will occupy the entire area of clear vision on the retina known as the yellow spot and only somewhat larger than a pinhead. *At the same time, the eyes will take in the whole page* without distinguishing the details. Actually the same thing takes place in the case of a distant landscape; here, however, the object measuring several yards (for example, a church, house, bridge, etc.) produces an image which falls within the limits of the yellow spot. For this reason the clearly visible details of nearby objects will be but a fraction of an inch in size while the *details of a distant view or landscape will take up several and* perhaps dozens of yards.

The uneducated person is not aware, naturally, of this property of the eyes; still, it impels him, and people generally (and even animals), to move the eyes along the objects if the image on the retina exceeds the limits of the yellow spot. In everyday life this displacement of the eyes is known as detailed examination of an object.

At first sight this may appear to be a major defect of the eye. Why isn't the structure of the retina as a whole the same as that of the yellow spot? If this were so all the work of examining objects with the resulting loss of time would be unnecessary. Actually, however, this perfection would be a misfortune for man: while able to take in all the details of the objects with equal clarity, he would have no reason to move his eyes and thus would be deprived of the sole reliable means of discerning the topographical relations between the parts of a visual picture. It is doubtful if he would be able visually to ascertain the disposition of objects and of their parts in space.

But thanks to the constant exercise of the eyes in visual acts, man learns to distinguish by means of the muscular sense the movements of the eyes upwards and downwards, to the right and to the left, and once they are distinguished, he simultaneously differentiates, by way of sensation, the topographical relations between those parts of the object which we designate by the terms: top, bottom, left side and right side. Some forty years ago, while everybody knew that the images of objects appear on the retina in an inverted form, they could not understand why we see the objects in the right way and not upside-down. At present this puzzle has been cleared up.

We apply the term "top" to that part of the object which we can touch by raising the arm and which we can clearly see by elevating the eyes in the same direction. But the eye-balls, being round, move within their orbits like spheres around their centres. Hence, when the anterior surface of the eye moves upwards the posterior surface, together with the retina, is displaced downwards.

Now let us imagine that before the eye O there is an object *AB* whose image *ab* on the retina is greater than the yellow spot *cd* (Fig. 1).

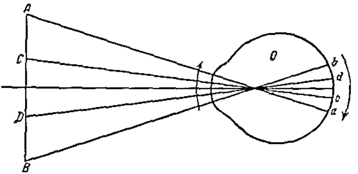


Fig. 1

In order to see point *A* clearly, the eye must be so placed that the centre of the yellow spot should coincide with point *a*, i.e., the yellow spot should be opposite point *A*. But for this purpose, the posterior surface of the eye-ball, together with the retina, must be moved downwards and the anterior surface upwards. We do not see the downward movement of the posterior half, but we are aware of, and we observe it in others, the upward movement of the anterior half. Which of these directions, then, determines the name of the movement if not the visible displacement of the anterior surface?

Appellations are usually given to things which we can see or feel. Hence, when looking at point *A* we say we are looking upwards, and when looking at point *B* we say that we are looking downwards.

Thus, insofar as the topographical analysis of visual pictures can be reduced to a series of confrontations of pairs of objects *according to their position, all three elements of object thinking* are furnished by the movements of the observer's eyes: the act of looking round the outlines of objects furnishes the subject and the predicate, while the passage of the eyes from one object to another gives the copula, or the relationship between subject and predicate.

5. In some cases memorising the outline suffices not only to isolate an object, but also to *recognise* it as such, i.e., to *distinguish* it from similar objects. But as a rule the constant and distinctive sign of the object is formed not by one but by a

number of attributes. For example, we have enumerated more than six attributes of an orange, of which only three constitute its external distinctive sign—form, colour and odour. Consequently, recognition presupposes ability to isolate from the sum of attributes those which are most characteristic and to memorise them as a group. Even the mere separation of attributes from one another is regarded as a psychical operation, and all the more so the isolation of the characteristic features. It is easy to understand that a feature will be characteristic of a particular object only when in other objects it is either barely indicated, or completely absent, or manifested in an entirely different way. Hence, when recognition of objects coincides with the distinguishing of them from one another, this obviously presupposes a series of comparisons, i.e., of acts that are of an indubitably psychical nature. The following consideration also leads us to this conclusion. For sensation an object is the sum of its attributes, but in practice a certain part is isolated from the sum and takes the place of the whole. In appearance this is a mental knack having apparently in man's psychical organisation the same grounds which impel him to designate objects by short conventional signs, i.e., by appellations. Comparatively simple observations show, however, that the elaboration of the raw impressions, which is implied here, takes place wholly in the recesses of memory, outside consciousness, i.e., without the participation of mind and will. One has only to recall that animals, too, can recognise external objects.

If we judge of memory by its effects there can be no doubt that these are the work of a definite mechanism, perhaps the most wonderful of its kind in the world. Like Edison's phonograph, it records, preserves and reproduces external influences, but leaves all the marvels of this instrument far behind. After all, the phonograph responds only to acoustic phenomena and records only individual cases, whereas memory enters in its registers all the influences exerted on the five sense organs (including the oscillations of muscular sense) and records not one but millions of series of impressions. Moreover, it singles out the constant, i.e., the most frequent attributes of uniform impressions, thus separating them in the consciousness from the secondary attributes; lastly, it classifies all the attributes according to their relationship to the object, similarity, etc. And this mysterious activity, which begins in infancy and lasts throughout life, is the so-called ideational elaboration of raw impressions. However complex this activity is and how much the components of the impressions are reshuffled, the images and sounds impressed in the memory are retained to the degree to which recollection of the event is similar to the event and to which the images are recognised as having been seen and heard.

Although this brief enumeration of the properties of memory adds nothing to what has long been known to any educated person, it contains everything that explains the act of recognising objects by their characteristic attributes.

From infancy and throughout his life man is surrounded by groups of objects and obtains series upon series of impressions. The attributes of the objects are not only deposited in the memory alongside one another, they are juxtaposed link by link according to similarity, i.e., form with form, colour with colour, etc. Proof of this is the direct sensation of contrasts between the form of objects (high and low, wide and narrow), their size, brilliancy of colours, etc. At first, when the infant has not yet learned to see, to hear and generally to make proper use of its sense organs, the disposition of the members within a series is in all probability casual and unstable; but little by little a certain order is established in this chaos: with the separation of the objects from one another, the attributes, no longer a haphazard consecutive series, are grouped according to the relationship to the objects. We become conscious of intervals in the series, but the comparing of the neighbouring groups goes on as before. The more frequent the repetition of the influences exerted by certain objects, the clearer and firmer in the memory are those attributes which are more permanent and striking and which contrast more sharply with the similar attributes of other objects. This is what we term the distinctive signs of an object. These signs are registered in the memory along with the other attributes of the object, but more firmly and more distinctly, and are more readily reproduced. Their production in the consciousness becomes easier with each encounter with an object possessing these signs.

We do not know what takes place inside us during these encounters: the process is too fleeting. (Donders measured it and found that it lasts only thousandths of a second.) But it can be assumed that what takes place is a kind of comparing of an actual impression with the one that is reproduced followed by ascertainment of their identity. For example, I visit a certain person on rather important business; always I have seen him with a beard, but now all of a sudden I find him beardless. You may be sure that despite the important business that has brought me to this person, my first thought at the sight of him will concern not my business, but his beard. I have known this person by a number of other distinguishing features, but one of them was my memory of his beard.

Thus, although the acts of recognising objects are the result of a highly complex elaboration of repeated external influences, *they do not indicate any distortion of real impressions.* The isolation of certain attributes into a sign is the result not of a deliberate mental analysis, but of the unconsciously acting mechanism of memory. For those animals that run swiftly the capacity to recognise objects at the slightest indication is a vital necessity; this capacity plays a big role also in the everyday life of man as a time-saving factor. For instance, if we read to ourselves, following the text with the eyes, i.e., recognising the words by their first letters, we can get through a book in one evening, but, reading aloud, we will hardly get halfway through.

6. Now, in accordance with the order of our exposition, it is time to examine the question of the comparison of objects with one another. Enough has been said about comparison as a process: we know that it is an act of memory effected without the participation of mind and will. I shall, therefore, dwell here on other aspects of this question.

If on the whole memory can be regarded as almost the most wonderful mechanism in the world, then its capacity for comparing the objects and phenomena encountered with those memorised, irrespective of time and space, can be described as man's most precious intellectual treasure. Thanks to this capacity, man compares mentally not only the things he experienced in childhood, adolescence and old age, not only the things seen, say, in America and here in Moscow, but also the life of today with things that took place in antiquity. Hence, thanks to memory with its comparisons, contemporary man can participate, so to say, in the life of the universe without leaving the narrow limits of his terrestrial existence. To what, if not to similarity, do we owe our knowledge of the life of ancient people, as well as of those who live beyond the oceans? Memory enables us to look not only at the present and the past, but also to peep into the future. And how great is the importance of comparison by similarity in natural sciences! Modern physics owes its most brilliant pages to comparison; and it is comparison that imparts a definite sense and charm to the science of the forms of the animal organism. Indeed, it cannot be otherwise, since a broad horizon, unrestricted in time and space, lies open before comparative memory. It is possible to compare almost everything in the world, and this possibility is widely used in everyday life. What a variety of comparisons is applied, for example, to human beings! They are compared with the stars of the firmament, with stone and wood—to express heartlessness, with diamonds and pearls, with worms—by contrast, with elemental forces, with vipers—to express malevolence, with doves—to express purity, and with numerous quadruped —to express less flattering properties. Frequently seemingly incommensurable things are compared, and yet such comparisons are not only sensible, they contain a definite measure of truth.

A comparison makes sense if the similarity affirmed in the three-member sentence seems to our sensation real. It is sensible, for example, when we say that a person with long legs and a long nose resembles a crane; but it has no sense if the same form is compared with a tortoise. What is it then, that makes us believe that the similarity is not only seeming, but real?

It is the axiom which lies at the base of the empirical and scientific knowledge of the external world and which states:

*No matter what the external objects are by themselves, independently of the consciousness—even if the impressions obtained from them are merely conventional signs—a real similarity and a real difference always correspond to the perceived similarity and perceived difference.*

In other words:
*Similarities and differences distinguished between the objects perceived are real similarities and differences.*

7. The last category of mental confrontations is the establishment of the causal interdependence between objects, or more precisely, between factors of phenomena. This question can be best analysed by means of an example.

A person is walking in the street when suddenly he is hit by a stone. An investigation reveals that the offender is a mischievous boy, who more than once has done harm to passers-by, that he is almost a street urchin who has rude and indifferent parents. The investigation yields a canvas which enables us to connect a series of facts by their causal dependence. The principal reason for the offence lies in the qualities of the parents; the effect is the life of the boy as an outcast of the street with its bad examples; this effect is at the same time the cause of the boy finding it agreeable and even necessary to throw stones at passers-by; this, the effect of the second cause, is in its turn the cause which impelled the boy to throw the stone; and the consequence of the latter is the injury caused by the stone. In everyday life, especially when a person is involved in something as an agent, this explanation is more or less sufficient, although here again it proves that actually there is no difference between cause and effect. But when the same scheme is applied to phenomena in which the operating factors are equivalent, the isolation of one—as an operative cause, and of another—as a subordinate factor, as well as the separation of the effect from the cause is impermissible. For example, a stone which we have picked up falls back to the ground. According to the theory of causality, the principal factor is the earth with its gravitation, while the stone is inactive since it participates in the phenomenon passively, by its weight, i.e., falls more rapidly than a feather. Actually, however, this is not so. The stone attracts the earth just as the latter attracts the stone, but this attraction is so feeble that the earth does not reveal any perceptible movement towards the stone. Here we have not a causal relationship, but the interaction of two factors, one of which is enormous and the other—insignificant. Fire is regarded as the cause of burning: this is likewise untrue, because here we ditions of scientific experimentation. But we have already examined this question earlier, and we know that within these limits the indications of the higher sense organs correspond to reality.

Thus, *reality corresponds to all the elements of object thinking as far as it concerns those links and relations between objects in space and time that are perceived by us.* In relation to any human being the world of objects existed before his thought; hence, the external world with all the links and relations between its objects has always been the primary factor in the development of thinking. But this does not mean that thought, which borrows its elements from reality, only reflects them like a mirror; this reflection, one of the precious faculties of the memory, exists alongside the equally precious faculty of decomposing variable sensations into their components and of combining facts separated by time and space into a single whole. In man's encounters with the external world, the latter offers him only single cases of links and relations between objects in space and time; nature is, so to say, a conglomeration of individuals; it knows no generalisations, whereas memory begins to generalise the moment it first manifests itself in the child.

## THE PHYSIOLOGICAL ASPECT OF OBJECT THINKING*[75]

I deem it a great honour to be the first to address you with a scientific speech. As we have gathered here for a festival of scientific thought, I believe that it will be appropriate to choose *thought as a subject for our discussion.*

In appearance thought is a purely psychological problem; and it really is, as far as the stages of its development are concerned, including abstract or symbolic thought. But our task is much more modest: we shall consider here only those most elementary forms of thought which appear already in childhood and which to a degree are inherent in animals. You will see *that in this comparatively narrow sphere the physiologist is* entitled to have his say, all the more so because this sphere was already investigated by Helmholtz, the greatest of all physiologists, the man who laid the foundations of the future physiology of object (visual) thinking.

Thus, we shall speak here of the problem of thinking in terms of external objects perceived by the sense organs, as well as *of the physiological elements of which object thinking is formed* before it is expressed in words, and of the organs that participate in its formation.

But how to approach this task? There are as many object thoughts—if not more—as there are objects of the external world with their distinct individual attributes, because, as we know, thought includes not only the separate integral objects,

* Speech delivered at the general session of the Ninth Congress of *Russian Naturalists and Physicians on January 4, 1894.*

but also the object and its part, the object and its quality or state, etc. Hence, our problem can be solved only on the condition that almost the entire infinite diversity of thoughts is reduced to one or several general formulas embracing all the essentials of thought. Otherwise, it would be necessary to analyse hundreds of thousands of cases. Fortunately, a formula of this kind has long been in existence, and we made its acquaintance during our school-days when we studied grammar.

It is *a sentence consisting of three parts—subject, predicate and copula.*

*This formula, it is true, was deduced* not for a thought that is still in the process of formation, but for its ready form, for a thought already expressed in words; but in the absence of any other objective expression of thought, we shall take this formula as the point of departure.

However, before proceeding, we should convince ourselves that the foregoing formula really covers practically the entire infinite diversity of thoughts. Without being convinced of this, it would be very risky to base deductions on this formula.

Fortunately, its universality can be established easily. Among all peoples at all times, among all tribes and at all levels of mental development the verbal image of thought has been reduced, in its rudimentary form, to our three-parted sentence. This explains why we understand with equal ease the thoughts of a man of antiquity found in written relics of the past, the thoughts of a savage and those of a man of our own times. This also enables us to affirm with certitude that the latent inner *processes engendering silent thinking, identical for all* human beings, are effected by mechanisms which always function like parts of a machine. At first sight, this conclusion may seem to be too bold, but imagine what would happen if the action of the factors engendering thought were not subordinated in all men to uniform laws. Then each would have his own thought structure, his own logic—not in the humorous sense, often applied to those whose actions we do not understand—but literally. In order to understand one another, men would have to create a considerably more difficult science than present-day logic; but, thank god, we can understand one another even without the help of logic.

And so we have the necessary formula and our task boils down to finding the physiological equivalents of all three parts of the sentence, i.e., subject, predicate and copula.

This is precisely what we are going to do. But we must first establish the general sense of each of the three elements. A thought is a thought not because it consists of three parts of *differing denominations, but because it has a definite sense*. Our job, then, is to establish the sense of each part of our sentence.

In any object thought certain real things of the external world perceived by our sense organs correspond to the subject and to the predicate. Consequently, the common essential feature of these is that *they are products of the external influences on our sense organs*.

As to the third part of the sentence, i.e., the copula, the matter is different, at least in appearance. Its verbal image is usually deprived of any object character; it expresses the relation, connection, interdependence between the subject and the predicate. The copula bears, so to speak, not an essential, but an ideational character, since it determines the sense of the thought. Without it, the subject and the predicate would be two separate objects; but because of it they are united into a group possessing a definite sense.

But a multitude of connections, interdependences and relations exists between the objects of the external world, all the sciences treating of the external world being full of them. Consequently, our formula which is simple, as far as the general sense of the first two members is concerned, may prove to be highly diverse in respect of the sense of the third member. In this case it would again be necessary to examine not one, two or three general cases, but a multitude of them.

But this difficulty, too, was surmounted long ago. All the conceivable relations between the objects of the external world are now reduced to three principal categories: *coexistence*, *succession* and *similarity*. Spatial relations correspond to the first of these forms, and sequence in time—to the second. Causal dependence is also regarded as a particular case of succession. But how to prove the tripartite interdependences and connections between the objects of the external world?

They can be proved by the following three considerations.

The external world in its entirety appears to man as a space filled with separate objects, or, what is the same, by a group of objects each of which is of a definite magnitude and occupies a definite relative position. The elements of this group, apparently, exist in common and are interconnected only by spatial relations, differing from one another in size, form and place in the group.

Say a change takes place in the state of a certain member of the spatial group, it will appear to our sense as having a beginning, continuation and end, no matter what this change may be, i.e., it is always of a certain duration. That is why we say that everything in the external world occurs in space and time.

As to connections according to similarity, their importance in the external world derives from the following.

The natural sciences, speaking broadly, treat of the links, relationships and interdependences between the objects of the external world and their components; everyone will, of course, agree that the results obtained by the natural sciences are products of thought of a higher order; meanwhile, the history of the natural sciences shows that man's progress in the theoretical knowledge of the surrounding nature is due wholly to the comparison of objects and phenomena by similarity. In the classification systems of the descriptive sciences this is expressed in a direct way; but the same thing takes place in physics. Among the latest problems tackled by this science are: transmutation of energy, comparison of electricity with light, and the attempt to reduce all phenomena to various forms of motion.

Now that the general sense of all the elements of a three-member sentence has been defined, we can establish the general formula for an object thought according to its essence.

*An object thought is a discrete group the elements of which are of an object character and may be interconnected in three ways by similarity, by spatial relationship* (as members of an immobile spatial group) *and by succession in time* (as links of a successive chain).

We can now proceed to the solution of our task, i.e., to determine the physiological equivalents of all the elements of a thought expressed in words, to indicate the *factors whose co-*

equivalents, but also the two factors (the third will be considered later) participating in the formation of a thought—the repeated external influence and the exercised apparatus of perception.

Now let us turn to the equivalent of the third element which connects the subject and the predicate into a spatial group or successive chain.

Since the times of Kant the view has been widespread that man has a special organ—a kind of internal vision—for perceiving the spatial relations and the relations of succession, an organ which directly furnishes the consciousness with information concerning the foregoing relations. This idea was, in a way, justified, because this organ really exists and should be designated as *the organ of muscular sense.*

The activity of this organ can be best elucidated by means of an example.

When we observe a group of objects or when we examine the details of one complex object, the eyes pass successively from one point to another. Thanks to this, we obtain a series of visual impressions produced by separate parts of the object; the intervals between these impressions are filled with the movements of the eyes and head, i.e., with the contractions of certain muscles of the eyes and of the head accompanied by a muscular sense. Everyone knows from personal experience that the movements of the eyes and of the head immediately convey to the consciousness information concerning the position of the point observed relative to the point observed previously, i.e., indicate whether it is above or below, to the right or to the left, farther from the observer or nearer to him. Hence, due to the movements of the eyes and head, the complex visual image is broken up into separate parts which are interconnected by spatial relations, and it is the muscular sense that unites all the visual elements into a spatial group. The point is that the muscles of the eyes and of the head participating in the acts of vision play the role of goniometers which furnish the consciousness with varying sensory goniometric indices depending on the location of the given point in space, or, what is the same thing, on the direction and extent of the movements of the head and eyes.

But this is not all. These goniometers provide the consciousness with sensory indices concerning not only the extent of the movement effected by them, but also its speed. For instance, when we follow with our eyes the flight of a bird, we are conscious of the direction of its flight thanks to the goniometric indices provided by the muscular sense, and of the speed of the flight thanks to the rate at which the eyes and the head are displaced when following the bird. *The point is that the muscular* sense is of a certain duration which varies according to the rate of contraction. True, some other sensations, for example, the acoustic sensation or the sensation of pain, are of a protracted nature too; but these forms convey to the mind only the duration of the sensation, not its rate. There is no such thing as a rapid or a slow pain; a sound may be long-drawn or abrupt, but it cannot be swift. When we speak of a rapid tempo in music or when we say that the speech of some people is fast and that of others slow, what we really have in mind is a greater or lesser duration of separate sounds in the musical melody or speech, or a greater or lesser duration of the mute intervals between them. The ear excellently measures the briefest intervals of time, but *it cannot measure speed, because a sound is* not perceived as a movement and speed is an attribute of movement which presupposes a simultaneous sensation of the extent and time of the displacement. Conversely, in a contracting muscle both elements are present and both are perceived separately.

Hence, *since a thought is a discrete group in space and time, in the sensory group it is the motor reaction of the exercised sense organ participating in the act of perception that always corresponds to the copula.* Located at the turning-points of the visual, tactile and other *forms of sensation, the muscular sense,* on the one hand, communicates a discrete character to the impression, and, on the other, unites its elements into a group having a definite sense.

Now it remains only to examine the act of comparing the objects of thought according to similarity.

Here the organs of memory come into play. I say "the organs *of memory*" and not "the organ", because from the standpoint of the physiologist the concept includes the central accessory apparatuses of the sense organs and of all the acquired complex movements.

However wonderful the general structure of the animal organism may be, the mechanism of memory is, perhaps, the greatest miracle of the animal, and especially of the human, organisation; it is a mechanism because it functions independently of consciousness, judgement and will, according to immutable laws common to all people. We are so accustomed to the phenomena of memory that the miracle does not surprise us; but one has only to compare its activity with that of a similar apparatus designed by man, and the miracle will be striking. Edison designed an instrument which resembles human memory—the phonograph; everyone knows, of course, the enthusiasm which this mechanical marvel evoked all over the world. Yet, compared with the oldest of all known instruments, i.e., human memory, this modern marvel is a mere toy. Indeed, the phonograph records sounds only, while memory registers the indication of all the senses and does so every minute throughout life, sometimes for a hundred years; it is at rest only at the time of deep dreamless sleep. A phonograph recording is at best a more or less exact reproduction of complex acoustic movements, while the memory not only records impressions, it classifies them in full or in part. Upon recording an impression the memory deposits it in the recesses where all other similar records accumulated during the life span are preserved and kept in an order so perfect as to be the envy of the best organised library. *All the impressions produced by objects* and their attributes, qualities, states and interrelations are registered in these recesses according to four main categories: that which preceded the given impression; that which accompanied it; that which followed it; and that which resembles it wholly or in part. Accordingly, the registration assumes the form of a continuous but discrete sensory chain the elements of which are linked either by casual or by constant connections. In the case of repetition of uniform impressions those casual neighbouring elements which are not repeated are, in most cases, not preserved in the record, whereas the constant elements are retained as a group. The constant elements existing alongside, with constant goniometric sign in the interval are registered as a spatial group, if the goniometric sign is variable in time, they are registered as a group in motion; lastly, a serial registration according to similarity yields the form which we are considering here.

But this is not all. Like the phonograph, memory acts in two ways: it not only records what has been felt, it reproduces it wholly or partly in the sensory form generally known as recollection. In order to reproduce a record, the needle repeats the movements performed by it during the recording; the same thing, in fact, occurs in the nervous system: recollection evokes a repetition of the process which took place at the moment of the real impression.

However, here, too, the difference between the phonograph and the memory is tremendous. In the phonograph the reproduction is indissolubly connected with the recorded text and follows it step by step, note by note, letter by letter, but in the sphere of sensation this hardly happens even when the exact repetition of the actual impression acts as the impulse to its recollection; the reason for this is that the recollection is effected more rapidly than the corresponding real impression. Usually a slight, transient and even barely perceptible hint suffices to evoke reproduction of the thing experienced. For example, an aria or poem, if learned by heart, can be fully reproduced in the memory when prompted by the very first notes or words. Sometimes an impression is reproduced at the hint of a certain accessory circumstance which preceded or accompanied it. We cannot as yet properly explain these complex phenomena, but there are grounds for believing that a serial registration of impressions corresponds to the fixation in the central nervous system of the successive processes which determined the given sensory series. From this standpoint, the phenomenon of reproduction at a hint is perfectly comprehensible—the hint being the impulse which initiated the corresponding nervous act *in the previous real impression; and when the nervous act is* restarted by the hint, it goes on to the end.

In any case, from what has been said you will gather that the indispensable condition for the reproduction of an impression is some other impression, more or less fragmentary, but *always more or less similar*—partially, wholly or even accidentally—to the reproduced impression. Similarity is the sole condition for the reproduction of impressions; hence, it is a law, and its roots, clearly, are located in our sensory organisation.

This is the reason why even in object thinking the present can be compared with the past and things seen in one place with those seen a thousand miles away; and this also is the reason why people who have reached a higher level of intellectual development, can think in terms of our entire planet and even relive the life of our remote ancestors.

Lack of time prevents me from enumerating all the intellectual advantages enjoyed by man thanks to his memory; I shall confine myself to saying that memory is the source of mental life.

When the real impression produced by a certain object is repeated, say, a thousand times, it appears in the consciousness simultaneously with its recollection; a confrontation by identity takes place, and this results in the mental movement which we know as recognition of the object. This, the simplest form of thought—a form inherent even in animals—is the beginning of mental life. Indeed, without memory we would not be able to recognise the objects, with the result that they and all their attributes, would be unknown to us for ever, because we think only in terms of known objects.

Hence, the elements of silent object thinking are the products of the action of the external world on our sense organs, while the factors the co-operation of which gives birth to thought are: a repetition of external influences, an exercised sense organ and the organs of memory. As to the process of thinking, in the case of it arising directly from a real impression, it derives from a physiological series of reactions of an exercised sense to the complex external influence. But in the form of a recollection, the thought, in the physiological sense, is the repetition of the previous nervous process, taking place this time exclusively in the central nervous system.

## HERMAN HELMHOLTZ AS A PHYSIOLOGIST*[76]

At the request of fellow-members of this Society I have taken upon myself the highly flattering but extremely difficult task of acquainting you briefly with the main aspects of the great work done by the famous physiologist and physicist Helmholtz, to whose memory this session is dedicated.

In the study of the functions of the animal organism we know of two sound trends which sought to explain all vital phenomena from the standpoint of the knowledge accumulated in chemistry and physics. It would be out of place to speak here of the validity of these two trends; at the moment the important thing is to know that they existed and once we grant this, it will be clear to all that the significant steps made in one direction or other were closely associated with the advance of chemical and physical knowledge, and were the work of outstanding scientists in the fields of pure chemistry and physics. In this sense, the history of physiology knows three brilliant names—the chemists Lavoisier and Liebig, and the physicist Helmholtz. The first of these laid the general foundations of the theory of the transformation of matter in the animal organism; the second thoroughly elaborated and completed this theory. Helmholtz's great merit is his research in the delicate sphere of sensation; it was he who created the physics of aural sensations, revised the vast sphere of physiological optics and made a most valuable contribution to it; at the end of his work, which took many years of his life, he paved the way for physiology to the

* Speech delivered at a session of the Imperial Society of Friends of the Natural Sciences, Anthropology and Ethnography on November 16, 1894.

sphere of the higher psychical manifestations, namely, the sphere of thought by the discovery of the initial forms of visual thinking.

All this sounds quite modest, but behind it lies a really great exploit of labour and all that characterises the work of a naturalist of genius—profound thought and creative labours combined with brilliant experimentation and fruitful results which opened up new vistas for his successors.

It is impossible, of course, to squeeze the manifold aspects of his splendid activity into a brief paper. I shall, therefore, be happy if I succeed in tracing, at least in general outline, the path traversed by his thought in the elaboration of the phenomena of sensation and thus making comprehensible the outstanding results of his research.

From the brilliant speech just delivered by my predecessor, you know that Helmholtz made his appearance in science as an outstanding thinker and physicist already when he was a very young man. But fortunately for physiology this young man was a physician both by education and profession; he was, therefore, destined to become professor of physiology in Koenigsberg. He began his splendid service in this branch of science with a research which at the time was a veritable exploit both as regards boldness and realisation; I have in mind his experimental measurement of the rate of propagation of excitation along the nerve. The scheme of his research was daring because at that time the tendency was to attribute to the nervous processes the speed with which messages are transmitted over the telegraph-wire, whereas his measurements were carried out exclusively on the nerve of a frog 4 to 5 cm. long. The unexpectedness of the result obtained fully corresponded to the boldness of the experiment. Humboldt[77], who was astonished when he learnt from Du Bois-Reymond[78] that this speed was but 30 metres per second, immediately remarked that it was not greater than the speed of a tropical hurricane. Being of considerable theoretical importance from the standpoint of the nature of the nervous processes, this measurement proved fruitful also in its consequences: it became the point of departure for measuring the duration of various rapid processes in the animal organism and also for the psychometric methods used nowadays in physiological psychology. It should be added that it was in this research that Helmholtz first displayed his skill as an experimenter. His highly important investigations concerning the muscles, as well as his analysis of the duration of muscular contraction and intermittence of the nervous impulses as a result of voluntary excitation of the muscles, also belong to this period of his activity. The first of these researches marked the beginning of the application of the graphic method in the study of muscular activity.

But with all their brilliancy and significance these investigations were but by-products of the talent of the young Helmholtz who was still looking for the sphere of research that would correspond to the cast of his mind. Ultimately, he chose the domain of sound and light, and it was here that he accomplished his most brilliant research.

All his investigations in the field of acoustics can be found in his work *The Theory of Acoustic Sensations*. Here, the fusion of the physical and the physiological outlooks is manifested in greater measure than in any other of his works. When a physicist studies a particular subject, he is guided, of course, by the indications of his sense organs; but as a rule these indications remain in the background; they simply state the phases and variations of the phenomena, whereas the physicist is chiefly concerned with the objective side of the phenomena. But in the above-mentioned work, Helmholtz elaborated the acoustic phenomena simultaneously from both aspects: physically as movements, and physiologically as sensations. The result of this was that in his hands, the organ of hearing was turned into a delicate physical instrument responding to extremely diverse forms of acoustic oscillations according to a strict order, in many cases established by Helmholtz himself. Thus, with the help of the resonators which he designed, the ear solves the question of timbre, and reveals the physical causes of all those aspects of acoustic sensations commonly designated as soft, deep, sharp, nasal and other sounds. By means of the same analytical methods the vowels are attuned to the tones emitted by musical instruments as related acoustic forms. Not satisfied with the results of the decomposition of vowels into component elementary tones, Helmholtz reproduced them synthetically from the component elementary tones produced by the tuning-fork. This apparatus is a marvel of the experimental art. But this is not all. To complete the theory of the origin of vowels in the organism, the question of the part played in their formation by the various constituents of the human vocal apparatus had to be elucidated. Research in this field, which had been begun prior to Helmholtz's investigations, yielded the following result: the larynx produces not elementary, but complex tones, i.e., basic tones plus a number of overtones, while the oral cavity, being an accessory tube of the larynx varying in form during the sounding of vowels, acts as a resonator amplifying certain component overtones in the complex laryngeal sound. It would be no exaggeration to say that this research alone, i.e., the theory of the origin of vowels, would suffice to immortalise Helmholtz. But in his famous work he did not confine himself to this theory. Having characterised the musical tones and vowels, Helmholtz began to study the combination of acoustic movements; the outcome was his physical theory of the aspect of aural sensations designated by the terms "consonance" and "dissonance" of sounds This is followed by his purely physiological treatise on the probable structure of the aural apparatus which perceives and analyses complex tones. Actually, this apparatus should consist of a series of resonators within the limits of the volume and keenness of hearing. The structure of the end of the cochlear nerve, discovered by Corti[79] at this time, fully answered these requirements, and Helmholtz recognised this organ as the analyser of complex tones. So you see, Helmholtz not without reason regarded his treatise as a physiological one; in this work the organ of hearing invariably plays the role of a physical instrument which reacts in a definite way to external influences. In other words, he established a definite connection between the modifications of the external causes and those of sensation. By doing so, he delivered the aural sensation from its confused, chaotic state, decomposed it and communicated to it a definite form. This decomposition was based on physical factors in the organisation of the aural apparatus; that is why I said at the beginning that he created the physics of acoustic sensations—not of all sensations, as we have seen, but only of those which concern musical tones and the vowels of human speech.

From the physical point of view, this investigation was the most brilliant work done by Helmholtz in physiology, and not only because of its novelty and skilful research, but also because of the accord which he established between the physical and sensory aspects of the phenomena. In his other famous work on *physiological optics* this accord between the external influences and the sensory reactions had not yet been established; this latter investigation, while it is less brilliant, embraces a much wider sphere of action: in acoustics the matter is reduced to the decomposition of sensations, whereas in optics, as stated above, Helmholtz's research goes far beyond the confines of sensation—into the domain of sensory thought.

In the first part of his work on optics where the eye is treated as an optical instrument, Helmholtz made three discoveries; two of these won him renown in practical medicine. Thanks to his highly ingenious method of measuring the curvature of the refracting surfaces in the eye, Donders had revealed a hitherto unknown, but not infrequent defect in the configuration of the eye known as astigmatism. The moment the cause of this defect was established, a means of correcting it was found. But Helmholtz's ophthalmoscope, an instrument which made it possible to illuminate the fundus of the eye and to see the retinal image was of still greater importance for medicine. It can be said that at least one half of present-day ophthalmology is indebted for its existence to this simple instrument. His third discovery was the mechanism of the accommodation of the eye to distant vision. This discovery is of special interest because, deduced by Helmholtz from indirect data, it was subsequently corroborated by direct experimentation.

Although some of the chapters in the second part of Helmholtz's work, which deals with the conditions of the origin of visual sensations, are extraordinarily interesting (for example, the chapter on the physiological theory of the sensation of colours), I shall not dwell on them, because nothing appreciable can be discovered in this sphere even now. I shall, therefore, turn directly to the concluding chapters which treat of spatial vision and where Helmholtz appears as an innovator, because remaining on the ground of physiological experience he at the same time looks for a solution of the problem in the domain of psychology. It is this approach which reveals him as an innovator; before Helmholtz any investigator studying the border-area between the corporeal and the spiritual had to be either a physiologist or a psychologist—in no circumstances could he combine the two specialities. To make the meaning of Helmholtz's approach clearer, I shall say a few words about the tasks facing the physiologist-experimenter in studying spatial vision and about the methods of their solution, methods already elaborated before Helmholtz started his investigation.

The immediate effect of the excitation of the eye by rays of light of varying refractivity, irrespective of the nature of the source of light, is known as visual sensation. At this stage the sensation makes it possible to distinguish light from darkness, one colour from another, and also the successive effects of the excitation caused by light. But when the visual impression includes all the modifications connected with the shape, magnitude and position of the source of light in space, it is what we know as spatial vision. We perceive the surrounding objects as situated outside us at varying distances and in different directions, i.e., we localise them in space in three dimensions and, at the same time, distinguish the surface and volume of the objects, as well as their size. These aspects of vision, taken singly, constitute particular problems of the theory of spatial vision and can be studied by way of experimentation (i.e., from the point of view of their dependence on the structure of the visual apparatus and on other conditions introduced into the experiment by the investigator), unfortunately, they can be studied only on adults But this is not all. The study should end, if possible, in a general conclusion providing the answer to the following question where and how does the formless visual sensation acquire those accessories which communicate to it a spatial character? This question is an extremely difficult one, because in the adult the facts of spatial vision take the form of concepts, i e., they are complicated by psychical products of a higher formation, hence, when answering this general question, the investigator is obliged to isolate these psychical admixtures from the phenomena.

Now let us see what Helmholtz had at his disposal when he started his investigation.

In the first quarter of our century the physiology of vision was practically non-existent; for this reason the study of spatial vision was begun not from the beginning, i.e., not from particular questions, but from the end, from the general question: what is it that imparts a spatial character to our sensations and how is this done?

Stated in this general way, the question, according to Helmholtz, was of considerable philosophical significance; in fact it was regarded as the most important question in the science of the external world, as a question of the theory of knowledge of the environment. Everyone knows, of course, Kant's theory to the effect that the faculty of being able to feel (i.e., to see and to touch) the external world spatially is the product of the innate capacity of the perceiving mind; if we dwell on this question, as posed by Kant, his idea will not only be comprehensible, but even indispensable. The impression of space does not accompany all sensations in general, but only those which emanate from the external world. As an accompanying factor, this impression, if abstracted from the sensory act, appears in the consciousness as lacking any sensory base and as having a single attribute common to all spatial relations—that of being measurable. Lacking a sensory foundation, it can be only a product of the mind, not of a sense organ. Further, as everyone knows, Kant's theory outlived Helmholtz in the minds of numerous researchers; it has been the gospel of German physiologists until the thirties, when Helmholtz's teacher, the famous Berlin physiologist Johannes Müller[80] began his work on vision. From Müller's hands Kant's theory emerged somewhat materialised: spatial vision is an innate faculty, but the perceiving mind is supplied with a sensory appendage—the retina of the eye—which perceives itself spatially together with the images of the external objects falling upon it.

In this more physiological form, the theory was quite unexpectedly and thoroughly substantiated by Wheatstone's invention of the stereoscope. In this instrument the stereoscopic vision is ensured by the difference in the perspective flat images of objects viewed by the right and by the left eye; the retinas have the faculty of being able to see objects in relief, i.e., to take in the volume of the objects. And all the more so because experiments showed that the stereoscopic relief is perceived instantaneously, even when the picture is illuminated by an electric spark; it does not, therefore, depend on the movements of the eye.

To this we should add that it had already been established that some animals are able to move in space immediately after birth, which means that they are capable of spatial vision.

These, then, were the circumstances, testifying so strongly to the innate character of the sense of space, in which Helmholtz began his study. He started, naturally, from the very beginning, i.e., from particular cases of spatial vision, or, more simply, from the group of phenomena which involve the participation of what in common parlance is known as "sight measurement". The study led to two important conclusions.

Even in the adult with his highly developed capacity of spatial vision sight measurement, i.e., the movements performed by the head and eyes in the act of looking, nevertheless plays an essential role in defining spatial relations—that of introducing a measure into the definition.

The other conclusion is this:

The visual movements measure the spatial relations not directly, but through the medium of the muscular sense with which they are associated and which varies according to the direction, extent and rate of the displacements of the eyes and of the head.

In other words, Helmholtz regarded the motor apparatuses of the eye not only as auxiliaries of this organ in the act of clear vision, as they had been considered previously, but also as measuring accessories which convey to the mind sensory signs directly entering the composition of the visual impressions as measures of spatial relations.

Thus, the mechanism for measuring the spatial relations was found outside the mind, in the organisation of the perceiving eye; in order to pass from particular cases to the general question all that had to be done was to solve the two questions:

1) Does this mechanism exist singly, or is it associated with the retina which is capable of spatial vision and thus serves only for a more exact appreciation of what is furnished by the latter?

2) Is this mechanism necessarily controlled by the mind of the adult, or does it function from birth?

First, it was, of course, necessary to decide whether to accept or to reject the theory of the inborn nature of spatial vision then widespread among physiologists. Helmholtz, on the basis of facts accumulated in the course of his research, rejected this theory. His objections to it can be summarised as follows.

The facts observed on animals possessing an inborn capacity *for spatial vision are not applicable to man whose faculties de*velop slowly and gradually.

The so-called capacity of the retina of the adult to see objects in space is not an innate capacity; it is acquired by experience. If it were innate, signs of it would manifest themselves in people born blind but who acquired sight at a mature age as a result of surgical intervention, the moment these people come into visual contact with the external world. In reality, however, no such signs are in evidence.

The facts of stereoscopy can be explained by the faculty of the retina acquired as a result of experience rather than by an inborn organisation, because direct observations show that *stereoscopic fusion occurs only when the degrees of non-coin*cidence of the perspective pictures correspond to the cases of real vision. Beyond this no fusion takes place.

Here are the main points of Helmholtz's theory.

The eyes are so constructed that they move almost incessantly; *their movements are arranged in a certain system mainly due* to the fact that in the centre of the retinas there are tiny spots of clear vision and the eyes must be so moved as to make the images of the focal point fall precisely on these spots. The precision of the adult's sight measurement is directly associated with these movements; but such movements are incessantly performed also by the newly born child from the moment it begins to converge the axes of the eyes. Why, then, should we not admit that here again the same movements, which become increasingly systematised as a result of experience, begin to serve as means of measuring the spatial relations? There is, however, a very big difference between the conditions of vision of the adult and those of the infant. The adult's field of vision appears as a differentiated picture determining the course periments showed that the stereoscopic relief is perceived instantaneously, even when the picture is illuminated by an electric spark; it does not, therefore, depend on the movements of the eye.

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Helmholtz then passes to the domain of psychology and uses the phenomenon of memory to explain the development of spatial vision in the same way as the psychologists use it to explain the development of purely ideational formations; the whole thing is thus reduced to frequent repetition of the oculomotor acts under various subjective and objective conditions of vision, and to the formation of associations between the purely visual effects and the corresponding modifications of the muscular sense. According to the system accepted in psychology, these associations, becoming consolidated, free themselves from admixtures and ensure a definite conformity between the constant factors of spatial vision—the position of the observer's body, the position of the points in the field of vision, the position of corresponding images on the retinas, and, lastly, the muscular sense which expresses the direction and the extent of the displacement of the eyes aimed at ensuring clear vision of the points of the visual field. In a word, by means of the muscular sense experience trains the retina to master the art of independent spatial vision.

Helmholtz is on record as saying that he was reproached for his theory of the experimental origin of spatial vision both by Kantians of the old school (*Kantianer strikter Observanz*) and by physiologists of the nativist school. His answers to the charges of the latter, explaining as they do the physiological significance of his *digression into the domain of psychology*, are most instructive.

Helmholtz was compelled to look in this domain for a solution to the general problem mainly because it was impossible to attribute to the retinas an innate organisation capable of explaining the frequent and indispensable adaptation of spatial vision to the variable conditions of vision. Had he adopted the standpoint of the nativists, then he, as a physiologist, would have been obliged to ascribe to the retinas the innate capacity to see the volume of objects, a sense, which varies for different pairs of points. But precisely for which position of the eyes and of the body? Owing to the mobility of the body, this position changes almost continuously, and the images of the objects are displaced on the retinas with the same continuity. Hence, the assumption that the eye is endowed with an inborn sense of depth may be satisfactory for one, two or three positions, but for any number of others it would be not only useless, but even harmful. To explain the adaptation of vision, the nativist is obliged to admit that experience can overcome the inborn organisation; but when this happens the latter is rendered useless. On the contrary, experience, which trains the eye to function in diverse conditions of vision and, what is more, on an almost undifferentiated ground, explains the phenomenon of vision adaptation at once; here the generally known plasticity of the organs and the manner of their adaptation to the demands of practical life attest not against this theory but in favour of it.

As to the reproach for digressing into the obscure domain of psychology, Helmholtz's reply was: the fact of the association of sensations is as indubitable as the fact of sensation itself, and those who take him to task can, if they wish, identify the organ of memory with the sense organ; so far as he, Helmholtz, is concerned, it makes no difference whether this organ belongs to the province of psychology or physiology. As a naturalist, he is aware, of course, that the picture of the formation, consolidation and refining of associations used in psychology is obscure; for this reason he seeks a solution not in these details, but in the reality lying behind this picture—in the educational effect of experience. Here are his own words on this subject: Every movement which changes the picture of the objects can be regarded as experience by means of which we verify the already known disposition of objects in space. These words also explain his famous proposition: The acts of spatial vision, to the extent that they depend on experience, bear the character of unconscious conclusions. For him these acts are unconscious because they develop from associations in the innermost recesses of the unconsciously acting memory and manifest themselves at an early age when the child cannot as yet construct real syllogisms.[81]

For Helmholtz, then, spatial vision was, right from the beginning, measuring vision. If from the complex visual act one singles out, say, light, what is left will be spatiality, a spatiality that can be measured. And this measurability is the proof of the sensory character of the remaining part of the visual act, because the eye is equipped with a measuring appendage which in man begins to function a week after birth. This remaining part derives from the obscure muscular sense and for this reason gives the impression of being of an extra-sensory origin. True, in order to build his theory Helmholtz had to combine memory and its associated faculty with the visual apparatus; but who can now doubt that the organs of memory are integral parts of the sense organs? Without them, the indications of the sense organs, which disappear as soon as they arise, would leave man forever in the state of a newly-born child. We are grateful to Helmholtz for his intrusion into the domain of psychology, because from it there developed the most elaborated part of modern physiological psychology.[82]

With that I have come to the end of my task.

When the mental labours of a man yield such extraordinary results the question, naturally, arises: What was the secret of this chosen man? According to his friend Du Bois-Reymond, Helmholtz combined a philosophical mind with a gift for analysis and experimentation such as no one else in the history of science.

## THE PART PLAYED BY THE NERVOUS SYSTEM IN MAN'S WORKING MOVEMENTS[83]

Any mechanical work performed by man, no matter whether it consists in knitting a stocking, walking, carrying heavy loads or playing a musical instrument, is effected by the muscles of the arms, the legs and the trunk. The muscles are the motors of our body; but they cannot act by themselves, i.e., without impulses from the nervous system; so that along with the muscles, the nervous system participates in the work of man, and this participation—the subject of the present article—is extremely varied.

In order to convey in a brief paper a concise, but fairly complete description of the essentials of my subject, I shall resort to a graphic comparison.

Since work of any kind consists of a definite consecutive series of movements corresponding to a similar series of contractions of muscular groups in the arms, legs and trunk, the working functions of the entire neuro-muscular mechanism can be compared with the execution by a musician of a well-studied piece on the piano. The strings play the role of the muscles, the keys are the nervous centres—the levers leading from these to the strings are the nerves—while the musician is the unknown agent acting on the muscles from the nervous centres through the medium of the nerves. Moreover, the musician should be regarded as being an organic part of the musical instrument.

A correct and harmonious execution of the given piece on the piano demands, first of all, that the musician should be in a state of wakefulness, that he should be able to control his playing by his senses and to vary its rhythm, as well as the intensity and duration of the sounds; similarly with our unknown the whole process of the training consists in maintaining the body in a vertical position; the child moves its legs independently and moves them properly, without any instruction on the part of the adults. But the innate motor mechanics does not suffice to accomplish the act of walking; not being adapted to moving on a firm support at birth, the child has to learn the sensory signs which accompany the act of walking. In each step there is a moment when both feet touch the floor and at this moment the sense of support acts as a signal to the consciousness to detach the sole of one foot from the floor and to attach the other to the floor; this signal regulates the proper alteration of the movements of the legs in space and time. Should an adult be deprived of this sense, as is the case with people suffering from so-called ataxia, not only will he be unable to make a single step when his eyes are closed, he will fall. This example is of importance also from another point of view: it has been stated above that the ataxic patient who cannot make a single step when his eyes are closed, is capable of walking when they are open. This means that the normal regulator—the muscular sense—can be replaced by vision; and this replacement is possible in all cases when the eyes can follow the movement performed.

Further, everyone knows that in memorising sound-producing movements (and not in the process of performing movements already memorised!), for example, in memorising words, songs or musical pieces, the ear, and not the muscular sense, plays the role of the principal regulator. In this case, as in the case of the mute neuro-muscular mechanics, the regulatory action emanates from the motor effects of the apparatus.

*In what way is the muscular activity excited?* Unfortunately, we have but scant data on this. We have only general knowledge of the following three facts: the keys of the neuro-muscular mechanism (the nervous centres), which are brought into action by an agent of an unknown nature, are situated in an area of the brain the integrity of which is indispensable for all manifestations of conscious psychical life; we can indicate with some degree of certainty their location on the surface of the brain; in animals we can excite from these points the muscular contractions that take part in the working movements. As to the nature of the excitations proper which act on our keys, we are still physiologically in the dark; proof of this is the view, still widespread, that some impersonal force, or so-called will, is supposed to excite the muscular activity. And since this view is expressed even by educated people, I deem it necessary to dwell on it.

If we judge solely by the indications of the self-consciousness, it might seem that of all the vital manifestations of the human organism, the muscular activity is subordinated most of all to the action of will. In accordance with this, in former days even physiologists distinguished two kinds of movements: involuntary and voluntary; the effects of the contraction of the skeletal muscles, i.e., the muscles of the arms, legs and trunk, were included by them in the second category. If this theory were correct, will would be able to excite each muscle separately, since each muscle has its own definite pathways. The study of the corresponding phenomena, however, reveals the following: 1) in most cases will cannot act on the individual muscles; it exerts simultaneous action only on whole groups of muscles, and 2) will has power only over those movements which are of vital importance to the organism. Here are some examples. Six separate muscles effect the movements of each eye; the location of these muscles in both eyes is identical. For the purpose of seeing clearly objects situated in front of us at varying distances, we can converge the axes of the eyes inward (towards the nose) to a more or less considerable degree by contracting the so-called erect internal muscle. When we look up or down we raise or drop the eyes, and this is effected by the superior and inferior erect and oblique muscles of each eye. When looking at an object situated on our right we turn the left eye towards the nose and the right eye towards the temple; when looking at an object on our left, we perform the opposite movements. But there are no vital conditions requiring a simultaneous movement of the eyes towards the temples, or of one eye upward and of the other downward; the will, then, cannot produce these movements. Will has power over the respiratory movements of the thorax as a whole, which consists of two symmetrical halves with two separate muscular systems; but it has no power over each of these halves taken singly, because there are no conditions necessitating respiration by one half of the thorax only. Similarly, the will cannot contract one half of the abdominal muscles. When an unskilful musician studies a score, his impression is that the hand movements obey his will—he feels that the performance of these movements calls for certain efforts on his part. But when the score has been thoroughly studied, our musician passes from one movement to another so easily, rapidly and without effort that there can be no question of any intervention by will in each of his movements. What, then, happens to the will? When walking, we never think in terms of the movements performed by the legs; they are regarded as being free. But as soon as we make up our mind to watch each step and to perceive it as an act of will, our movements, no longer free, become constrained. The same is true of the respiratory movements and of all firmly acquired movements in general. It follows, then, that intervention by the will in these movements is not only superfluous, it is harmful, because it violates their harmony. So what are voluntary movements? Actually they are movements that are acquired by necessity. Hence they are free from any intervention of will as an impersonal agent. Things will be different if, remaining on the ground of psychology, we replace the meaningless concept of will by the real concept of "desire" in the form of a sensation with a definite content. Vital requirements engender desires, and the desires give rise to actions, in this case, the desire is the motive or the aim, while the movements are the action or the means of attaining the aim. When a man performs a so-called voluntary movement the latter appears in his consciousness after the desire. Without the desire, which plays the role of a motive or impulse, the movement would be senseless. In accordance with this point of view, the motor centres located on the surface of the brain are known as the psychomotor centres.

But whatever the nature of the excitant of the movements may be, one thing is clear: the impulses proceeding from the centres to the muscles along the nerves are in the nature of intermittent shocks following one another with a frequency of 19 to the second. This was proved by the experiments carried out by Helmholtz, the famous German physiologist and physicist.

*In summing up, a few words about the force of the excitatory* impulses. This can be best elucidated by means of examples.

The impulses originating from the centres are transmitted to the muscles along the nerves at a speed of a few dozen metres per second; at the same time the nerves are mechanisms which are excited by mechanical shocks at all points along their entire length. This circumstance is utilised in the following experiment: the experimenter takes a muscle from the leg of a frog together *with the nerve leading to it and, fastening the top end of the* muscle, suspends a weight of about 500 gr. to the lower end of the muscle (the muscle weighs about 5 gr.). The nerve of the muscle is spread out horizontally on a solid and smooth support. The experimenter then lets a particle weighing about 0.05 gr. fall on the nerve from the height of 1 cm. This shock, slight though it is, suffices to excite the muscle; upon contracting it raises *the suspended weight approximately 2 or 3 millimetres.* The work done by the shock expressed in gram-metres is: $0.01\times0.05=0.0005$; the muscle work provoked by the shock is: $500\times0.002=1$. Even these rough experiments show that the nervous impulses which produce the motor effects of the muscles are hundreds of times weaker than the latter; in reality, however, the natural impulses are thousands of times weaker. *A day's work performed by an adult during eight hours is* estimated at 200,000 kilogram-metres. If the muscular activity and the production of nervous impulses were due to the combustion of fat in the organism, then 200 gr. of fat would be needed for muscular work amounting to 200,000 kg/m (granting that 25 per cent of the heat produced as a result of combustion is transformed into work), while the production of nervous impulses would require less than 0.2 gr. The internal processes of sensation call for even less energy. A slight touch of the skin by a wisp of down produces a distinct tactile sensation; a slight touch to the helix is clearly perceived as a noise; *millionths of a milligram of an odorous substance suffice to ex*cite the sense of smell, etc. In a word, owing to its structure the nervous system perceives and transmits the very slightest impulses to the motor organs.

## THE PART PLAYED BY THE SENSE ORGANS IN THE WORK PERFORMED BY THE HANDS OF PEOPLE WITH AND WITHOUT SIGHT[85]

Everyone knows from experience that the eyes play an extremely important part in the work done by the hands. In order to ensure regular work movements, man is obliged to follow the movements of his hands with the eyes, i.e., to co-ordinate the rate and direction of the displacements of the two organs. The eyes act in conjunction, as a single organ, and their action is usually accompanied by auxiliary movements of the head. Hence, the problem of the part played by vision in the work of the hands boils down to the following questions: How are the hand movements co-ordinated with the simultaneous movements of the eyes? What determines this co-ordination? What is the importance of the auxiliary movements of the head?

To simplify the answers as far as possible let us imagine the following ordinary case: a man seated at the table picks up an object, say, a sand-box, with his hands and moves it over the table from one place to another. For the sake of greater simplicity, let us imagine that the moving arms of our man are straight lines Thus, if *a* and *b* (see the scheme attached)* are the points in the shoulders around which the arms rotate, and *m*, *n*, *p*, and *q* the points through which the displaced sand-box passes along the table, the pairs of lines *am* and *bm*, *an* and *bn*, etc , will be the simultaneous positions of the two moving arms. Of the four points, the two middle ones—*n* and *p*—located directly in front of the shoulders, can be reached by the hands without any displacement of the shoulders. But let us assume that the distance between point *q* and point *a* (of the left

* See Fig. 1 —*Ed.*

shoulder), is greater than the length of the arm. In order to place the object at point $q$ with both hands, the man will have to bring his left shoulder forward somewhat, and this will be an auxiliary movement in relation to the displacement of the arms.

Lastly, imagine that the man follows the movements of the sand-box with his eyes. In this case, it will be necessary to mark the points of rotation of the eyes between points $a$ and $b$ on the same scheme, because the eyes are closer to each other

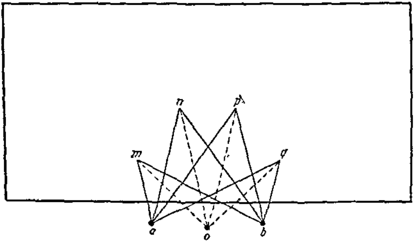


Fig. 1

than the centres of the joints of the shoulders. For the sake of simplicity, however, we shall mark them in points $a$ and $b$, since this will not change the mechanism by means of which the eyes follow the moving object. To be able to follow an object with the eyes, the first thing, of course, is to see it clearly; for this purpose, the eyes must be so placed relative to the point under observation that the latter is in front of the centre point between the pupils. For example, in order to see point $m$ clearly, the eyes must be turned to the left, and the right eye to a greater degree than the left; in order to see point $q$, the movements must be reversed. The straight line leading from the object to the centre of the pupil is the optical axis; if we prolong this line backwards into the eye-ball, it will pass through the centre of its rotation. Then, the pairs of lines $am$ and $bm$, $an$ and $bn$, etc., will be the converged optical axes of the left and right eyes which turn in succession to points *m*, *n*, *p* .... In this way only the object can be seen clearly and, what is more, as an entity, despite the fact that it is observed by two eyes. To the observer it will seem that he is looking with an imaginary eye located in the centre between his two real eyes (in the scheme the location of this imaginary cyclopic eye is indicated by point *o*) and that he is seeing the objects in the direction of the straight lines (*om*, *on*) leading from them to the cyclopic eye.

It follows, then, that the straight lines *am*, *bm*, *an* ... are simultaneously the successive positions of the hands in displacing the object and the successive positions of the optical axes of the eyes in following it for the purpose of seeing it clearly. This similarity extends also to the auxiliary movements. Thus, if point *q* is far enough to the right, so much so that the observer would have to move the left eye close to the nose in order to see the point without displacing the head, the position of the face is changed by turning the head to the right, towards point *q*.

However, when drawing an analogy between the displacements of the arms and the eyes, we made no mention of one important matter—the change in the length of the arms displacing the sand-box; when the box is at point *m*, the left arm is shorter than the right; conversely, when the box is at point *q*, the right arm is shorter; the length of the optical axes changes similarly. What does this show? Being imaginary lines, the optical axes cannot, of course, become shorter or longer; yet the difference in length is due not to any fiction but to the real difference in distance between the point observed and each of the eyes; moreover, this difference corresponds to the degree of adaptation of each eye to the given distance, without which clear vision would be impossible. The capacity of the eye to see objects clearly from varying distances is exactly the same as the capacity of the blind person to recognise by means of touch the forms of the things located at varying distances from his body; in this case the act of the blind person in contracting or extending the arms is identical with the mechanism of eye adaptation in persons with normal vision. In this sense, the act of looking can be compared with the action of tentacles which can be constricted or extended so that their free ends, upon coming together, touch the object observed at the given moment. *The optical axes, then, have a definite semblance to tentacles.*

There is another, and equally important, defect in our comparison of the movements of the arms with those of the eyes. For the sake of simplicity, we have drawn an analogy only for the case when the hands displace an object horizontally. In reality, however, when working, the hands are displaced in space, so to say, in three dimensions—up and down, to the right and to the left, forward and backward, and of course in all in-between directions; this is because they are capable of construction and elongation, of being flexed and extended in the joints, and also because they move in the spherical articulations of the shoulders. Does our analogy hold good in these cases? Yes, because *the eyes, being able to see close at hand and at a distance,* also move within their orbits like balls in hemispherical sockets. Consequently, our scheme gives a planary picture (horizontal projection) of, generally speaking, all the displacements of the arms and optical axes in space.

Lastly, it is hardly necessary to add to the foregoing that it makes no difference whether the eyes follow the movements of the hands when they are brought together at a particular point, or the movement of one hand only. What is really important in both cases is that the converged optical axes of the eyes follow the movements of the working hand and that the point at which the hand stops at a given moment is simultaneously the point of intersection of the optical axes which have also come to a stop.

This form of co-ordination can rightly be called a case of predetermined harmony[86] of hand and eye movements, because it derives, on the one hand, from the similar structure of the motor mechanisms of the arms and eyes, and, on the other hand, from the vital part played by sight in the hand movements precisely in this form and in no other. Indeed, from infancy onward we use our hands almost all the time as grasping and palpating instruments. *But the hands could not perform these functions without the control of the eyes, and of all the conceivable ways of optical control, the way described here is the simplest—the spatial displacements of the grasping and palpat-*

ing tentacles of the hands wholly coincide with the optical tentacles of the eyes.

But what controls the hand movements in the case of the blind?

The following simple facts supply the answer to this question: A woman used to knitting can knit a stocking without looking at it and can even read while doing so; a well-studied piece of music can be correctly played on the piano in absolute darkness. Hence, eye control is not indispensable for strongly habitual movements of a limited amplitude. This does not mean, however, that these movements take place automatically, without any control; the working person is obliged to pay certain attention to them, otherwise work would be impossible. For example, when the attention of the woman who is knitting and reading is strongly attracted by a passage in her book, she suspends her knitting. This means that she controls the hand movements even when reading. The manner in which the control is effected is not difficult to understand: the woman is conscious of the knitting needles in her hands and of the extent of the hand movements. In this case vision is replaced by two senses: by touch (mainly, in the tips of the fingers) and by the so-called muscular sense, i.e., the sum of sensations accompanying any movement of the limbs and any change in their position relative to each other. The fact that vision and these two senses can replace each other in movement control is convincingly proved by comparative observations on normal people and on patients suffering from ataxia, i.e., who have lost the sense of touch and of muscular sense in their limbs, while able to move them voluntarily. The normal person can stand and walk with his eyes closed, but the ataxic patient cannot, because he feels neither the firm support under his feet nor the degree of the muscular contractions which maintain the standing posture; this is why he falls down. When the normal person closes his eyes he can hold an object in his hands for any length of time; the ataxic drops the object because he feels neither the object itself nor the degree of muscular contraction necessary to hold it.[57]

The upper limb is not only a grasping instrument; its free end—the hand—is a delicate organ of touch; it is attached to the arm like to a bar which not only constricts, elongates and moves in all possible directions, but also feels each of these movements in a definite way. Like the retina of the eye, the palmary surface of the hands communicates to the consciousness the form of the objects; blind persons can read by feeling the embossed letters with their hands; the motor muscles of the hands, *like those of the eye-balls, give us an idea of the size of* immovable objects and of their position relative to the body, as well as of the direction and speed of the moving objects. If in the matter of its functions, the organ of vision can be compared to contractile tentacles extending from the body and having an optical apparatus at their ends, the hand, as the organ of touch, has no need of any comparisons because by virtue of its *structure it is a real palpating tentacle issuing from the body.* Thanks to vision, we can easily apprehend the form, size, position and displacements of the surrounding objects; that is why persons with sight do not develop the precious capacity of the hand to furnish similar information; but the blind person does, with the result that his hand, a palpating instrument, becomes a substitute for the seeing eye.

*In people with sight the control apparatus lies outside the* working hand, whereas in the blind it is located in the hand itself.

# SUPPLEMENTS*

## TWO CONCLUDING LECTURES ON THE ROLE OF THE SO-CALLED VEGETATIVE ACTS IN ANIMAL LIFE[88]

### LECTURE ONE

*Contents*: General results of the combined action of all vegetative processes in the animal organism.—Quantitative and qualitative invariability of the mass of the body in the adult organism.—Experiments on animals and human beings demonstrating the general ways in which the quantitative and qualitative status quo of the organism is attained.—General character of the chemical transformations sustained by external substances absorbed by the animal organism.—Regulation of intake and loss in the animal organism.—Normal value of income and expenditure in an adult person.—Are the excretions of the animal organism the result of the metamorphosis of nutritive substances entering the blood after digestion, or are they caused by the metamorphosis of tissues?—To what extent do the excreted substances indicate the intensity of the process of metamorphosis in the organism? The nature of all the vegetative acts of the animal organism, taken together. The concept of the animal organism and its environment

In our previous lecture we completed the exposition of the process of urine excretion, and also our review of the so-called vegetative acts of the organism. In the course of our exposition of the particular process we elucidated the general points of view which enable us to determine the significance of this process for the economy of the organism, i.e., the relationship between the particular process and all other vegetative acts of the organism. Equipped with this knowledge, we can now make another step forward: we can define the nature of all the vegetative processes taken together and their role in the life of the animal organism.

* This section contains selected passages from the works in which Sechenov elucidates and develops the basic ideas expressed in his classical works included in the present volume.—*Ed.*

Let us first examine the results produced by their combined action in the organism. The first of these consists in the more or less considerable quantitative changes that take place in the mass of the body at different periods. You know that these changes are very pronounced in childhood, when the mass of the body increases, and also in old age when, on the contrary, it decreases; in the period of maturity these changes are so insignificant that they are not taken into account at all. The second result of the combined action of the vegetative acts is that while undergoing quantitative changes, all parts of the organism retain throughout life their physiological properties, i.e., all their physical and chemical features. Only those parts of the organism which are more or less directly connected with sexual activity and which throughout life are subject both to quantitative and qualitative variation are the exception to this general rule. The process of forming permanent teeth in place of the milk teeth and the ossification of the numerous cartilages with the aging of the organism are also exceptions.

Generally speaking, the combined action of all the vegetative processes leads in the adult to a definite quantitative and qualitative status quo of all parts of the organism; in the child, it leads to an increase in the mass of the body the quality of which remains invariable, and in old people—to a decrease of the mass of the body with the same invariability of its physiological properties.

But these general results apply to the organism as a whole, in which, along with the vegetative processes, the so-called animal acts—movements and sensations—take place. Do not the latter, too, influence these results? Is it possible that the mass of all the muscles in the growing child increases only because the child is always on the move? Does the child's brain grow because it becomes increasingly active? These questions, clearly, cannot be answered by direct experimentation, because the vegetative acts cannot be artificially separated in the organism from the animal acts. There are, however, certain considerations and facts which help us in this respect. Let us admit that the growth of the child's muscles is really due to their movements, i.e., to the animal acts. Why, then, is the mass of muscle relatively small and why doesn't it increase in the adult worker, for example, in a blacksmith, whose muscular movements exceed in absolute number the movements of a child? If the brain grows in proportion to its activity, why does its volume remain unchanged in the adult whose thoughts and feelings are much richer than those of the child? Even this simple consideration shows that while the animal acts certainly exert an influence on the mass of the body, the influence is not so immediate as that of the vegetative acts.

The following observation demonstrates this in a more direct way. In animals which are in a state of hibernation the functioning of the animal spheres is reduced to the *minimum* for quite a long time, whereas the vegetative processes, though weakened, persist. In these conditions the mass of the body, despite the inactivity of the animal spheres, manifests only inconsiderable quantitative changes, caused solely by the fact that there is no intake of food throughout the period of hibernation.

Lastly, here are some indirect experiments which corroborate our point about the status quo of the adult organism. In order to acquaint you with the essence and method of these experiments, I shall dwell in detail on Boussingault's famous experiment with turtle-doves which marked the beginning of a series of such investigations. The French scientist was guided by the following idea: on the one hand, the adult organism constantly absorbs ponderable substances in the shape of food, drink and inhaled oxygen; on the other hand, it constantly eliminates ponderable substances in the shape of urine, excrement, perspiration and pulmonary exhalation; the mass of the body, however, remains quantitatively and qualitatively invariable. If the substances absorbed and eliminated are equal both in quantity and quality, the invariability of the mass of the body can be easily explained. It is only necessary, on the one hand, to collect all the substances absorbed by the organism and to ascertain their weight and composition, and, on the other hand, to collect all the substances excreted, to define their similar values and to compare them with the corresponding values of the absorbed substances. Boussingault performed his experiment on a turtle-dove. Having preliminarily established the daily amount of food and drink of a definite chemical composition which the bird needed to maintain weight, he found:

of free nitrogen. There is no need to adduce additional facts proving that in this experiment the excessive hydrogen and oxygen of the food were eliminated by the lungs and skin in the form of water—they had no other outlet. I shall, therefore, proceed now to interpret Boussingault's figures. They show:

1) that the external matter absorbed by the turtle-dove in the course of the experiment (which lasted eight days) passed through the organism without adding to it and without removing from it a single atom; it is clear that throughout the experiment the bird's body remained unchanged not having been subjected to any other appreciable influence;

2) that about $^{60}/_{73}$ of the external matter absorbed were eliminated from the body undoubtedly by way of oxidation (substances eliminated with the urine are not taken into consideration, but they, too, in all probability are products of protein oxidation); and

3) that about $^{4}/_{5}$ of the carbon, hydrogen and oxygen of the food are eliminated via the skin and lungs; as to nitrogen, birds get rid of only one-third of it in this way, the remainder being eliminated via the urinary tract.

The first conclusion confirms the point made at the beginning of the lecture to the effect that in the period of maturity the animal body does not undergo any quantitative and qualitative changes. And taken together with the second conclusion, it shows that this result is attained through oxidation of the external matter absorbed by the organism and the elimination of the oxidation products, i.e., through acts on which animal processes (movement and sensation) do not exert any direct influence.

Thus, we have established the result of the combined action of the vegetative processes in the animal organism, and also the general way in which this result is attained. Let us now examine in particular how the intake and expenditure of matter are regulated. The balance of these two values is maintained in the animal organism by a variety of mechanisms. For example, the organism has absorbed a considerable quantity of water, the latter enters the mass of blood. This, clearly, will lead to an increase in the mass of blood. The blood vessels will dilate and the pressure of the blood against their walls will increase. The result will be an intense seeping of the water through all the capillaries, and especially in those organs where the blood is always under high pressure, for example, in the kidneys; hence —greater secretion of urine. This is an example of a purely mechanical regulation. There are also regulations which maintain the balance between the amount of solid food absorbed and of the excrements of the body, but the nature of these regulations has yet to be scientifically ascertained. You will recall from the lectures on respiration that at the time of digestion, when a large mass of nutritive substance enters the blood, the absolute quantity of exhaled carbonic acid increases. The lectures on urine secretion have shown you that the quantity of the eliminated urea increases with the augmentation of the proteins of food. Consequently, when more matter is introduced into the organism, the process of its destruction is intensified simultaneously; but just how this compensatory mechanism is brought into action is still unknown. It is said that the blood, being modified by the absorbed substances, excites the nerves, that the excitation provokes a reflex of the respiratory muscles and is accompanied by greater flow of oxygen in the organism. When the supply of matter to the organism ceases, the well-known sensations of hunger and thirst serve as regulators. They incite the organism to make up the deficiency of matter through the consumption of food and drink. The mechanism of these regulators is even more obscure than in the preceding case, because here we have to do with sensations, i.e., acts on the border-line between physiological and psychological phenomena. If, despite the hunger and thirst, matter is not introduced into the organism, there is no compensation for the losses; still, some kind of compensation takes place because the losses decrease in quantity.

The limits within which all these factors really regulate the intake and loss of matter, fluctuate considerably in individuals. Hence, we often see people of a mature age whose bodies instead of remaining the same, begin suddenly to grow in width. This indicates that regulation is possible only within certain limits.

In order to establish the norms of a physiological phenomenon, it should be studied not in one, but in numerous subjects. Sometimes this yields splendid results. The Belgian statistician

Quetelet, for example, who counted the number of marriages contracted in Belgium over a number of decades, found that the number in any forty-year period remained constant. Everyone will agree, of course, that marriage is a more arbitrary act, and hence more subject to fluctuation than the act of satisfying hunger; and yet even this seemingly variable value proves to be constant when it concerns masses of people.

Let us now examine the normal values of intake and loss in the adult organism.

Many investigators, following the example of Boussingault, have carried out numerous observations both on men and animals along the same lines. But of the available scientific researches I shall cite only Barral's table relating to the adult and the latest works of Bischoff on the nutrition of carnivora. The first research gives an approximate idea of the value of the normal metamorphosis in the adult, whereas Bischoff's works examine the relationship between the substances eliminated, on the one hand, and the nutritive and tissue substances, on the other.

**Barral's Table**

An adult person: age—29, weight—47.5 kg.*

| | Carbon | Hydrogen | Nitrogen | Oxygen | Water |
|---|---|---|---|---|---|
| Absorbs in summer time per 1 kg of body during 24 hrs., in grammes | | | | | |
| with food . . . . . . . | 5.6 | 0.9 | 0.4 | 4.0 | 38.8 |
| by way of respiration . . . . . . . . | — | — | — | 10.4 | — |
| Eliminates per 1 kg of body during 24 hrs., in grammes | | | | | |
| through the lungs and skin . . . . . . . | 3 12 | 0.81 | 0.16 | 20.13 | 17.06 |
| through the kidneys | 0 29 | 0 06 | 0.21 | 0.15 | 20 59 |
| per anum . . . | 0 19 | *0 03* | *0.03* | *0.12* | *1.15* |

* Besides, tables relating to a carnivorous animal (a cat) and a herbivorous animal (a horse) were cited in the previous lectures. In carnivorous animals the nitrogen of the food is almost fully eliminated with the urine. The tables are not reproduced here since they are generally known.

These figures do not differ essentially from those obtained by Boussingault. In both cases the greater part of the oxygen, hydrogen and carbon absorbed with the food is eliminated via the lungs, and the greater part of the nitrogen via the urine. In his latest work Bischoff endeavours to prove that if there is normal nutrition of the animal organism, i.e., if the body does not undergo qualitative and quantitative changes, the entire quantity of the nitrogen of food is eliminated via the urine in the form of urea. If the urea reveals a deficiency of nitrogen as compared with the nitrogen consumed with the food, this deficiency indicates a growth of nitrogen tissues; at the same time the weight of the body may be unchanged because some kind of compensation may take place, for example, at the expense of a more intense combustion of fats. If the quantity of nitrogen eliminated by the urea exceeds that introduced into the organism with the food, this would indicate an intense destruction of nitrogen tissues; in this case, too, the weight of the body may be unchanged, because the loss of nitrogen can be compensated by a slower combustion of fats. But in all these conclusions, except the last, which is undoubtedly correct, at least in its first part, Bischoff disregards the following circumstance: a certain quantity of nitrogen is always eliminated by the lungs in a free state, as well as by the skin—in the form of peeling epidermis, and, lastly, in the form of urea which is always present in sweat. These losses must be deducted from the nitrogen deficit in the urea; only then can one speak of a growth of nitrogen tissues. Further, Bischoff tries to prove that the urea is a product of the metamorphosis of tissues and not of the protein substances in the blood, because, in his view, the blood possesses only the conditions necessary for the oxidation of substances, and nobody has ever succeeded in obtaining urea from protein artificially in this way. But neither can it be obtained artificially from tissues. In our lectures on muscle nutrition we made points which lead to the belief that urea may be a product of the metamorphosis of tissue (the presence of creatine and creatinine). From the lectures on urine secretion you already know that the quantity of the urea eliminated *rapidly grows* with the increase in the intake of animal food. With respect to the exhaled carbonic acid, there is, as you know, the same duality of source of origin. Consequently, the substances ejected by the animal organism are, undoubtedly, products of the metamorphosis both of tissues and of the alimentary substance absorbed by the organism. From this standpoint, the first conclusion from the experiments of Boussingault should be understood as follows: the external nutritive substance when passing through the organism leaves in it some of its atoms, but takes from it in return exactly the same number of atoms and of the same quality; as a result, *the external nutritive substance seems to remain without change* after its passage through the organism. In trying to prove his proposition, Bischoff wanted to ascribe to the urea the role of *an absolute criterion for the nitrous metamorphosis of the tissues.* This, as we now see, cannot be admitted. At best, *the quantity of eliminated urea can be used as a conventional index of the intensity of nitrous metamorphosis taking place in the organism.* Moreover, elimination of the urea acquires this significance only in those cases where the unity of the hygienic and dietetic conditions is strictly observed during the observations. We could arrive at a sounder judgement of the metamorphosis of substances in the organism by the quantity of the carbonic acid exhaled, because the latter actually eliminates from the organism practically all the carbon of the food. You will appreciate the reasons for which the water which is exhaled has no significance whatever as a measure.

We now have at our disposal everything necessary to solve the problem which forms the basic idea of this lecture. You are aware of the general result of the combined action of vegetative processes in the adult organism; you know the conditions under which this result is attained, i.e., the regulation of intake and loss; you are aware also of the intensity of the process of metamorphosis and its general chemical nature. What, then, is the essence of the vegetative acts of the organism? It can be described as a continuous, life-long chemical metamorphosis of the external substances absorbed by the organism—a metamorphosis in which the organism itself is one of the links.

From this, naturally, comes the concept of the animal organism generally. Unfortunately, up to now this concept has suffered much from distortion, so it will not be out of place if I say a few words about it. I presume that you have heard or read that the animal organism is regarded as a body which includes all the conditions necessary for its normal existence. This is a false and harmful idea because it leads to grave errors. Any organism is inconceivable without an external environment for its existence; hence, a scientific definition of the organism should include also the environment by which it is influenced. Since the organism cannot exist without the external environment, all the talk about what is more important for life—the environment, or the organism itself—is absolutely senseless.

## LECTURE TWO

*Content:* Sources of animal heat.—The works of Dulong and Despretz.—Is animal heat transformed into living mechanical power in the form of muscular movement?—Heat regulation. —Significance of heat for the acts of the animal organism —Heat distribution in the body

If the aggregate of all the vegetative processes in the organism is, in essence, simply a chemical metamorphosis of the external nutritive substances, consisting almost exclusively in their oxidation by the oxygen exhaled, it follows that these processes are accompanied in the organism by the same phenomena that are usually observed in the process of oxidation. Combustion, for example, is always accompanied by heat; the same thing is bound to take place in the organism. Since the metamorphosis of substances is a life-long process, the generation of heat must be every bit as constant. While all these phenomena exist in every animal organism, they are particularly pronounced in the so-called warm-blooded animals, including man. Notwithstanding the steady loss of heat in these animals, the body temperature, given normal conditions, is always the same; moreover, in our latitudes it is always higher than the temperature of the external environment. This is because the animal organism generates at any given time as much heat as it loses. Consequently, if all the heat lost within a certain time could be accumulated and measured, the value thus obtained would express the amount of heat generated by the organism for the same time. If, in addition, we could establish on the basis of the organism's excretions (products of oxidation) the amount of matter consumed (oxidized) during the same period, then, knowing the amount of heat usually generated by the combustible substances of the organism as a result of the combustion, we could supply the answer to the following question: is animal heat originated solely by the process of oxidation or not? It will be clear that in the first case the value of the heat loss and the quantity of heat generated as a result of the combustion of substances are equal, while in the second case they are not.

This problem was suggested by the Paris Academy of Sciences for solution; as a result, the works of Dulong and Despretz appeared in the twenties of the last century. These works, being similar both in their basic idea and in the character of their execution, can be considered jointly. The French scientists admitted that:

1) carbonic acid and water are the sole final products of oxidation in the organism;

2) the quantity of carbon consumed is determined by the quantity of carbonic acid exhaled; as to the amount of hydrogen consumed, it is determined by the excess of the inhaled oxygen over the quantity of oxygen exhaled with the carbonic acid;

3) the quantities of heat generated by the combustion of carbon and hydrogen are invariable, no matter whether prior to the combustion these substances are in combinations or free.

Thus, the comparison of the heat loss with the amount of heat generated as a result of oxidation proved to be experimentally quite easy. A water-calorimeter was used to determine the first value, while the second was determined with the help of an accessory apparatus which made it possible to measure the amount of oxygen inhaled by the animal during the calorimetric experiment and the amount of the carbonic acid exhaled. I shall not describe these devices because from the point of view of determining respiratory factors they no longer meet present-day requirements; I shall, therefore, turn to the results. If the amount of heat determined by way of calorimetry be taken as 100, then the amount calculated on the basis of the combustion of carbon and hydrogen ranged in Dulong's experiments from 68.3 to 83.3 and in Despretz's, from 74.1 to 90.4.

These results seem to show that on the average only threefourths of all the animal heat generated derive from oxidation of substances in the organism, while the remainder derives from another source. However, such a conclusion would be premature.

From the point of view of modern science, the experiments carried out by Dulong and Despretz are fraught with errors not only as regards their methods, but also from the standpoint of the principles on which they were based. For example, they wholly disregard the fact that in the course of the metamorphosis protein substances, which, probably, yield carbonic acid, also yield urea, creatine, uric acid, etc., in other words, compounds that are more stable than protein and whose formation must, therefore, be accompanied by the generation of heat. It makes no difference whether carbon and hydrogen (which form carbonic acid and water) are consumed in a free state or whether they preliminarily enter such compounds as fat, sugar or protein.

If we suppose, for example, that the heat generated by the combustion of one gramme of grape-sugar is caused exclusively by the combustion of its carbon to the point at which carbonic acid is formed, then one gramme of sugar must yield 2.933 caloric units.* But if we subject a gramme of sugar to fermentation, it will yield 0.455 gr. of alcohol. The combustion of this amount of alcohol to the degree at which carbonic acid and water are formed, yields by itself 3.268 caloric units; besides, as we know, the fermentation is accompanied by the production of heat and, consequently, by its simultaneous loss. Stearic acid can be taken as another example. If we admit (the empiric formula of stearic acid is $C_{36}H_{36}O_4$) that in the process of its combustion atmospheric oxygen is consumed for the oxidation of 36C and 32H, then one gramme must produce 9.905 caloric units, but in reality the combustion produces only 9.700 units. Moreover, the French scientists supposed that in the course of the experiment the animal did not undergo any cooling; in reality the reverse must have happened. Lastly, Dulong used La-

*The empiric formula of grape-sugar is $C_{12}H_{14}O_{14}$; the equivalent amount of carbon is 6; the heat generated by the combustion of carbon amounts, according to Favre and Silberman, to 8.080 caloric units.

voisier's figures for the combustion of carbon and hydrogen, but they proved to be underestimated.

Owing to these errors, the calorimetric data of Dulong and Despretz are too high, while the figures calculated on the basis of the products of respiration are too low. Consequently, it is quite possible that animal heat is generated exclusively in the body by the chemical reactions taking place in it. In any case, we are not entitled to admit any other sources of heat, at least not until fresh investigations along the lines of Dulong and Despretz give a more precise answer to this question.

The experiments of the French scientists were performed on animals. Their calorimetric results, clearly, could be applied also to man by reasoning as follows: a dog of a given weight loses and, consequently, generates a certain amount of heat per hour. Consequently, the heat generated by a man weighing twice as much as the dog would be double, by a man weighing three times more—treble, and so on.

This deduction, however, would be wrong, and for the following reason. From the Dulong-Despretz experiments it follows that in an animal at rest (when it is kept in the calorimeter) there is a direct relation between the intensity of the respiratory factors and the amount of heat produced in the body: the greater the intensity of the former, the greater the value of the latter. From the lectures on respiration you know that not only in animals of different species, but even in animals of one and the same species there is no proportionality between the mass of the body and the intensity of the respiratory factors. You will recall that if a dog in the space of an hour exhales a certain quantity of carbonic acid, a dog of twice the weight will exhale, given the same conditions, not twice the quantity of carbonic acid, but less. Hence, it is impossible to apply to man—on the basis of weight—the data relating to the generation of heat in animals; this is all the more impossible owing to the difference in their make-up. In order to make up for this deficiency, Helmholtz and Barral calculated, independently and in somewhat different ways, the approximate intake and loss of heat in man during a period of 24 hours.

Here are their results:

Helmholtz's Table

| Heat intake | Heat expenditure* | | |
|---|---|---|---|
| | Heating the food and drink | Heating the air inhaled | Evaporation of water eliminated via the lungs |
| 2,700,000 cal. | less than 70,157 cal. 2 6 per cent | 70,032-140,064 cal 2.6-5 2 per cent | 397,536 14.7 per cent |

* The remaining 77.5 per cent of the heat generated is lost in the skin, i.e, through radiation, convection and water evaporation.

Barral's Table

| Heat intake | Heat expenditure | | | | |
|---|---|---|---|---|---|
| | Water evaporation | Heating the air inhaled | Heating the food | Liquid excrements | Radiation and convection |
| 2,706,076 cal. | 699,801 cal 25 85 per cent | 100,811 cal 3 72 per cent | 52,492 cal 1 94 per cent | 33,020 cal. 1.22 per cent | 1,819,952 67 22 per cent |

A greater consonance of figures in such approximate calculations could hardly be expected!

Let us turn now to the interesting question of whether the *heat of the organism is converted into living mechanical power.* In order to formulate this question clearly, I will cite an example. You know that the mechanical work of a steam-engine consists in turning the wheels; consequently, a certain part of the mechanical power produced by all machines is spent on each turn of the wheels. But this power derives from the heat generated as a result of the combustion in the engine. Hence a certain amount of the total heat is spent on each turn of the wheels. It follows, then, that in conditions of an equal intake of heat the steam-engine uses up more heat when it is working than when it is idle. Consequently, its cooling is more rapid. The same must take place in the animal organism if it has the conditions for the conversion of heat into mechanical work. Here the loss of mechanical power is due mainly to the muscular movements of the body which are transmitted to the environment and, in general, to the external objects coming into contact with the body and are thus lost to the latter.

Now let us see what happens to the heat of the body when the latter passes from a state of rest to motion, if the heat is really converted into muscular contraction. The consequences can be extremely varied under two different conditions:

1) when the general intake of heat in the organism during work is the same as the intake during rest,

2) when the intake is greater.

In the first case, the body, passing from the state of rest to work, will cool off if the usual loss of heat through the skin and lungs is not diminished; it may retain the previous temperature if the cutaneous and pulmonary loss decreases by the exact amount of heat converted into mechanical work; lastly, the temperature may rise if the heat loss decreases at a more rapid rate.

In the second case the consequences may be even more diverse depending on whether the growth of the heat intake is proportionate to the mechanical work or not.

These problems await an experimental solution. Unfortunately, so far science knows only of one attempt in this direction.

But before dwelling on it, I shall cite facts which prove that the first condition is not present in the animal organism. Movement, as we know, leads to a considerable intensification of the respiratory acts; at the same time we know from the works of Dulong and Despretz that this intensification brings with it an increased production of heat; consequently, when the body passes from rest to work the general intake of heat always increases. We observe this every day: as a result of mechanical work, the body gets warmer. This circumstance, however, does not prove that mechanical work is not accompanied by a loss of heat. We can assume that the growth of the heat intake is much greater than its expenditure on mechanical movements; we can also assume that the loss of heat through the skin and lungs during work tends to decline. These aspects have been subjected to experimental investigation. The experiments consisted in the following.

A man was placed in a small room equipped like a calorimeter; being at complete rest, he inhaled air from one gas-meter and exhaled into another; the two meters were installed in the calorimeter. The experiment showed the amount of the oxygen consumed and of the heat lost through the skin and lungs. Thus, it was possible to determine the amount of heat produced in the organism per unit of weight of consumed oxygen, i.e., the thermal equivalent of this gas in the organism. In the second series of experiments the same man and in the same calorimeter performed certain movements expressed in units of mechanical work; the effect of these movements was directed to an object situated outside the calorimeter. In this case, too, the experiments determined the amount of the oxygen consumed and the amount of heat lost and, consequently, the relationship between them. The experiments supplied the answer to the following questions: Does the absolute amount of heat lost through the skin and lungs change as a result of work, and is this value proportionate to the amount of oxygen consumed or to the amount of heat produced in the body, if, as the author does, the first factor is taken as a criterion for the second?* If the relationship between the calorimetrically determined heat and the amount of oxygen consumed is smaller during motion than it is during the state of rest, it is obvious that part of the heat escapes during mechanical work. Here are some of the data obtained from these experiments.

| State of the subject | Absolute heat loss through skin and lungs in 1 hour | Heat loss per 1 gr. of consumed oxygen | |
|---|---|---|---|
| | | Rest | Work |
| Rest | 143 9 | 5 21 | — |
| | 146 9 | 5 52 | — |
| | 147.9 | 5.48 | — |
| Work | 245.6 | — | 2.17 |
| | 283 6 | — | 2.64 |
| | 302.1 | — | 2.37 |
| Rest | 189.0 | 2.73 | — |
| Work | 325 2 | — | 2.08 |
| | 356.3 | — | 2.27 |

* This somewhat arbitrary supposition is the weak point of his work. It is like measuring the value of the heat generated by firewood (not coal) burnt in a machine with the quantity of oxygen consumed, while ignoring the fact that with an abundance of this gas some of the chemical metamorphoses of the combustible may vary qualitatively as well as quantitatively, and this, naturally, modifies the thermal equivalent of oxygen.

The figures in the first column prove that the absolute amount of heat lost via the skin and the lungs increases during work; this is as it should be if we bear in mind that the absolute amount of heat generated during work also increases, which leads to a rise in the temperature of the skin, and to a greater evaporation of water from its surface. The considerable difference between the figures in the last two columns could be taken as proof of body heat being converted into mechanical work, provided the author's supposition concerning the invariability of the thermal equivalent of oxygen in the organism, when the latter passes from rest to motion, were proved experimentally. But since this has not been done, we are forced to regard the conversion of heat into mechanical power in the animal organism as a mere probability.

In any case the intensification of the respiratory acts during work safeguards the body against possible cooling; on the other hand, the more intense activity of the skin is a guarantee against excessive heating of the body; consequently, respiration (the absorption of oxygen by the organism) and the activity of the skin are two antagonists which regulate the animal heat and whose joint action determines the constancy of temperature in the human body (36° to 40°C).

Now a few words about the importance of heat in the economy of the animal organism.

If the animal is subjected to artificial cooling resulting in a loss of heat that can no longer be regulated by intensified respiratory acts, the body temperature drops and the animal dies. But before death considerable changes are observed in its mobility and sensibility: the former weakens, the latter is suppressed.

Frogs, for example, do not die at a temperature of 0°, but the movements of their extremities become slow and sluggish like those of a turtle. Everyone knows, of course, that when the skin is cooled, say, by ice, it is rendered practically insensitive. Further, experiment has revealed that the cooling of the nerves retards their conduction of excitation.

Lastly, according to people who were frozen well nigh to death, but who survived, the cooling of the body induces somnolence, which is followed by a loss of consciousness, i.e., by suppression of the activity of the nervous centres. Animals in the state of hibernation are another striking example of this nervous suppression; at this period their body temperature is much lower than normally. These facts are proof of the importance of heat in the animal acts of the body. Of the probable role played by heat in motion you are already aware; but it is still impossible to determine whether or not there is a connection between heat and the activity of the nervous masses. The usefulness of heat to the animal organism is not confined to the foregoing facts; heat is also necessary for chemical metamorphosis in the organism within the limits in which it takes place normally. This follows from the fact that often, if not always, heat contributes to oxidation, which, as you know, is the basic feature of chemical metamorphosis in the organism. The heat and the chemical acts of the animal organism are interdependent; while the former derives from the latter, it is at the same time the *conditio sine qua nôn* of their regular course. Thanks to this, a slight rise in the temperature of the human body above normal does not lead to death; an animal dies only when the increase reaches 6° to 8°C. The reason for this death cannot be explained, because this temperature (46° to 48°C) is still a long way from the level at which coagulation of the proteins takes place.

Thermal measurements show that the heat is unevenly distributed in the animal organism. Facts obtained by thermal measurement reveal the following phenomenon: the temperature is high in those parts of the organism where the intensity of the chemical acts is considerable and where the heat loss is impeded; it is low in those parts where the reverse conditions prevail. For this reason the skin temperature is lower than that of the internal parts of the organism; tissues abundantly supplied with blood are warmer than anaemic tissues (for example, the muscles and the connective tissue); the blood in the right half of the heart is warmer than that in the left half, because when the blood passes through the capillaries of the lungs it is cooled by the air. The temperature of the blood in the hepatic veins is very high because the chemical processes in the liver are intense. If much blood rushes to the skin, the temperature of the latter rises (for example, the ear becomes heated after section of the cervical part of the sympathetic nerve); conversely, pallor of the skin is caused by a drop in temperature. In a word, if you know the conditions which determine the local temperature variations at different points in the body, you will be able to understand the resulting modifications of the corresponding phenomena.

Note. I delivered these lectures at the beginning of the year and in March submitted them to the magazine *Meditsinsky Vestnik*. This explains why, in my last lecture, I could not take into consideration the work of Traube concerning the relationship between respiration and muscular activity (*Virchow's Archiv*, 1861). In effect, the work contains only one new feature; it is an attempt—not an experimental one either—to introduce into Dulong's experiments more plausible figures for the heat produced by the combustion of the carbon and hydrogen of food. Of infinitely greater importance is the recent work by Béclard which proves, by means of direct measurements, that a working muscle, i.e., a muscle transmitting the living power of its contraction to the surrounding objects, emits less heat to the exterior than a muscle contracting with the same force but not performing any work. This proves that heat is converted into the living power of muscular movement.

follow the transection of the hind roots: the movement of the extremity is as easy and free as that of the normal one. The effect of the transection of the hind roots is, clearly, more profound than mere cutaneous insensitivity; it would appear that the resulting derangement in the co-ordination of movements depends mainly on the fact that other conditions (besides cutaneous sensitivity) associated with the integrity of the hind roots disappear from the organism. What exactly these conditions are cannot be established in the case of the frog, though they are clearly revealed in the case of human beings. Patients suffering from a degeneration of the dorsal columns of the spinal cord, i.e., from the disease known as locomotor ataxia, offer opportunities for these observations. The description of the onset of this disease, given below, is based on the clinical observations of my friend Professor Botkin. The commonest manifestation is that while the patient retains the capacity for fairly strong voluntary muscular contractions, he loses, to a greater or lesser degree, the ability to regulate both the direction and the force of these movements. For example, he can firmly squeeze the hand of another person, but the act of grasping objects, so simple for the normal person, necessitates a great effort on the part of the patient, for he accomplishes it only very slowly and in a clumsy way. The same thing can be observed with leg movements: to bend the leg of a patient who voluntarily excites the extensors, i.e., resists the act of flexion, is every bit as difficult as in the case of the healthy person; yet the patient can walk (i.e., combine the muscular movements of the legs in a definite sequence as regards direction and time) only with difficulty and always in a slow and clumsy way. Examination of this type of patient usually reveals only a certain loss of cutaneous sensitivity in the limbs where the movements are abnormal. However, the degree to which the movements are deranged does not always conform to the degree of paralysis of the cutaneous sensitivity; cases are known when the latter remains relatively intact, yet the co-ordination of movements is seriously deranged, and vice versa. Instructive for comprehension of the mechanism of these phenomena is the role played by visual acts in the deranged movements of such patients. When a person suffering from ataxia controls his movements by vision he can, though with difficulty, impart a corresponding form to the movements, i.e., expediency; he can walk, for example, pick up an object and hold it in his hand. But it suffices for the patient to close his eyes and he loses not only the capacity to walk, but even to keep on his legs; he drops the object which he held in his hand when his eyes were open, etc. It is clear that *in these cases visual sensations direct the movements and thus compensate for the loss of the other sensory factors which guide the voluntary movements of the normal person.*

The entire explanation lies in this incontestable fact. Indeed, from this fact it follows with absolute clarity that when the voluntary movements are not guided by the sensory factors, they become not only deranged but even impossible. Our fact also shows that while the visual acts serve as guides they are far from being the only decisive factor in the co-ordination of the voluntary movements because, as we have seen, in persons suffering from ataxia the movements are deranged even when their eyes are not closed. What, then, are these other sensory regulators of movement? The answer is this: they are the sum of the sensations which proceed from the skin and from the other tissues of the moving skeleton.

The significance of cutaneous sensations for the act of walking and voluntary movements is, of course, beyond doubt once we give thought to the conditions which determine the combination of movements. For example, the person who has lost cutaneous sensibility in the legs does not feel a firm support under his feet when walking; it seems to him that at every step he is about to fall into an abyss. Moreover, if the eyes of this patient are closed he will not be conscious of the movements when one of his feet touches the floor and when the other must be detached from the floor, i.e., of the regular acts of walking. The matter would be different were we to admit that along with cutaneous sensibility the leg has another kind of sensibility which varies with each of its movements, with every contact of the foot with the floor and, in general, with every, even the slightest, change in the state of the leg muscles. In this case the co-ordination of movements into the act of walking and into other voluntary muscular acts would be possible even with a considerable loss of cutaneous sensitivity, as is the case in reality. In which part of the leg is this sensitivity localised? In all probability in the muscles, because of all the parts of the leg these are the only organs which change their position at every movement, even the slightest. That is why science admits the existence of a special vague muscular sense* which along with the cutaneous and visual sensations is, so to speak, one of the principal guides of our consciousness in co-ordinating movements. From what has been said about the spinal disease it follows that a leading role among these guides is played by the muscular sense, despite its vagueness, and that the visual acts, despite their definiteness, play a much less important role. This latter circumstance inclines us to the belief that the mechanism through which the muscular sense co-ordinates the act of walking and the voluntary movements generally is absolutely similar to the mechanism that co-ordinates the reflexes of a decapitated animal into expedient movements. If this is so it would explain, on the one hand, the co-ordinating role of this sense, which does not find any subjective expression in the consciousness and, on the other hand, it would show that this sense is localised in the posterior half of the spinal cord. However, these questions are for the future to solve. For the time being it only remains for us to describe in a few words the most probable mechanism of the participation of sensory factors in the co-ordination of movements (of course, in general outline).

Sensations proceeding from the skin and muscles and accompanying the onset, ending and all phases of each muscular contraction determine the duration of these contractions, as well as the sequence in which the muscles are contracted one after another. This can be proved also from the experience of patients suffering from ataxia. Deprived of the guidance of the sensory factors, such patients, in cases of severe ataxia affecting the limbs, are unable to discern the beginning and end of elementary muscular acts, for example, flexing the fingers; consequently, although they can rapidly contract the necessary muscles, these patients, when their eyes are closed, have difficulty in distinguishing the state of muscular contraction from

* Other facts proving its existence are mentioned in the theory of visual acts

that of muscular relaxation; as a result, they always drop whatever objects they may have in their hands. The intervention of the sensory factors into the sequence of muscular sensations can be illustrated by the alternate movement of the legs which, in persons suffering from ataxia, is absolutely impossible when their eyes are closed.

Consequently, as long as the muscular contraction lasts, a continuous sensory excitation proceeds from the skin and muscles of the moving part of the body to the nervous centres; the nature of this excitation changes with the modification of the movements, thereby determining the direction of the subsequent motor acts. We are still in the dark as to the exact location of these sensory centres.

So much for the description of the structure, properties and activity of the most essential part of the cutaneous and muscular apparatus in the animal organism; we say most essential because the direct central nervous connection between skin and muscles is confined, in the nerve centres, to the mechanism which co-ordinates the movements.

Now a few words about the general physiological significance of the apparatus which we have just described.

Taken as a whole and, moreover, in isolation from the other parts of the brain, this apparatus enables the animal to avoid the harmful external influences which *directly* affect the surface of the body; it is, then, part of a mechanism the functioning of which makes us believe that every animal possesses the instinct of self-preservation.

If we bear in mind that the motor part of our apparatus can be stimulated to action not only by the sensory impulses emanating from the skin, but also by excitations from the sphere of the olfactory, optic and auditory nerves, it will become clear that this combination enables the animal to avoid harmful influences even when these are exerted *from a distance*.

Moreover, the motor part of our apparatus is subject to the action of will. The latter in addition to bringing into action separate, more or less considerable, parts of this apparatus and thereby producing more or less extensive voluntary movements in the body, is able to modify the force of the movements and even to suppress them. It follows, then, that the functioning of our apparatus is at the base of all the instinctive and voluntary movements of the body. Such is its general physiological significance.

It will not be out of place to examine now the relationship of the olfactory, optic and auditory nerves to the motor part of our apparatus, as well as the conditions which engender the voluntary movements; however, we shall consider these questions later, when dealing with the theory of the sense organs. For the moment we shall touch only on those mechanisms of our apparatus which violate the correlation between the intensity of the excitation and its effect—the movement. It is clear that these mechanisms are two in number—one restraining the movements, the other intensifying them.

## § 79. The Inhibitory Influence Exerted by the Brain on the Reflex Activity of the Spinal Cord

Cases of animals being subjected to extra strong stimulations and of their will restraining and even fully suppressing the resultant movements indicate the existence of mechanisms of the first kind. Such cases are, of course, frequent in everyday life; we know, moreover, that in human beings this phenomenon is invariably connected with certain psychical factors thanks to which the suppression of the movements associated with pain is always regarded as a voluntary act. It would be wrong, however, to think that such things are confined to man only; those who have performed painful operations on animals know that some animals endure pain calmly and stoically, i.e., without moaning and tossing This shows that animals, too, can suppress involuntary movements. And this circumstance enables the physiologist to approach the study of the phenomenon experimentally, of course, without including in his researches those aspects which impart a voluntary character to the act.

Let us examine first by means of two simple examples all possible explanations of the act of voluntary suppression of movements.

Suppose that one of the fingers of a person is so stimulated that it involuntarily flexes in all the joints; in other words, there takes place a reflex from the stimulated part of the skin to the flexor of the finger. In these conditions the absence of flexion can be explained either by the will resisting the flexion and exciting the antagonistic muscle, i.e., the extensor of the finger, or by its faculty to suppress as well as to produce muscular movements, or, more precisely, to inhibit the end of the reflex. No other explanations are possible. The first explanation may seem simpler because it does not presuppose the existence of two separate apparatuses exerting opposed influences on the motor drives of the body; the existence in the body of antagonists for each group of muscles is another argument in favour of this explanation. But the first of these arguments is shaky, and for the following reason: if we admit the power of will to invert the direction of movement, we thereby recognise the existence of a special apparatus performing this function. But this is by no means simpler than assuming the existence in the body of a mechanism for suppressing movements. As to the second argument, it, too, is not incontestable. In the human body there takes place a kind of voluntary suppression of muscular movements which simply cannot be explained by the innervation of the antagonists; this is the voluntary suspension of the respiratory movements after exhalation. Respiratory movements are, as we know, of an involuntary character, though they are to a degree subject to will. We know, too, that the diaphragm, the contraction of which produces the act of inspiration, is the principal respiratory muscle, while the muscles of the abdominal wall are its direct antagonists. Knowing this, everyone will easily understand that when respiration is voluntarily suspended at the moment of exhalation, contracting impulses continuously proceed to the diaphragm as long as the state of suspension lasts. From the point of view of the first explanation, the absence of these impulses is to be ascribed to the excitation of the abdominal muscles, which, however, does not take place in reality: even in normal conditions we are conscious of the slightest contraction of these muscles, since it is accompanied by distinct sensations; however, at the moment respiration is suspended, we do not observe any sensations of this kind even in such morbid cases as rheumatism of the abdominal muscles, peritonitis, etc., which render the contraction and extension of the abdominal walls painful. Lastly, if we grant that will can suppress movements even in cases of extra strong stimulation, and that, in addition, the mind does not receive any signal of muscular tension it will be quite obvious that the suppression of the movements simply cannot be explained by the play of antagonists; were this the case, any strong stimulation would evoke a visible tension of both muscular groups.

Thus, of the two foregoing explanations we should regard as the more probable the second one which approaches the suppression of the movements in a direct way, i.e., admits the existence in the body of special nervous mechanisms suppressing involuntary movements. In the past few decades this idea has found much support in a number of facts concerning the inhibitory influence of the vagus nerve on the cardiac movements, as well as the similar influence exerted by the splanchnic nerve on the intestinal movements; besides, the intensification of spinal reflexes observed in animals after decapitation has likewise been advanced as an argument in favour of the existence in the brain of mechanisms inhibiting spinal reflexes. At one time it was believed that the inhibitory mechanisms are in a state of constant (tonic), even though weak, excitation, thereby moderating the spinal reflexes as long as the brain is connected with the spinal cord; but the moment this connection is interrupted (as a result of decapitation) the spinal reflex apparatuses, no longer restrained by the brain, begin to act more intensively.

The problem remained in this state until 1862 when experiments proved that the brain of the frog possesses certain mechanisms the excitation of which greatly weakens the spinal reflexes. The areas of the brain producing this effect occupy all of the space between the hemispheres and the upper limit of the medulla oblongata; they are, then, situated in front of the co-ordinating centres. But the most active points are, apparently, located in the anterior cross-sections of this space, namely, in the cross-sections of the so-called visual chambers which in the frog are found directly behind the hemispheres. The experiments which revealed the existence of these mechanisms consist in the following: the hemispheres of the frog are removed by a transection of the visual chambers; the cross-section of the latter is exposed. The reflex capacity of the spinal cord is then measured according to the Türck method; after this, crystals of sodium chloride slightly moistened in water, or defibrinated blood, are placed on the cross-cut of the visual chambers and the reflex capacity is measured again. The above-mentioned parts of the brain (i.e., the visual chambers and the *corpora quadrigemina*) *can be stimulated also by means of light induction* currents by attaching pins to the leads of a secondary coil and sticking the pins into the visual chambers or *corpora quadrigemina,* perpendicularly to the longitudinal axis of the body (again after the preliminary removal of the hemispheres). In both cases, *no matter how weak the stimulation, the first effect is always a decline of reflex activity in the animal.* It is this that distinguishes the results of these experiments from the similar *stimulation of the cross-sections of the spinal cord mentioned* in connection with the general physiology of the nervous centres. It will be recalled that in the latter case the first effect of the stimulation, corresponding to the state of excitation of the reflex apparatuses, was an intensified reflex activity, and that the subsequent decline of this activity followed from exhaustion. But when the brain is subjected to stimulation, the state of excitation is expressed by a decline in reflex activity. *Moreover, this decline is immeasurably greater than that caused by the stimulation of the spinal cord.*

Experiments also show that the suppression of reflexes resulting from stimulation of the visual chambers, is not accompanied by pain or movement; it is, therefore, natural to ascribe this effect to the excitation of some special mechanisms which are absolutely different from the sensory and motor apparatuses of the organism.* In other words, the mechanisms inhibiting the reflexes are of a specific nature.

The structure of the inhibitory apparatuses has not yet been subjected to detailed investigation. We shall, however, cite some *facts which will help us to obtain at least an approximate idea*

* They could, of course, be related to the sensory pathways if we admit, for example, that the decline in reflex activity is caused by a slight excitation of the sensory fibres situated in the cross-section of the visual chambers—an analogous phenomenon is found in the organism (see the suspension of respiration caused by the stimulation of the superior laryngeal nerve); but in this case it would be necessary to admit the specific role of these fibres in relation to the reflex apparatuses.

(perhaps even erroneous) of this structure (naturally, in general outline).

Three essential parts are to be distinguished in an inhibitory mechanism, as in any centrifugal nervous apparatus; they are: the centre, the principal drive and the peripheral mechanism, or, in general, the apparatus subjected to the action of excitation emanating from the centre. The problem, then, is, first of all, to define the general nature of these parts and their localisation. The beginning of the centrifugal nervous mechanisms is always the centre; since the apparatus is accessible to objective investigation, i.e., since it is excited by the usual nervous stimuli, it begins, evidently, immediately behind the cerebral hemispheres. Consequently, if we regard the actual beginning of the inhibitory mechanisms as the real centre, it will appear that the central part of our apparatus occupies all the space between the hemispheres and the medulla oblongata, because along this space the stimulation of the cross-sections of the brain results in the suppression of reflexes. This also determines the site of origin of the principal centrifugal drives; it lies on the border between the *corpora quadrigemina* and the *medulla oblongata*. As to the other end of the mechanism, namely, the peripheral one, it might seem that it should be in the muscle, since this is where the effect of the excitation of the inhibitory centre is manifested. However, a simple argument will show that this is not so. We have mentioned the reasons which lead us to the belief that all the fibres of the anterior roots without exception terminate in the cells of the spinal cord. On the other hand, experiments have not discovered inhibitory fibres in the muscular nerves. Consequently, the central drives of our apparatus must terminate in the spinal cord and not at any lower level, and most assuredly in the nerve cells; in other words, they are located entirely in the density of the central nervous masses and belong to the category of inter-central conductors. But where, exactly, do these conductors terminate? Do they overstep the boundaries of the collecting centres of the *medulla oblongata* and terminate in the spinal cord, or not? As regards the reflexes of the trunk and extremities, these questions must be answered—with a high degree of probability—in favour of the spinal medullary termination, that is, if we assume that our apparatus has the same structure as all other centrifugal mechanisms of the body, namely, if we assume that the effector organ—in our case, the mechanism which suppresses the reflexes—is located at the peripheral terminal of the apparatus. With this approach, the problem can be solved by way of the following experiment: if the inhibitory mechanisms of the frog are strongly excited by stimulation of the visual chambers and if the frog is then decapitated, the spinal reflexes will be inhibited long after the decapitation. This means that when the peripheral organ of the inhibitory mechanism is excited from the centre, the excitation persists for a long time.

The absence of a strong inhibition of reflex activity in conditions when the spinal cord is subjected to direct stimulation does not contradict the idea that the inhibitory mechanisms terminate here; it merely indicates that the peripheral apparatuses of the latter, unlike some of the other peripheral apparatuses of the body,* *are not excited by the usual nervous stimuli.* As for other topographical details concerning the inhibitory drives, they are determined by the following series of experiments. If we transect one half of the spinal cord of a frog, or even one anterior quarter of this organ after exposing a cross-section of the visual chambers, stimulation of the latter will, in most cases, not produce inhibition of the reflex activity, or call forth a very weak inhibition of this activity in the hind extremity of the side where the transection of the spinal cord was performed, while on the opposite side the inhibition preserves its normal character. If we transect a posterior quarter of the spinal cord, the irradiation of the inhibitory influence over the corresponding side of the body** is not impeded. These

* The non-excitability of the peripheral ends of the apparatus is by no means an exception: later we shall see that the fibres of the tympanichord are ramified in the salivary gland; when stimulated in the nervous trunk these fibres intensify the salivary secretion, whereas direct electric stimulation of the gland itself will not have this effect.

** There is one aspect of these experiments which refutes the idea that the intensified reflex activity after decapitation is caused by the removal of the inhibitory mechanisms of the head which are in a state of weak tonic excitation. The experiments show that the inhibitory influences irradiate only *over the anterior parts of the spinal cord; as we know,* transection of the latter does not intensify the reflexes; on the contrary, intensiexperiments show that the inhibitory drives lie in the anterior parts of the spinal cord, or, in other words, in the anterior columns of this organ. As to the possible connection between the right and left halves of the inhibitory drives in the spinal cord, nothing positive can be said in this respect at present. The problem of the connection between the inhibitory mechanisms and the motor drives of the spinal cord likewise remains unsolved.

This covers the sum of the positive facts relating to the inhibitory influences of the brain on the spinal reflexes, or, what is the same thing, on the involuntary movements of the striated muscles in the trunk and extremities. But if we apply even this limited number of facts, observed on the frog, to higher vertebrates, it will explain all the phenomena where involuntary movements are suppressed by will. In this case, we shall have simply to admit that the underlying processes of will act on the central parts of the inhibitory mechanism as described above.

## § 80. Conditions Determining the Intensification of Reflexes Caused by a Weak Stimulation of the Skin

Of the many things intended for examination in this chapter it remains for us to analyse the conditions thanks to which in certain cases—when the linkage between the brain and the spinal cord is intact—involuntary movements caused by the stimulation of the skin are too strong compared with the degree of the stimulation. The simplest and most striking example of this is the tremor with which the body reacts to the sudden touching of the skin, i.e., to a purely tactile stimulation. But since the experimental study of the conditions which determine this reaction has just begun, we can cite only a single experimental fact by way of an answer, true an incomplete one, to the question. Discovered by Pashutin, it consists of the following. If we stimulate the frog's visual chambers or the *corpora quadrigemina* by a weak intermittent current, as is done when we excite the inhibitory mechanisms, we observe, along with inhibition of the reflex movements resulting from the stimula-

fication is manifested only after transection of the posterior and median columns of the spinal cord.

tion of the skin by an acid, a pronounced intensification of the tactile reflexes (this is our terminology for the reflex movements produced by a purely tactile stimulation of the skin). Exactly the same thing seems to take place in the frog under these conditions: the slightest touch to its skin (especially on the fore extremities) makes the body start. Pashutin's experiment proves that when the middle parts of the frog's brain are in a state of excitation, the tactile reflexes are intensified. But the mechanism of this phenomenon is, so far, unknown to us.

This fact should be confronted with another, observed this time in animals suffering from strychnine poisoning. In these animals the tactile reflexes attain maximum strength: if the animal is shaken ever so slightly, or if a whiff reaches its skin, tetanic convulsions ensue; yet the reflexes of poisoned frogs to the action of acid are weakened rather than intensified (Matkevich). When a poisoned animal has been decapitated, the tactile spinal reflexes lose much of their strength.

It should be pointed out, however, that all that has been said above relates to tactile reflexes only; as to the conditions which determine the intensified ending of the reflex movements provoked by painful stimulations, they are absolutely unknown.

Before ending this chapter it is necessary to touch on the link between the central parts of the musculo-cutaneous apparatuses and the fibres of the sympathetic nerve. This link is manifested in the fact that any (for example, electrical) stimulation of the abdominal part of the sympathetic chain, any stimulation of the abdominal plexuses, and of the trunks of the splanchnic nerves provoke in animals, along with sensations of pain, movements of the head, trunk and all its appendages. These phenomena could, of course, be explained by saying that the sympathetic fibres are connected exclusively with the brain division of the musculo-cutaneous centres; however, experiments with decapitated animals (frogs) show that these fibres are connected also with the reflex centres of the spinal cord. In these conditions the stimulation of the sympathetic trunks continues to provoke reflexes in the muscles of the trunk and of the extremities.

These phenomena have not yet been investigated, notwithstanding their extreme importance. All we know is that not all the segments of the sympathetic chain provoke sensations of pain and reflex movements (for example, the cervical part of the sympathetic nerve does not contain these fibres); we know, moreover, that the sympathetic fibres enter the spinal cord through communicating branches. But the problem of their relation to the spinal cells and, in general, of the ramification of the sympathetic fibres in the spinal cord, still awaits elaboration. The disregard shown for these problems is such that to this day we still do not know exactly in which tissues and in which organs the sensory (and reflex) fibres of one or another part of the sympathetic chain with its plexuses are ramified. As we shall see later, the lack of this knowledge is keenly felt in the study of the innervation of the abdominal viscera.

Now the reader will, undoubtedly, understand that there can be no question of the physiological significance of the connection between the musculo-cutaneous apparatuses and the fibres of the sympathetic nerve.

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Just as this chapter was about to come off the press, Mr. Berezin, an assistant in the physiological laboratory of the Petersburg Medico-Surgical Academy made a highly important discovery which signifies a big change in the previously held views concerning the interrelation between the reflex and the sensory fibres of the skin—the view which I have elaborated in § 72.

By sectioning the spinal roots of the frog's hind extremity singly or in groups of two and three, Berezin found that so long as one superior root was left intact, the conscious sensitivity of the skin of the hind leg persisted in a normal animal even when the painful cutaneous stimulation (by acid) was not very strong, though the sensibility was somewhat weakened. In other words, painful stimulation provokes reflexes in the hind leg and in the anterior part of the body even when the lateral half of the spinal cord is transected on the side of the sectioned roots, or when a piece of the posterior half of this organ is cut out on the level of the fourth vertebra. But if the animal is decapitated (its spinal cord remaining undamaged) with one superior root left intact, even the strongest skin stimulation (by *means of sulphuric acid) fails to provoke body movements.*

This experiment brings out most clearly the difference between the sensory and the reflex fibres of the skin in the hind leg of the frog*....

Of no less importance is the following, subsequent experiment of Berezin: when only one superior root is left intact in the frog it suffices to remove the hemispheres for the reflex movements in the body to be completely eliminated.

From this it follows that in the frog's brain reflexes movement may appear as a result of conscious pain sensations. Indeed, nobody admits the existence in the cerebral hemispheres of any apparatuses similar to the reflex apparatuses; on the other hand, it is the mechanisms producing conscious sensations that are usually localised here.

The fibres leading from the skin of the hind legs to the brain *along the medial and inferior roots are connected with the co-*ordinating centres; that is why, when all the roots are intact, brain reflexes may take place even after the cerebral hemispheres have been removed.

Lastly, Berezin's discovery refutes the point of view advanced by me in § 73 concerning the relationship between the co-ordinating centres and the cells of the posterior horns. This relationship was expressed in the idea that the points of the brain where the sensory drives converge play the role of collecting centres with respect to the spinal cells. Now this view, naturally, loses its validity because the sensory drives are separated along their entire length from the reflex pathways. However, the idea that the co-ordinating mechanisms play the role of collecting centres with respect to the cells of the anterior half of the spinal cord remains valid for the motor part of the entire cutaneous-muscular apparatus.

* Here Sechenov refers to §72 of his book and explains the respective drawing.—*Ed.*

## PROF. SECHENOV'S FIRST LECTURE IN THE MOSCOW UNIVERSITY[90]

According to the new University Statutes, the professor, upon retiring, is invested with the right to teach at universities in the capacity of assistant professor. I have availed myself of this precious right, and the administration have been good enough to allow me to deliver a series of lectures; as a former student of the Moscow University, I am really happy that at last the opportunity has come my way to be of use to my Alma Mater. As an assistant professor my duties will be to contribute to the successful teaching of physiology; and I shall endeavour to do this by reading special courses of lectures. The subject-matter of the syllabus presented by me to the Faculty is the "physiology of sensation"; the lectures are designed for students who have already attended the regular course on physiology. So when delivering my lectures I shall assume that the students are already acquainted with the fundamentals of the general physiology of the nervous system and with the theory of the sense organs.

I shall not, therefore, dwell in detail on the first point—how and within what limits should we study the acts of sensation. As we know, physiology studies the way in which these phenomena are associated with their material substrata, i.e., with the functioning of the sense organs; however, the sphere of its research takes in also some of the phenomena which take place in the other organs and which accompany or follow the acts of sensation. Wherever the link between sensation and the material substrata cannot be established, physiological research inevitably comes to a stop.

Moreover, the works of the famous German physiologist Helmholtz, devoted to physiological optics and acoustics, contain direct indications as to how physiological research can be carried out in studying the acts of sensation and the limits within which this is possible. I, too, intend to confine myself to these limits.

*Sensations as acts of the consciousness with all their inherent specific features* (which enable us to distinguish light from sound, taste, etc.) *will be outside the sphere of our discussion; we shall examine only the conditions under which the basic forms of each sensation are modified, as well as the secondary phenomena which take place in the organism as a result of acts of sensation.* We shall see later what the latter imply.

Now that the subject and the limits of our research have been established, it is necessary to put in order the materials of the research, i.e., to find, if possible, a definite common principle for the classification of the multiform acts of sensation. I shall dwell on this question in detail, because you will not find the answer to it in any textbook of physiology and also because the whole of our discussion will be shaped by the manner in which we develop this question.

As we know, modern physiology regards the animal organism as a kind of machine the purpose of which, in the final analysis, is to maintain individual life,* i.e., to preserve the anatomical and physiological integrity of the organism over a more or less long period, notwithstanding the destructive influences to which it is subjected. We know, moreover, that the muscles and the glands are the principal working organs of the body. The former perform purely mechanical work, while the latter secrete various juices. Lastly, all of you know the relationship between the nervous system and the effector organs with all of their functions. Just as the production of different juices is effected by different glands, various movements are performed by different groups of muscles: some of these, for example, flex and extend the limbs, others constrict and dilate the lumens of the tubular organs, still others move the trunk of the body, etc. Clearly this discreteness of the work of the effector organs cor-

* I leave aside sexual activity which is not indispensable to the maintenance of individual existence.

responds to the discreteness of the associated nervous mechanisms whenever the latter directly participate in the work of the particular gland or group of muscles. But who of us does not know of this participation? For not a single muscle in the body can function normally without being subjected to the action of impulses emanating from the nervous system; the same is true of many glands (salivary, sudoriferous, lachrymal, gastric, and, probably, also the mammary glands and the pancreas). If, for example, the brain and spinal cord of a frog are removed, or if the frog is poisoned with curare, it will lose the capacity to move, although its muscles will continue to react to artificial stimulation (electric current) by contracting. If the tympani-chord of a dog is transected the submaxillary gland will cease to produce normal juice, although it preserves the capacity to secrete fluid (so-called paralytic saliva).

Thus, the entire motor system of the organism in the shape of the muscles and numerous glands functions normally only under the action of impulses emanating from the nervous system; at the same time the structure of these organs is such that they can work even in the absence of normal nervous influences, for example, as a result of artificial stimulations. How, then, can we reconcile these two facts—on the one hand, the indispensability of the nervous impulses to the normal functioning of the muscles and glands, and, on the other, a certain independence of both from the nervous influences?

These facts can be easily reconciled if we draw a parallel between the muscles and glands with their nervous mechanisms, on the one hand, and machines, on the other. In this case a muscle, abstracted from its nervous connections, can be regarded as an essential component of a machine designed to perform mechanical work, and the nervous apparatus as an accessory device corresponding to the regulators which enable the mechanic to operate his machine, to accelerate, decelerate or stop its work altogether. The nervous system initiates the work of the muscles and of (certain) glands, and since the functioning of this system, like that of a machine, is at times accelerated (due to certain requirements of the organism), or decelerated and even stopped altogether, it is clear that the entire regulation derives from the nervous system.

In most machines the regulation is done by the operator whose hand brings a particular device into action. But there are some regulators which replace the operator's hand: they come into action, so to speak, automatically, but actually under the influence of certain changes in the functioning of the machine. The safety valve of Watt's steam-engine is the best known example of such a regulator. As the pressure of the steam in the boiler exceeds a definite limit, the valve automatically widens the exhaust outlet, and vice versa. The numerous devices of this kind are called automatic regulators.

*In the animal, which is a kind of self-acting machine, the regulators are also automatic, being brought into action by the changes in the state of the machine or in its functioning. As the work of these regulators is expedient, they replace the hand of the operator which is guided by his mind.*

This approach to the role of the nervous mechanisms facilitates an understanding of the vital importance of the sensory acts.

*Sensation corresponds to the action of the signalling part of a regulator. Brought into action by the changes in the state or functioning of this or that part of the animal machine, the signalling mechanism in its turn brings into action a certain device* (in the form of motion or secretion of juice) *aimed at eliminating the particular abnormality.*

There are multitudes of these regulators in the organism, and their activity is essentially directed at safeguarding the anatomical and physiological integrity of the body. In these regulatory functions sensation actually plays the same signalling role, but its manifestations and its interrelation with those parts of the mechanisms which cause motion or secretion of juice greatly differ. I will avail myself of these differences in order to systematise the sensations. And I will be bold enough to regard my classification as rational, because, as we shall see later, it embraces the two aspects of sensation (its qualitative manifestation and relationship to motion) which determine its physiological significance, i.e., its significance for the life of the organism. For greater clarity, I will describe the various categories of regulations by means of examples.

The first category is formed by the activities of the more simple mechanisms serving, so to speak, the provincial or the minor interests of the organism, mechanisms which secure the anatomical and physiological integrity of separate parts of the animal machine.

The eye has three regulators of this kind: nictitating, lachrymal and photomotor. The first two function jointly and ensure the integrity and limpidity of the anterior part of the eye-ball The effect produced by them can, without any exaggeration, be compared with the effect of wiping a window with a wet cloth. Their activity is engendered by external factors acting on the sensory surface of the eye-ball; this can be proved in different ways. The normal external influences are so weak that we do not feel them at all; but, the moment they are somewhat intensified (wind, cold air, volatile caustic substances, etc.), they produce, along with sensations reaching the consciousness, an intense flow of tears and nictitation. A similar effect is produced by a speck of dust or dirt in the eye. Conversely, if we close the eyes the nictitation ceases. The acts begin with the irritation of the sensory surface of the eye-ball (the fibre of the trigeminal nerve); the excitation is then transmitted to the orbicular muscle of the eyelid (along the fibres of the facial nerve), as well as to the lachrymal gland (along the lachrymal branchings of the trigeminal nerve). Both phenomena belong to the category of reflexes, and, as such, they become impossible when the sensory surface is separated from the reflective centre (by a section of the trigeminal nerve). The activity of the third mechanism consists in regulating the amount of light falling upon the retina by constricting the pupil as the intensity of the light increases This is also a reflex (from the fibres of the optic nerve to the fibres of the oculomotor nerve) which takes place outside the consciousness (even to a greater degree than the preceding reflexes).

Let us now turn to another, lower part of the head. We shall see that the act of sneezing, engendered by irritation of the inner sensory surface of the nose, is a manifestation of the activity of a special apparatus which prevents foreign bodies and irritants from getting into the respiratory tract. The motor part of the act consists in filling the lungs with air through the mouth and in a subsequent violent and abrupt expulsion of a reverse current of air from the lungs through the nose, which is often accompanied by an abundant secretion of tears (the latter are eliminated through the nasal cavity). This, too, is a reflex act.

If a person lying on his back throws his head far backwards and water is carefully poured into his nose (experiment performed by E. H. Weber), the posterior outlet of the nasal cavity is closed by the uvula, as in the act of swallowing. Here again we have a reflex which essentially corresponds to the closure of a valve along the length of the respiratory tract.

In the larynx we find similar protective mechanisms. Above the vocal chords any stimulation of the sensory membrane of the larynx produces a reflex closure of the glottis; this corresponds to the closure of a value preventing foreign bodies from making their way downwards. But should a foreign body pass through the glottis with the result that the mucous membrane becomes irritated below the vocal chords, this causes coughing, i.e., the act of expelling the foreign body, essentially corresponding to the act of sneezing.

The oral cavity, while less protected against the action of irritants, is safeguarded by reflex salivation which follows any irritation of the walls of the cavity. But the salivary reflexes are expedient in yet another respect: coinciding in time with the introduction of nutritive substances into the mouth, as well as with the acts of mastication, they ensure an economical expenditure of the gastric juice; they emerge precisely when the juice is needed for digestive and swallowing purposes.

On the way from the mouth to the stomach, in the area where swallowing turns from a voluntary act into an involuntary one, there are neuro-muscular mechanisms designed to prevent the food from getting into the nose and the respiratory tract; these mechanisms come into action independently of the consciousness. But alongside these mechanisms, there are others of whose reflex activity we are conscious; I have in mind the urge to vomit when the uvula or the root of the tongue are subjected to irritation, and the urge to swallow, caused by a catarrhal swelling of the uvula.

In the stomach there are three known regulators: the secretion of gastric juice evoked by stimulation of the mucous membrane in all the areas studded with peptic glands; reflex vomiting caused by stimulation of the mucous membrane near the inlet; and, finally, spasmodic closure of the outlet *(sphincter pyloricus)* when the stomach is filled with food. (If we remove the stomach from an animal killed immediately after feeding, we shall see that it does not become evacuated no matter how much it may be distended by the food.) The expediency of the first two acts is clear from the examples cited above; as to the third act, its expediency is determined by the fact that gastric digestion necessitates time, in view of which an open outlet from the cavity of the stomach would not be a favourable factor.

The functioning of all these mechanisms is characterised by the following aspects: all of them ensure the integrity of separate parts or organs of the body; in all cases the acts develop as reflexes (reflected movements) with their machine-like uniformity and regularity: a stimulation of the sensory surface is inevitably followed by a movement of one and the same order (i.e., produced by one and the same group of muscles), and the entire act is either only slightly complicated or not complicated at all by conscious sensations. Notwithstanding this latter circumstance, or, to be more precise, probably because of it, we must in all cases attribute to the sensory surfaces of the nervous mechanisms a considerable degree of excitability and to some of them also a so-called specific irritability. For example, the pupil is especially sensitive to light; the urge to vomit does not derive from any contact with the uvula; thus, the contact of a bolus of food with the uvula does not generate this urge; the salivary apparatus is excited predominantly by definite flavouring substances and not by all of them indiscriminately, etc. If this delicate sensitivity or slight excitability were proved in all cases, it could explain for us both the relatively unconscious character of the acts, attributing its cause to the extreme weakness of the normal stimulations, and the inevitable emergence of movements after the excitation.

The acts of emptying the urinary bladder and the rectum lie on the border between this category of regulations and the subsequent one.

As regards the effect produced by the regulators, the two acts are equivalent to those considered above, because both ensure the functional integrity of definite organs.

But here the sensation with which the act begins is already of a conscious character, and its signalling role is particularly clear. I have in mind the urge for micturition and that for defecation which, as we know, are based on sensory stimulation of the mucous membrane of the urinary bladder and of the rectum near the outlets, by the contents of their cavities. Another apparently essential feature distinguishing these regulations from the preceding ones is that the motor reaction is not connected here so fatally with the signal as in the first case: on receiving the signal, man may disobey it; thus the act of emptying the two cavities acquires a certain voluntary character. Highly diverse motives may induce man to disregard the signal; *consequently, not only man's will, but also his reasoning* interpose between the signal and the expedient movement. Lastly, everyone knows that the emptying of the two cavities can be done deliberately, without any sensory signal. But does it follow that the structure of our new regulators differs from that of the preceding regulators, that here the signalling and motor parts are separated, while in the preceding case they are interconnected like the parts of a machine?

Observations and direct experiments prove the opposite. In man both mechanisms are ready at birth and are brought into action in the first months of life, though, of course, not through conscious and voluntary innervation. In the adult, too, they can operate unconsciously. Further, it is known that man can disobey the signals only to a limited degree. Desire, at first weak, can become so compelling that one is forced to yield to it; such, for example, is the irresistible desire to micturate, brought on by the artificial stimulation of the cervix of the urinary bladder, or the desire to defecate observed in acute diarrhoea. It is true that in some cases the urinary bladder of the typhus patient or of a person who has lost consciousness may be greatly distended without causing any contraction of the emptying muscles; but this can be explained not only by the suppression of the voluntary innervation, but also by a disturbance in the signalling part of the mechanism. Besides, it should not be forgotten that in the bladder the action of *detrusories urinae* is opposed not only by a muscular sphincter, but also by an elastic one; for this reason it is easier to retain the urine than to suppress, for example, the acts of coughing and sneezing. However, man can in some degree suppress even these acts and also the act of winking. On the other hand, winking, coughing and sneezing can be reproduced in a voluntary way, in the absence of any sensory stimulation. Consequently, a separation of the signalling parts of the act from its motor parts due to the suppressive influence of will is observed also in the regulators of the first category. But the movements of the pupil, the second part of the act of swallowing, the action of the gastric sphincter and the glandular secretion are really independent of will and cannot be reproduced voluntarily. The matter, then, is actually reduced to the following: in those cases where the effector organ of the regulator is not subordinated to will, the act is of an obviously machine-like character, even if the excitation provokes conscious sensations; the connection between the signalling and motor parts of the mechanism seems to be direct and indissoluble. But when the effector organ is subordinated to will, the act can take place in two ways: either automatically (coughing or sneezing in the state of deep sleep, etc.), or voluntarily; in different cases the intervention of will may be more or less pronounced. Accordingly, the act requires a more or less voluntary character, and the connection between the signalling and motor parts of the regulator seems to be interrupted.

The second category of regulations includes the so-called *systemic senses* with their motor effects. The background to all the multiform manifestations of this category is formed by the vague aggregate sense (probably engendered by all the organs of the body supplied with sensory nerves) which in healthy people is known as the sense of general physical welfare and in weak, or sick people—the sense of general indisposition. Although a feature of this background is its calm, vague sense, its influence is felt not only on the working activity of man, but also on his state of mind. It determines the normal tone of all the processes taking place in the body, which physicians designate as *vigor vitalis* and which in man's psychical life is usually called the state of mind. This background, however, is not always calm and placid: normal perturbations take place in it from time to time, as a result of which one or another special form of a systemic sense stands out of the general sensory picture and becomes predominant. We know of a number of normal or physiological forms of this kind; they are: hunger, thirst, sexual sense, the urge to do something, fatigue and drowsiness. As to the pathologists, they know a multitude of such forms which are variations of the sense of indisposition and pain; but we shall not consider them here.

All the physiological forms of a systemic sense have the following common aspects. The sense is as indecomposable as *in all cases of the first category, and it, too, varies only in* intensity. Like the preceding two transitional forms, a systemic *sense always bears the character of a desire (to eat, to drink,* to satisfy the sexual needs, to act, to rest, to sleep); it therefore *appears periodically and disappears the moment the desire has* been satisfied. For the same reason, the sense develops gradually and so imperceptibly that its beginning cannot be traced. But once it has appeared and developed, it reaches our consciousness and, like the basic vague form, strongly influences even our psychical state. Growing stronger, the sense at last acquires such a violent impulsive character that it turns, *through the medium of the psychical activity,* into a source of diverse complex activities aimed at satisfying the particular desire. Topographical indefiniteness of the systemic senses is another of their common features. This means the following: Man always correctly associates the sensations of the first category of which he is conscious to those areas where the excitation affects the sensory surface; the cause of winking, for example, is associated with the eye, the cause of sneezing—with the nose, etc. But *hunger, thirst, drowsiness and the sexual sense cannot be* related to any definite area. How, then, are we to compare this *series of highly complex phenomena with the first category* of cases mentioned above?

True enough the phenomena are here immeasurably more complex; and yet, in their essence they are manifestations of the activity of definitely constructed regulators. Thus, hunger, thirst and the sense of satiety regulate the periodicity and quantitative expediency of the intake of food. Fatigue is a signal to discontinue activity. The sexual instincts ensure the integrity, of the species, etc. In all these cases the sense also plays the role of a signal which, as in the case of a machine, is alerted by changes in the conditions of its operation. Essentially, it makes no difference in what way the systemic sense develops, and whether it is engendered also in a definite area corresponding to the sensory surfaces of the first category, or whether it is caused by excitation of the central part of the nervous system (for example, as in the case of the sense of suffocation). The point is that the modifications which constantly take place in the state of a machine and which are an indispensable condition for the operation of the automatic regulator, are here in evidence as well.* The real difference between the systemic and partial regulators is that the latter influence only small groups of muscles, whereas the former set in motion, so to speak, the entire motor system of the organism. Moreover, the purposes of the regulation are dissimilar in these cases: the partial regulators ensure the integrity of the minor parts of the organism, while the systemic regulators safeguard the integrity of the animal machine as a whole and the integrity of the given species. There is another, still more pronounced difference: a systemic sense evokes actions of expediency exclusively through the medium of our psychical activity, so that these actions acquire a consciously voluntary character. However, this is only partially true. the actions of ravenous animals or of animals in heat assume a forced character; a protracted lack of sleep accompanied by pronounced physical fatigue leads to sleep even when conditions are abnormal (it is known, for example, that the soldiers in the advanced batteries at Sevastopol slept when off duty during heavy bombardments). Consequently, even from this point of view the functions of the systemic regulators do not differ essentially from those of the mechanisms that ensure evacuation of the urinary bladder and the rectum (this is why I regard these two acts as a transitional stage from the first to the second category).

In both cases the basic features of the structure of the reg-

* Including those pathological cases in which the particular systemic sense is distorted

ulators are the same; only the connection between the signalling and the effector parts becomes more and more complex, reaching the highest degree of complexity in man with his highly developed psychical organisation.

Between the second category and the subsequent, third one, we must place the vague system of sensations of a mixed origin which accompanies every muscular movement, or, more precisely, every displacement of the skeletal parts relative to each other. For the sake of brevity, this sum of sensations is sometimes designated (though incorrectly), by the words "muscular sense". There is another intermediate form—the system of cutaneous sensations; this, however, does not include the tactile sensations which belong to the subsequent, third category.

Everyone knows from practical experience that man controls his movements with the help of two senses: vision and touch. Under the control of the eyes he directs his movements towards a definite (visible or imaginary) aim, and the realisation of the aim is in its turn conveyed to our consciousness by the eyes or by touch or by both simultaneously (sometimes also by other senses). However, even a blind man can control the movements of his limbs; and if he can communicate a definite direction to them, this presupposes another control sense equivalent to vision. And this sense, inherent both in blind people and in those who can see, really exists; it consists in our capacity to feel and to appraise with definite precision any change in the relative position of parts of our body and the act of their displacement, irrespective of whether the latter be passive or effected by means of muscular contraction. The sensations accompanying these changes are of a mixed origin; they arise from the tension and relaxation of the skin and of the subcutaneous layers, predominantly near the joints, as well as from the active contractions and passive extensions which play their part in muscle displacement. There is no doubt that despite their vagueness, these sensations play a leading part in co-ordinating the contraction of individual muscles; the mechanism of this regulation still remains to be discovered. The indications furnished by the muscular sense constitute the sensory roots of the notions expressed by the words top, bottom, front, rear, right, left, straight, forward, turn, upwards, incline, quick, slow, intermittent, etc.

Taken in this broad sense, the muscular sense can be described as the direct regulator of movements; at the same time it is a sense which helps the animal to appreciate at any given moment the position of its own body in space, both in the state of locomotion and at rest. Consequently, it is one of the instruments of the animal's orientation in space and time. In this capacity, the muscular sense apparently serves the purposes of the body as a whole and, like the systemic senses, arises not from a strictly definite small area of it, but from systems of sensory organs. Further, being as vague as a systemic sense, it can, unlike the latter, vary greatly, depending on its place of origin and on the nature of the movement. In this it is not unlike the sensations of a higher order, but, being completely impassive, it occupies a separate place.

Thermal and pain sensations, like the tactile sensations, are inherent in the skin. The thermal sensations have not been subjected to any great investigation because their capacity to provoke motor reactions in animals is inconsiderable; we shall, therefore, leave them aside. Pain sensations, on the contrary, are the source of highly diverse movements and have been more or less thoroughly studied from the point of view of their association with these movements. The general essence of the phenomena of pain sensations becomes clear from the following facts. Pain is felt along the entire surface of the skin; no matter which part of it is hurt, the pain is invariably accompanied by movements of expediency on the part of the animal or man, movements directed towards one and the same aim: to remove the cause of pain or to evade the irritating agent. Reactions of this kind, relating to the particular point of the skin, bear the character of involuntary movements and are known as cutaneous-muscular reflexes; the sum of the reactions affecting the skin surface as a whole expresses the activity of a vast systemic apparatus safeguarding the integrity of the entire outer surface of the body which, clearly, is most exposed to the hazards of life.

The structure of the cutaneous-muscular mechanisms is in the main the same as that of the above-mentioned elementary regulators where the effector organ is subordinated to will. An expedient cutaneous-muscular reflex can set in without the participation of consciousness, with automatic regularity; but it can be complicated by conscious sensations, by the intervention of will; lastly, it can be reproduced deliberately, without any sensory stimulation. The only difference between these phenomena and the activity of the elementary partial regulators is that here one and the same group of muscles invariably acts in one and the same direction, while there the grouping of the muscles may vary greatly both in the number of the muscles in operation and in the sequence of their combined activity.

The last category of regulations derives from the activities of the higher sense organs and their motor effects. Taste and olfaction are usually reckoned among these sense organs. And taste and olfaction render highly important services to the animal: they enable it to distinguish edible from inedible substances, to smell the prey and the enemy; but in the life of man the signals emanating from these senses play a much smaller part than those furnished by sight, touch and hearing. Still, they manifest the peculiarity which distinguishes the sensations of this third category from all the preceding forms.

If a mote gets into the eye it produces the same sensory effect no matter whether it is of wood, stone, or iron, whether regular or irregular in form, irrespective of colour, etc.; its presence disturbs or hurts the eye, and in this latter case it differs little from the action of a drop of irritating liquid. It is a different matter when the mote is examined visually: the eye discerns its colour and shape with such precision that its indications can be expressed in words (i.e., in terms designating the given colour and shape). It is this *capacity to furnish sensory indications varying in form in accordance with the changed conditions of excitation* which distinguishes the higher sense organs from all other sensory surfaces; and the reason is to be sought in their more complex and more developed organisation. The simpler the apparatus that receives the stimulation, the more uniform the sensation, and vice-versa. By the number of adjectives by means of which man expresses the various aspects of sensations furnished by the sense organs we can easily judge varying degrees of their perfection. For example, olfaction and taste provide but three main categories of qualities: agreeable, disagreeable and acrid smells and tastes; but with the latter category we associate the intervention of pain sensations.

Tastes are further subdivided into sweet, bitter, salty (this adjective derives from the name of an object), and sour. Since there are no other special terms for designating degustatory sensations, the quality of any other taste is usually determined by the name of the object to which it belongs: for example, the taste of a hazel-grouse, the taste of wine, the taste of cheese, etc. The same is true of olfaction: here, too, while the sensations are highly diverse, there are no terms with which to designate them. That is why we say: the smell of mint, of a lily, of a cigar, of ammonia, etc. As to vision, it furnishes five categories of qualities: the outline of the object, its colour, size, shape and, lastly, its position relative to the body. Some of them include numerous specific forms with special designations; for example, the first includes a circle, an oval, a triangle, etc.; the second category—red, orange, yellow, etc.; the fourth category—round, cylindrical, three-edged, etc. Cutaneous sensations are still more varied, because they include, along with the four visual categories (except colour), also thermal sensations, the sensations of smoothness, roughness, hardness, elasticity and softness of the objects touched. But the diversity of the acoustic forms accessible to the human ear is, perhaps, greatest of all. Suffice it to say that a part of them—a considerable part—lack any special verbal designation (as, for example, in the case of the definition of colours); they can only be represented conventionally in the form of written symbols. These sounds, articulated into speech, are complex sounds, each being a definite acoustic image. It will be appreciated that the aggregate of all lexicons and of all dialects does not cover even a hundredth part of the wealth of existing forms; the lexicons contain neither the grammar inflexions nor the intonations of living speech, or the immense diversity of noises and inarticulate sounds with which Nature is replete Animals do not understand the sounds of human speech, but they are familiar with the noises in Nature and are able duly to appreciate them partly as a result of experience and partly by instinct.

Another feature of the higher sense organs is that the sensations which they provide are not as subjective as, for example, the sensations of pain or hunger; we relate them mentally to the external factors which cause them. In animals, judging by their motor reactions, resulting from the indications of their sense organs, these properties are directly connected with the capacity of the sensory mechanisms to become excited under the action of external factors. Thus, in dogs the olfactory sensations are hardly less objective than the visual and aural sensations. But this is not the case with man because his tactile sensations, the source of which is situated close by, are of an objective character, while his olfactory sensations are most likely of a subjective nature and are related to their external causes only by way of experience, through the medium of the other senses.

In any case the vital importance of the higher sense organs is determined by the foregoing two properties—by the differentiated nature of the impressions and their objectivisation.

*They are instruments by means of which the animal communicates with the external world.* From our point of view, it is by means of these instruments that the animal obtains sensory signals or signs from the external objects, the diversity of which depends on the level of development of the particular receptor organ. Whereas in the preceding categories the signals had their source in the body itself, here they come from the external environment. In most of the previous cases the result had the significance of a purely protective measure against influences that had already affected the body. Now its significance is much broader: coming from afar, the signals warn the animal and, being highly diverse, they can spark off not just one machine-like, uniform motor reaction, as in the preceding cases (for example, constriction of an orifice, closure of a valve, etc.), but a series of similar reactions. From this it follows that the latter appear only in response to those complex sensory signals which are exteriorised by us. When a sunbeam falls on our eyes it may evoke constriction of the pupils and the act of winking; it may compel us also to turn the head, etc. But this is not a reaction of the "optical apparatus". The sight of a wolf to the sheep, or the sight of a sheep to the wolf are precisely the kind of signals or sensory images we have in mind and which provoke in both animals motor reactions of an opposite nature.

It is hardly necessary to add that the sensations we are discussing here serve the organism only in a conscious way.

The services rendered by the higher sense organs, especially by sight, are far from being confined to those mentioned here. The capacity of the eye and of the motor apparatus of the eye-ball rapidly to grasp the shape and the relative positions of external objects enables the animal not only to displace its body, but to move very swiftly. It is due to the eyes that the animal can distinguish at a distance moving objects from immovable ones. Vision (spatial vision) is, therefore, regarded as *the main instrument of the orientation of the animal in space and time.*

Now, if we summarise what has been said concerning the services rendered by the higher sense organs and their relation to motion, their regulatory role becomes obvious, and the type of regulation, as far as all other traits are concerned, appears to be the same, manifesting certain complications only in particulars. In normal conditions the signals provoke expedient motor reactions exclusively through the medium of psychical activity, since the animal's consciousness attaches a certain meaning to the signals; that is why the link between the two halves of the regulator can be called a psychomotor link. A scarecrow, for example, frightens sparrows only for a time; later, due to observation and experience they no longer fear it. But the urge to micturate, which provokes a voluntary motor reaction, is bound to have a corresponding meaning also for our consciousness. Consequently, this circumstance does not signify any essential difference between the acts we are now considering and the preceding forms of regulation. All the more so, because some animals deprived of the cerebral hemispheres, i.e., so to speak, of their consciousness, still preserve the capacity to appreciate the most elementary spatial relations and are able, for example, to avoid objects which they encounter on the way.

Another complication is that in the sphere of the higher sense-organs signals often remain without motor response or at least without any expedient motor reaction. For example, being in a state of rest, the animal, apparently, is absolutely indifferent to the surrounding habitual objects, though it might seem that these impressions should act as signals and provoke corresponding reactions. Why, then, are there no reactions? If we could answer this question, we could answer also another one of a more general nature, namely: What characterises the state of the central nervous system which corresponds simultaneously to the calm and rhythmic flow of the acts of consciousness, i.e., sensations, and to the motor quiet of the body? Alas, our knowledge in this respect is still very limited. All we know is that when the mind is absorbed in a meditation which does not give rise to any movements in the body, the sensory signals, too, are suppressed and do not reach or barely reach the consciousness Consequently, it may be assumed that an inhibitory state of the motor apparatus of the body corresponds to the motor quiet.

Lastly, there is one more complication in the motor part of the regulator. Hunger, for instance, can force the animal to its feet and impart to its search a more or less emotional character, *but it lacks the elements which could impart a definite direction* to the animal's movements and modify them in conformity with the conditions of the locality and the fortuities of all possible *encounters. In these cases, i.e., when the locomotor apparatus* is functioning, the sensory signals act not on a certain group of muscles, as when we, at rest, deliberately bend the fingers or the knee, etc., *but on the nervous mechanism of locomotion* For this reason the act of locomotion, which in its primitive form is automatically regular, acquires a considerable degree of elasticity; and since the modifications of its activity are strictly co-ordinated with the purposes of the locomotion (escape from an enemy or in pursuit of the prey) and with the conditions of the locality, the movement acquires a rational character, as if the animal were deciding whether it is expedient to turn, to jump, to slow down, etc. But it is obvious that when the animal is in pursuit it has no time for reflections of this kind. Consequently, the expediency of its movements shows that the link between the signals and the regulatory impulses in locomotion must be very close indeed.

In other words, from this point of view too the difference between regulations of varying kinds is not fundamental.

Thus, the vital importance of sensation, within the limits in*dicated in the beginning of this lecture, is determined first by* its relation to the effector organs, by its faculty to provoke expedient reactions and, second, by the qualitative aspect of the sensory products—*the capacity of the sensation to become* modified in accordance with the changing conditions of excitation. In the first sense, sensation is one of the principal instruments of self-preservation, in the second, it is an instrument of communication with the objective world—one of the main foundations of the psychical development of man and animals. In its first aspect sensation belongs wholly to the domain of physiology, in the second it links up our science with psychology.

During this term I shall examine only the first aspect of sensation, in the next I shall expound, within the limits of physiology, the theory of sensation as an instrument of communication with the objective world. This year our special study will be the nervous mechanisms linking the skin with the skeletal muscles; next year we shall concentrate on the eye.

## PHYSIOLOGICAL STUDIES[91]

[Selected passages from separate chapters]

### PHYSIOLOGY OF THE NERVOUS SYSTEM

The dependence of the conscious acts of sensation and of the movements of the body on the nervous system is the main and the most striking feature in that vast and at first glance extremely varied picture of nervous phenomena. Anatomically, this dependence is manifest in the fact that from the central areas of the nervous system, from the brain and the spinal cord, nerves radiate *to all the sensory points of the external surface of the body* (i.e., to the skin and to all the so-called higher sense organs—gustatory, olfactory, optical and aural) and *to all the skeletal muscles.**

Physiologically, this dependence is expressed in the paralyses of sensation and motion when the integrity of the areas of the central nervous system from which the corresponding nerves issue *is violated or when these nerves are destroyed.* For example, blindness may set in as a result of the destruction of the middle divisions of the brain or of a section of the optic *nerves; paralysis of sensation and motion in the arm may be* caused by the destruction of the cervical enlargement of the spinal cord or by a section of the axillary nerves.

*This can be explained in the following way.*

When a certain external impulse evokes a sensation in the consciousness, this process, despite its rapid development, rests *on a successive series of changes in the states 1) of the sensory*

* Nervous pathways extend from the central areas of the nervous system to other organs of the body, in addition to those mentioned above; but here we speak only of the latter, because the processes taking place in these organs are more comprehensible and are most useful for making the initial acquaintance with the nervous system.

surface on which the external impulse exerts the definite influence, 2) of the nerve issuing from it, and 3) of the centre connected with the particular nerve. The external impulses evoking this sensation are generally known as *excitatory agents* or stimuli, and the changes evoked by them in the states of different parts of the sensory apparatus are known as *excitations*. For example, the normal excitatory agent acting on the eye is light; when light exerts this action, we say that it passes through the transparent media of the eye, excites the retina (the end of the optic nerve), the optic nerve and the optic centre. So long as the pathway leading from the surface to the nervous centre is intact, the apparatus functions normally. But the moment any upset takes place at any point—whether on the surface, in the nerve, or in the nervous centre—sensation ceases. Similarly, any movement of the arm, leg, trunk, etc., is based on a series of changes taking place in the states 1) of the nervous centre, 2) of the motor nerve issuing from it, and 3) of the muscle connected with this nerve. These changes, too, are called excitations. In the sensory apparatuses the excitation proceeds from the periphery of the body to the centre and is transmitted along the nerve centripetally, while in the motor apparatuses it is transmitted centrifugally. Any violation of the integrity of the pathway leads in the former to the loss of sensitivity, and in the latter—to a paralysis of motion.

Thus, any sensory apparatus of the body consists of three parts: a surface which perceives the external impulses (*a* in the attached scheme); a nerve or conductor leading from the surface to the centre (b), and a centre (c) on the activity of which the sensation depends [Fig. 17].*

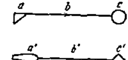

Fig 17

Any motor apparatus consists: of a centre (c') from where the impulses proceed centrifugally along the nerve (b') which here, too, plays the role of a conductor of excitations, to the effector organ (*a'*), i.e., muscle or gland.

Another, no less striking, feature in the picture of nervous

* The numeration is Sechenov's.—*Ed.*

activity is the diversity of the relationships between sensation and motion.

From everyday experience we know the following.

When the higher sense organs function exclusively as means of mental communication with the external world, their functioning may not be reflected in the sphere of motion. For example, listening attentively or observing closely the things taking place around us, as well as reflecting on things seen or heard can be purely sensory acts, i.e., not accompanied by movements.*

Conversely, the movements of the normal person never proceed independently of sensation, no matter whether they are involuntary or performed with a certain purpose; in both cases they invariably follow some mental movement. Without this condition, man's movements would be aimless and senseless.

Consequently, *there must be some kind of a connection between the sensory and the motor apparatuses of the body;* this connection is apparently located in the central nervous areas (i.e., in the brain and spinal cord), between the points of excitation of the sensory and motor nerves. In our scheme it is seen as a dotted line drawn between the centre of sensation (c) and that of motion (c′) [Figs. 18 and 19].

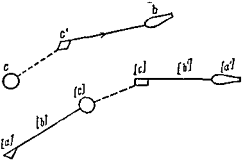


Fig. 18, Fig. 19

Although the nervous phenomena in which sensation is combined with the activity of the effector organs are most varied in appearance, in the vast majority of cases, *namely, when the functioning nervous apparatus includes a sensory surface and a conductor* leading to the nervous centre (as shown in our scheme), they have the following common features:

1) the act always begins with an external impulse stimulating

* I say "can be", because any mental state is usually accompanied by a certain mimic expression, or, in the final analysis, by a movement.

the sensory surface and ends with the activity of the effector organ;

2) the beginning and the end of the act are always co-ordinated in order to achieve a definite aim—to protect the body as such, and its parts.

To elucidate the second of these propositions I will take the liberty of making a small digression.

If we leave aside the processes of reproduction and confine the sphere of man's psychical activity only to manifestations based directly on the instinct of self-preservation, we can regard the animal organism as a special kind of machine the sole purpose of which is, in the final analysis, to maintain the individual existence, or to preserve the anatomical and physiological integrity of the body. The nervous system, as a part of this body, functions, naturally, also as a machine, and its purpose, too, is to maintain the integrity of the body.

In this sense all phenomena in which sensation is co-ordinated with motion or juice secretion are associated with the functioning of the special apparatuses which make up the animal machine. Each of these apparatuses taken as a whole, i. e., in connection with the effector organ, is a protector of the body, while its nervous part regulates the effector organ. Thus, in the above-mentioned sensory-motor scheme the entire apparatus, from *a to a′* inclusive, acts as a protector of the body, whereas its part, from *a* to *a′* excluding *a′* acts as a regulator of the effector organ *a′*.

The protective significance of these apparatuses is elucidated in the introduction to this book where it is also said that each apparatus consists of a signalling part which, so to speak, warns the body of irregularities in the state or operation of the machine, and a motor part which eliminates these irregularities. To this the following should be added.

As regards their structure, the nervous regulators of the animal machine belong to the category of automatic regulators. In machines designed by man regulators of this kind are set in motion not by the hand of the operator but by impulses from the machine itself when irregularities appear in its work; thus the impression is created that the regulators function by themselves.* It is clear that under these conditions the regulators of the animal machine must be highly sensitive to any irregularities in its state or operation; a few examples will show that this property is contained in their signalling parts. In the elementary forms of the nervous apparatuses the signals of the regulator do not reach the consciousness. Their sensitivity to changes in the state or operation of the machine fully corresponds to the "sensitivity" of a physical instrument, for example, a thermometer, a balance, etc. Regulators of this kind are known as *reflex apparatuses*, and the entire process, from beginning to end, is known as a *reflex*. The forms of the regulation can be best described with the help of examples.**

These data show that between the influences of the sense organs upon the movements and the activity of all the regulators described above there is a real gulf. It might seem that the only thing they have in common is that in both cases the motion is co-ordinated with sensation, thus generating activity which is useful to the organism; but what an enormous difference in the forms of their interconnection! The sensations transmitted by the sense organs to the consciousness serve as sources of motion not directly, but through the psychical activity, insofar as the consciousness of the animal attaches a definite meaning to the signal. The sight of the scarecrow, for example, gives the sparrow a feeling of horror with all its motor consequences, but the feeling does not last long; as a result of observations and experience the sparrow soon learns not to be afraid of the same image. When an animal adjusts its run to that of the prey which it is chasing and to the conditions of the locality, its movements, which are directed by vision, seem to be of a deliberate character, as if the hunter animal were capable of reasoning and deciding when to turn, when to jump or to slow

* A classical example of this kind of regulator is Watt's safety-valve used in steam-boilers. The valve regulates the pressure in the boiler by enlarging the orifice through which the steam escapes when the pressure exceeds a definite limit.

** At this point Sechenov repeats textually a considerable part of his *first lecture in the Moscow University on September 6, 1889*, beginning with the words: "The first category is formed by the activities..." (see p. 529) and ending with the words: "*...orientation of the animal in space and time*" (see p. 542) —*Ed.*

down. In short, the influence of the sense organs on motion resembles the higher manifestations of the nervous activity which the physiologists designate as "psychomotor activity". These peculiarities clearly distinguish our last category of regulations from all the preceding ones, and yet there is no gulf between them. Even the necessity, say, to evacuate the urinary bladder, being the signal for a voluntary motor reaction, must acquire in the animal's consciousness precisely this meaning and no other. At the same time we know that a few hours after birth many animals (goats, calves, colts, and others) are able to regulate their locomotion by means of vision. Lastly, direct experimentation has proved that some animals deprived of the cerebral hemispheres, or, so to speak, of consciousness, are still able to appreciate the significance of the simplest spatial relations and can, for example, avoid objects in their way. Consequently, optic motor acts may assume a psychomotor character even when the ability of the animal to reason on the basis of life experience is fully excluded.

Thus, the regulation of movements by vision repeats to some degree what we have seen in such simple phenomena as the act of micturition: in both cases the action of the regulator may take place outside consciousness and will, whereupon the act assumes a machine-like character or it is accomplished with the participation both of the former and the latter and thus assumes a psychomotor character.

There is no doubt that the domination of the "principle of co-ordination of movement with sensation" goes beyond the bounds of the phenomena described here (regulation of movements by the higher sense organs). From here it undoubtedly spreads to the sphere of the special instincts (predominantly in animals) and to the so-called acquired movements (mainly in man). This can be demonstrated quite easily. Instincts always derive from forms of sensation of an irresistible character, say, hunger; the other part consists of a complex series of movements aimed at satisfying the given requirement. Acquired movements, in their turn, develop solely under the influence of vital requirements; when fully developed, they differ from instinctive movements only in the greater mobility of the link between motion and sensation. Here again, as in the functioning of the regulators mentioned above, the separating factor is the will with its ability to produce motion deliberately, without any corresponding sensory stimulus, or to suppress it despite the action of the latter.

In all probability the domination of our principle extends even farther, to the point at which sensation turns into a *motive* and an *aim*, and motion into *action*; but this domain lies beyond the boundaries of physiological research; strictly speaking, the latter stops at the control of movements by the higher sense organs because physiological experience has not yet been applied to the sphere of special instincts and has only slightly touched upon acquired movements.

Now that we have considered the category of phenomena which involve sensation at different stages of development, we should, naturally, pose the following question: Do all the nervous apparatuses derive from the co-ordination of movement with sensation, and if not, do they, in essentials, correspond to the type of regulators of work? As a rule we answer the first part of the question in the negative by isolating into a special category of "automatic activity" those nervous processes the sources of excitation of which have yet to be established or which obviously do not derive from any sensory surface; as to the second part of the question, I believe it should be answered in the affirmative.

A basic condition for the action of a nervous apparatus as a regulator is that it should be sensitive to all the changes which take place in the state or operation of the machine and which it is called upon to eliminate; the question as to how it does this is a secondary matter. We know, for example, that some areas of the nervous centres can be excited by the blood flowing through them; at the same time it has been proved by direct experimentation that these areas engender influences which control the respiratory movements, i.e., the work by means of which the respiratory (gaseous) exchange between the blood and the body is maintained at a definite level. It is clear that the entire nervous apparatus of respiration with all its accessories, the function of which is to control the gaseous exchange, plays the role of a regulator; and yet its autonomous activity is determined by impulses not from the sensory surfaces but from the centres themselves, under the influence of blood. We do not know whether it is the central formations directly transmitting the motor impulses that become excited, or whether the respiratory centres include formations equivalent to the sensory centres and the blood acts on the latter. If we bear in mind that on the basis of the available experimental data the respiratory movements are engendered by an almost imperceptible and continuous sensation of suffocation (in the same way as nictitation is engendered by imperceptible sensory influences on the surface of the eye-ball), we can assume that there are equivalents of the sensory centres.

Another example relating to the category of automatically acting apparatuses is the heart, considered apart from its associations with the neuraxis. There can be no doubt that the nervous apparatuses (embedded in the walls of the heart) also play the role of regulators; these nervous apparatuses not only generate or transmit the motor impulses, they co-ordinate in addition the contractions of the auricles and ventricles, ensuring thereby a regular alternation of their activity. We do not know precisely where and how the motor impulses are formed; but we do know that an essential role in the work of the heart is played by its extreme sensitivity to various phenomena—mechanical, thermal and chemical. This circumstance suggests the idea that cardiac movements are caused either by direct excitations of the motor centres or by indirect excitations emanating from the equivalents of the sensory surfaces.

These examples enable us to see the external features distinguishing the category of automatic activities from the previously described reflex type. Whereas phenomena of the latter type are of a sporadic nature, taking place under definite conditions and often at irregular intervals or even accidentally, apparatuses of the first kind function continuously, like real automatons, extending their reserves of energy gradually, little by little. But the human heart, respiratory muscles, sphincter of the urinary bladder or of the rectum, etc., sometimes function for more than a hundred years; consequently, there can be no question here of a form of activity in which considerable reserves of energy are spent gradually; it can only be a question of constantly replenishing small losses of energy and of the way in which the motor impulses are formed, i.e., whether they result from the periodical activity of the organ or whether they are caused by a continuous tonic excitation. In other words, in the category of "automatic activity", too, the centres act solely under the influence of external stimuli and co-ordinate the work of the effector apparatus with these impulses.

Thus, to sum up, all the known nervous acts are divided according to their origin into the following categories:

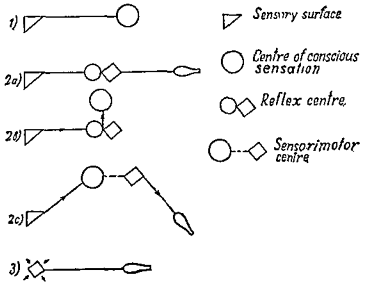


Fig. 20

1) Acts of sensation (sight, hearing, touch, etc.),

2) Acts of the reflex type: a) simple reflexes, b) reflexes *complicated by conscious sensation, c) sensorimotor acts,*

3) Acts of a central origin.

The diagram indicates the principal parts of the apparatuses enumerated above (Fig. 20).

The diagram shows that the nervous part proper of these apparatuses (i.e., the regulators) includes the surfaces which receive external impulses, the nerves (signalling and motor) and the centre. That is why the physiology of nerves should consist of two parts: general and special.

The first should describe the common aspects of the receptor surfaces, the common properties of the nerves and the common aspects of the nervous centres. But our knowledge of the sensory surfaces and of the nervous centres is so insignificant that the so-called general physiology of the nervous system is actually reduced to physiology of the nerves.

## THE FUNCTIONS OF THE HEMISPHERES

From the foregoing description of the functions of the midbrain the reader will appreciate that although a decerebrate animal is a wonderfully constructed motor apparatus able to protect itself against external acts of violence, to stand, move and even avoid obstacles in its way, it is but a pitiful sensory automaton compared with the normal animal, i.e., the animal whose brain is intact. Without the hemispheres, sensation, with a single exception (remnants of vision), is merely a formless link in the design of the motor apparatus and for this reason bears a close resemblance to what we designate as sensitivity in man-made apparatuses; in the normal animal it assumes the incomprehensible forms known to us as sensations of light, smell, sound, etc.

The animal not only sees, hears and feels by touch; all that is seen and heard appears to it in the form of images, and the animal, so to say, appreciates the significance of these images for its own existence, partly by instinct and partly by experience. Some of these sensory influences leave the animal totally indifferent, others, on the contrary, attract it, still others evoke fright and, for this reason, are avoided by the animal. In short, sensation which in a decerebrate animal is formless, acquires an imaginative, conscious* and intelligent character when the cerebral hemispheres are intact.

In the absence of the hemispheres, sensation is combined with motion in such a uniform way that all the phenomena of the skeletal mechanics are, naturally, divided into three cate-

* Possibly sensation is formless when it is not of a conscious character and vice versa. If this could be demonstrated beyond doubt, then the so-called "conscious character" of sensation would ensue from its having some form or other

gories: defensive, respiratory and locomotor movements. In the presence of the hemispheres, there appear, along with the above-mentioned combinations, new ones which are so diverse in form and content that the acts are already designated as "actions". Such are the various instincts with all their motor manifestations. At this stage the sensorimotor combinations still resemble the machine-like character of reflexes and locomotion, since the instinctive motive is always expressed by uniform external actions irrespective of any change in the condition of the action. But in addition to these phenomena the normal animal manifests a multitude of others, where the actions are so expedient that the animal gives the impression of being able to reason. It not only distinguishes the conditions under which it acts, but chooses the proper mode of action, depending on the circumstances; it exhibits, so to say, ingenuity and resourcefulness. And that is why we attribute to animals, by analogy with man, intelligence and will.

But this is not all. Instincts are inherited by the animal because they are transmitted from generation to generation in an invariable (?) form. The capacity of the animal to adapt its actions to the changing conditions is acquired solely by experience and is regarded as not being hereditary. The instinctive combinations of sensation and motion are due to a special organisation of nervous mechanisms every bit as innate as the nervous mechanism of walking in many animals. There is no such organisation, of course, for actions that are governed by intelligence and will, owing to the variability of these actions. Here, the combining of sensation and motion into a variably acting nervous mechanism takes place only in the course of individual life. To make this combination possible the brain must have certain plasticity, and this it has. This is proved by the highest and most remarkable of all the capacities innate in animals with intact hemispheres—the capacity to learn. Many birds, for example, can be taught to speak. The untrained dog neither gives the paw when asked to do so, nor will it stand on its hind legs; but in the circus trained dogs walk both on their hind and fore legs, move up and down a ladder forwards and backwards, balance on a rolling ball, etc. Horses learn to change their gait at a signal of their trainers, to bow, to move on the hind legs, to assume unnatural postures, etc. Of course, these movements are acquired by animals solely under the action of the sensory factors, but they are of definite interest to the physiologist for the following reason. They show that peculiar and unusual combinations of sensation and motion can develop in the organism of the animal owing to the cerebral hemispheres; these movements explain the emergence in the animal of sensorimotor combinations that are acquired not in the circus, but in life, under the influence of everyday sensory stimulations. The mode of life of animals of one and the same species is on the whole similar; but not all animals are equally clever and not all of them have the same character and the same habits; it is common knowledge, however, that intelligence, character and habits leave their imprint on the actions of animals. The things that distinguish the mature wild animal from the young as regards comprehension and resourcefulness, or that distinguish a "beast" which has been hounded from one which has not are the products of experience.

And so, generally speaking, the physiologist believes that the following four categories of phenomena depend on the integrity of the cerebral hemispheres: instincts, conscious sensation, conscious movement and the co-ordination of the two last-mentioned into conscious action. It would be wrong to think, however, that every form of instinct and of conscious sensation or movement results solely from the activity of the cerebral hemispheres. In complex acts of sensation only those aspects which we designate as the quality of sensation (light, smell, taste, etc.) and its conscious and reasonable character, are attributed to the activity of the cerebral hemispheres. The same is true also of the movements dependent on the activity of the hemispheres; in these movements the share of the hemispheres is but those aspects thanks to which the movements are regarded as products of the intelligence and simultaneously as manifestations of the will.

Unfortunately, the time for the physiological, i.e., experimental, study of the animal instincts has not yet come; and for this reason we shall not dwell on the matter. We are unaware of the processes that take place in the hemispheres when we perceive light, smell, etc., nor of the process that determines the conscious character of the sensation. Hence, the experimental study in this sphere has so far been confined to ascertaining the sites or sections of the hemispheres on which the above-mentioned traits of sensation depend. As regards voluntary movements, the situation is somewhat better, thanks to the creative elucidation of this question by *Helmholtz.*

Even the few facts known to us thanks to Helmholtz's research are of such importance that it is essential to consider the question of the relationship between will and the movements of the body.

If we recall all the known cases in everyday life when will *influences our movements, it might seem that the power of* will extends to almost all the motor organs of the body, or at least to all the skeletal muscles and to some of the muscles of the cavitary organs. For instance, we can wink, cough, sneeze, bring together or tense the vocal cords (in singing) at will or refrain from winking, coughing or sneezing and suppress the spasms of the laryngeal muscles. We can reproduce and suspend respiratory movements at will. The abdominal musculature is also subordinated to our will, to say nothing of the arms and of the movements of the legs in walking.* In a word, the power of will over the skeletal muscles seems to be boundless, and its action is twofold—it easily produces movements and as easily suppresses them.

However, it is not difficult to see that the power of will over the muscles is far from being boundless and that in many cases it is conventional. The respiratory muscles with their nerves in the right and left halves of the body are two separate systems; however, nobody can voluntarily respire or sing by using only one half of these muscles. In the case of the eyes the corresponding phenomena are of an even more pronounced character. We can easily lift or drop at will both eyes simultaneously, turn them to the right or to the left and move them towards each other. The same movements can be performed by each eye separately (when the other one is closed); the explana-

* This is best illustrated by the following: a person who can write with his right hand, can write also with his left hand, as well as with both feet and by moving his head and even the trunk.

tion is that each eye has its own muscles which move it upwards, downwards, to the right and to the left. But no one can look with one eye to the right and with the other to the left, or with one eye upwards and with the other downwards, although there are separate muscles with separate pathways for such combined movements. The point is that owing to the necessity to ensure distinct vision (details concerning the eyes can be found below) the eyes are accustomed from childhood only to those combined movements over which will has definite power; as to abnormal combinations (one eye looking upwards, the other—downwards, or one to the right, the other—to the left), they are not formed, nor can they be formed, because they are not necessitated by life. This is particularly clear from the following. In everyday life we look in front of us or slightly downwards much more frequently than we look upwards. Our optical axes are most frequently inclined when we perform manual work. In this case, we usually look at something close at hand, with the result that there is a more or less considerable convergence of the optical axes, while looking upwards is usually associated with distant vision and requires only a slight convergence of the optical axes. This explains why it is easy to converge the eyes when the optical axes are inclined and very difficult to do so when we look upwards. This also explains the power of our will over the movements of the arms, especially of the right one: of all our limbs the arm is exercised most in highly diverse movements, being the body's chief effector organ. On the other hand, we know from the phenomena of ataxia that the power of will even over the arms and legs is of a conventional character: the moment the legs are deprived of the sense of support, or muscular sense which accompanies the movements, will loses its power. The same is true of swallowing: it is possible to perform at will five or six swallowing movements in rapid succession, but the seventh or eighth attempt will inevitably fail. The explanation is that swallowing movements are possible only when there is saliva in the mouth which is the object of swallowing; but it is impossible when the mouth is dry, because the successive phases of swallowing are determined by the sense which accompanies the movement of the object to the pharynx and into it.

From what has been said it follows that the so-called *voluntary movements* are actually *habitual movements acquired as a result of vital necessity*. Movements that are not necessitated by life cannot be formed, even if there are the corresponding motor elements.* No matter how simple the voluntary movement may be (for example, when we extend the arm to take up a pen, move the ink-pot, etc.) it is always based on a definite aim of which man is conscious, i.e., on a certain psychical movement; that is why voluntary movements are rightly called in physiology *psychomotor acts*.

The influence exerted by will in suppressing movements and impulses (coughing, sneezing, etc.) is self-evident, and its part in the nervous life of man does not call for any demonstration. But we have stated above that the existence of factors inhibiting the movements of the skeletal muscles in man has not been experimentally proved. How, then, are these two effects achieved? In view of the fact that men and animals can move forwards and backwards, and that for every movement of the head, trunk, leg or arm in a certain direction there is in the body an antagonistic movement in the reverse direction, both being equally subordinated to will, one might think that the suppression of movements and motor impulses is due solely to the interplay of antagonists. Unfortunately, nobody has proved this experimentally for those cases in which, despite the obvious existence of motor impulses, the body remains at absolute rest. For this reason, the phenomena can so far be explained in two ways and the choice of the explanation depends on whether it is inhibition or the antagonistic action of the motor elements that proves to be more applicable in the given case.

By analogy with what we already know about the pauses of the heart during diastole, about the respiratory movements in the phase of exhalation and the suppression of movements in the sphere of the skeletal muscles of the frog, we are entitled to assume that, whenever there are pronounced motor impulses which man suppresses by the power of his will while

* Man has special muscles for moving the helices yet he cannot move his ears voluntarily.

remaining at absolute rest, it is inhibitory factors that act in his body. Everyone knows how the whine of the bullet acts on the seasoned soldier and on the raw recruit. The recruit, so to speak, bows to each bullet, whereas the veteran gives the impression of being absolutely indifferent to the whine of the bullet, although, of course, the instinct of self-preservation induces him to bend down too. Some people endure acute pain *during an operation without screaming and without straining the muscles* of the body; of the same nature are all other cases when people display *self-possession* in critical circumstances. Something similar is observed in animals. When the trained dog stops and points out the game or when a cat lies stock-still before springing upon the prey, they are giving striking examples of suppressed emotional motor impulses; but here the suppression is best explained by the action of antagonists, because the body of the animal is highly taut. This has nothing in common with the state of rest of all the motor elements evoked by inhibition. Along with the will suppressing motion, there are cases when influences of a similar inhibitory nature proceed from the hemispheres independently of the will. For example, *intense intellectual activity suppresses motion and renders man* insensitive to influences which in other circumstances would impel him to move; perhaps, this also explains the involuntary suppression of movements (even respiratory movements) by man or animal when listening attentively to a sudden sound, or looking intently at a certain object.

Since in all these cases suppression of movements is not accompanied by the slightest straining of the muscles which suspend the movements, the suppression is effected exclusively *by inhibitory agents, and vice versa. I repeat: there have been* no direct experiments proving the correctness of these interpretations, except, perhaps, the following phenomena which were observed on animals subjected to brain operations and which are interpreted by Goltz* as the effects of inhibitory influences. In dogs deprived of the frontal lobes of the hemispheres Goltz observed a sharp intensification of cutaneous-mus-

* The leading authority in Europe in the field of cerebral operations on dogs.

cular reflexes on the side of the lesion after the morbid post-operation fits had terminated; his explanation is that the operation removes the mechanisms which inhibit the spinal reflexes. Conversely, the seemingly paralytic phenomena which directly follow the lesion of the hemispheres and which gradually disappear with the recovery of the animal, are regarded by Goltz as effects caused by irritating the surface of the wound, i.e., by exciting the inhibitory influences.

This brings me to the end of my brief description of the main features of the activity of the cerebral hemispheres in animals and in man. Of course, all that has been said in no way exhausts the entire sum of the facts observed, but an exhaustive examination of them is not the purpose of the present essays; our purpose is to indicate those features of the cerebral activity which provide a clue to an understanding of the phenomena taking place in animals subjected to brain operations and in persons with morbid lesions of a particular part of the cerebral hemispheres. These criteria enable me to proceed to a description of experiments performed on the hemispheres; however, it will be necessary to preface this with some preliminary data concerning their structure and their relation to other parts of the cerebrospinal axis.

## THE SENSE ORGANS

The sense organs of the animal body consist of the following three parts: the receptor or signalling surface which receives the sensory impulses, the conductor which leads from the receptor surface to the centre, and the centre itself. The higher sense organs, i.e., the organs of sight, touch, hearing, smell and taste, while no exception to this rule, display, however, a number of features resulting from their specific role in the life of the animal. They are instruments of the animal's sensory communication with the objects of the external world; for this reason their receptor surfaces which perceive the external impulses are located on the outer surface of the body, being more or less exposed: the olfactory surface is located in the upper and middle parts of the nasal cavity, the gustatory—predominantly on the upper surface of the tongue, the tactile—in the skin, the visual—at the bottom of the eye-ball, and the aural—in the cavities of the ear labyrinth. Another feature is that each of these receptor surfaces (except the cutaneous) is relatively small and all are located in the head, which is the anterior and mobile extremity of the body. This is because of the functions of the sense organs: through them the animal receives from the external world sensory signals which guide it in all its actions and movements.*

When the animal is on the move, its head is always in front, and is the first to encounter the impulses falling on the body from various points in space. This location in the anterior extremity of the body is particularly important for those sense organs by means of which the animal receives sensory signals from afar, namely, the visual, aural and olfactory organs. Equally understandable is the advantage of their location in a mobile part of the body: because the head can turn to the right and to the left, upwards and downwards, the animal can orient its sense organs directly towards the impulses emanating from various points in space.

As to the detailed structure of the receptor surfaces there is a common feature which should be mentioned. In the event of a sensory nerve being divided, say, into 15,000 branchings when reaching the receptor surface, the latter is formed of 15,000 nerve-ends. Entering into the composition of the peripheral organ, each of these branchings, i.e., each nervous fibre or fibril is sometimes held up on its way to the free surface of a nerve cell; but it always terminates in this cell or in a metamorphosed cell with a special appendage which is actually the end of the nervous fibre or fibril. This imparts to the receptor surface the character of a mosaic composed of microscopic elements; and each of these elements is a functional as well as a form-making unit of the receptor surface. These relations are shown in the scheme attached [Fig. 53], where $n$ designates the branchings of nerve $N$, $a$—the terminal nerve cells and $b$—their appendages.

* However, the location of the gustatory surface in the head has nothing to do with the head being the anterior extremity of the body; the reason is that the beginning of the food-receiving cavity, at the entrance to which lies the organ of taste, is located in the head.

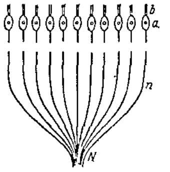


Fig. 53

This functional mosaic can be best observed in the skin. For this purpose, the investigator applies the legs of a pair of compasses to different areas of the skin and tries to find the minimal space between the legs of the compasses needed to obtain two distinct sensations. It appears that this minimal space varies for different areas of the skin; above this limit the separateness of the sensations is the more distinct the larger the space between the legs of the compasses; below it, the contact of the legs of the compasses with the skin is perceived as a unified sensation. This can be explained in the following way. When the legs of the compasses act upon two adjoining elements of the mosaic (*a* and *b*) a unified sensation results; but given a non-excited area (c) between two elements subjected to tactile stimulation, the sensations produced by the legs of the compasses do not fuse and their separateness is perceived the more strongly the greater the number of the non-excited elements between the legs of the compasses *(d, e, f)* [Fig. 54].

The nerve appendages have a twofold role. When the receptor surface is subjected to the normal action of a stimulus which excites the nerve directly, the appendage is merely a more sensitive part of the sensory apparatus than the conducting part; but when the surface is stimulated by agents that do not act on the nerve directly it plays the role of a transformer, i.e., an apparatus converting the perceived movement from one form, which does not excite the nerve, to another which acts on the nerve directly. From this point of view, the ends of the aural and tactile nerves are not in need of transformers, because

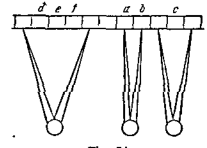


Fig. 54

the mechanical shocks that normally act on them are capable of exciting the nerve directly; here the effects of excitation are explained solely by the greater excitability of the nerve ends. As far as the eye is concerned things are altogether different; the optic nerve is not excited by light directly—proof of which is the existence of the so-called blind spot of the retina (see below). But light is a normal stimulus for the organ of sight and, what is more, the eye is sensitive to light. Consequently, the movement of the light must be converted into another form to become a stimulus for the nerve, and this is effected by the nerve appendages in the retina. The same is true of the ends of the gustatory and olfactory nerves.

Thus, generally speaking, the function of the terminal appendages of the sensory nerves is either to reinforce the action of the weak normal stimuli or to convert the excitatory movements from one form into another.

The reaction of the skin and nerves of the frog to aqueous solutions of acids is a striking example of the greater sensitivity of the nerve ends compared with that of the nervous trunks. In the decapitated animal, direct stimulation of the cutaneous nerves by means of a mixture consisting of one part of concentrated sulphuric acid and three parts of water does not produce any reflex movements, whereas skin reflexes are easily provoked by a mixture consisting of one part of acid and 1,000 parts of water. In man the ends of the gustatory nerve are still more sensitive: a distinct sensation of a sour taste is provoked by a mixture consisting of one part of acid and 10,000 parts of water.

The second component of the sensory apparatuses—the nerves connecting the receptor surface with the centre—has no specific structural and functional features; these nerves are conductors of excitation in the ordinary sense and do not differ from other nerves.

The role of the third component of the sensory mechanisms—the sensory centres—can be defined as follows: its activity is indissolubly linked with the sensations of light, sound, smell, etc. Proof of this is the fact that sensation is fully lost when the corresponding nerves are transected or when the corresponding centres are destroyed. Unfortunately, our knowledge of the structure and properties of the sensory centres is so scant that there still is an unbridgeable gulf between their activity and the acts of sensation. The limited facts we know have been mentioned in connection with the description of the functions performed by the cerebral hemispheres.

Such, then, are the main features of the structure of the sensory mechanisms. Now I shall pass to the question of their excitation by normal agents.

Of prime importance here is the phenomenal sensitivity of our sensory mechanisms.

The experiments carried out by *Valentin* showed that the presence of 1/2,000,000 mg. of attar of roses in 1 $cm^3$ of air (the mass of the attar of roses, as we know, does not consist of odorous substance!) imparts to the air a pronounced scent. An open balloon with a capacity of 55 litres remained odorous for 3 months after being subjected to an admixture of 5 mg. of oil of cloves. It is not mere chance that the physicists have long used these facts to prove the extreme divisibility of matter.

The excitability of the gustatory nerves on the surface of the tongue is not as striking as that of the olfactory nerves, but, expressed in measures, it sometimes reaches fantastic dimensions. For example, one drop of acidified water (one part of acid per 10,000 parts of water) produces a distinct acid sensation on the tongue, although the drop contains only a bare 5/1,000 mg. of acid, and the nerve is excited not by this quantity but only by the part of the drop absorbed during the first second.

We have already seen that the sensitivity of the motor nerves to mechanical shocks is very high; yet it is insignificant compared with any deliberately slight touch to the skin (for example, with a hair) which suffices to engender a tactile sensation. In the silence of the night even the slightest touch to some parts of the helix produces the sensation of noise. Consequently, the aural nerve is every bit as excitable as the tactile one.

Lastly, about the sensitivity of the eye to light; here, as in the case of photographic plates, the decisive thing is not only the photometrically measured quantity of light penetrating into the eye, but also the duration of its action. In this respect experiments with the illumination of small objects, for example, letters of the alphabet, by momentary electric sparks in the dark and their simultaneous recognition give a clear idea of the immense sensitivity of the eye, since the illumination lasts but several millionths of a second and, besides, only an insignificant part of the light of the spark penetrates into the eye.

It is clear that due to this phenomenal sensitivity of our sensory mechanisms, the effects produced by them cannot but vary greatly, depending on the conditions of the excitation; in point of fact we see that the strength of a sensation experienced at any given moment is determined by the following four factors: the state of the organ prior to the excitation, the strength of the stimulation, the duration and extensiveness of its action. The following generally known facts illustrate the first of the above-mentioned influences: if we immerse the hand first in warm water and then in cool water, the latter will seem to be very cold, and vice versa; the light of a faintly illuminated room seems dazzling after an absolutely dark room, and vice versa. These quantitative modifications of sensations by contrast are based on the following property of the sensory mechanisms: the greater the excitation of the organ, the less sensitive it is to the effects of excitation of the same nature, and the more sensitive to excitations of an opposite nature. Hence, when a stimulation of constant intensity is of a protracted character, the sensation, after reaching a high level at the first moment, begins to decline, and the decline is all the more rapid the stronger the excitation. For the same reason the action of an intermittent stimulation is generally stronger than that of a continuous stimulation. Lastly, the effect of the extensiveness of the stimulation can be defined as follows: the larger the surface upon which the stimulation acts—other things being equal—the stronger the sensation.

The sense organs furnish the organism with sensations not only of differing intensity, but predominantly of different quality. It is by means of the sense organs that man and animals receive sensory signals from the external world and these signals vary in greater or lesser degree depending on the difference between the objects. Thus, the olfactory sense furnishes the consciousness with a vast category of diverse odours, the organ of hearing—by an infinite multitude of simple, complex and articulated sounds, the eye—by a similar variety of visual impressions, etc. For the animal these signals have a twofold importance. By means of them it makes the acquaintance of objects of the external world and it is guided by them in all its actions. Smell and hearing help the animal to distinguish at a distance a prey from an enemy; sight and touch guide the animal in its locomotion. In a word, thanks to the diversity of their indications which corresponds to the diversity of the objects and phenomena of the external world, the higher sense organs serve the animal as instruments of communication with the environment and of orientation in space and time, i.e., adaptation of its actions to the conditions of space and time.

But if we thoroughly examine the indications of the various sense organs, we shall easily see that they differ greatly in richness of content. Olfaction and taste obtain from each object (odorous only!) a *single indivisible* impression, while sight, hearing and touch obtain obviously complex and divisible impressions of more or less rich content. For example, the olfactory sense perceives in a lemon only one feature—its smell, and the gustatory sense—only the sour taste, whereas the eye perceives its round outline, spherical volume, colour, rough surface, size, distance, and position relative to the body of the observer (direction of vision). The indivisibility of the olfactory and gustatory impressions is expressed (apart from direct sensation) also in the fact that there are no names for these impressions in any language, and that the number of the specific names is very limited. We distinguish the smells of cheese, mint, vinegar, etc., i.e., we relate the names not to the smells, but to the objects that emit them, whereas in vision the colours have their individual names—red, yellow, green, etc. Actually there are but two specific names for smell (agreeable and disagreeable), three for taste (bitter, sweet and sour)*, eight—for sight (colour, planary form, size, distance, direction,

* An acrid taste or a pungent odour are not direct products of the olfactory and gustatory organs; they are caused by excitation of the mechanisms which, when subjected to strong stimulation, produce the sensation of pain.

volume, state of rest, and motion), eleven—for touch in conjunction with the muscular sense of the hands and of the body (heat, cold, planary form, size, distance, direction, volume, compressibility, weight, state of rest, and motion). In the sphere of hearing, all noises and sounds constitute genera, while the duration (short, long, continuous and intermittent sounds or noises), the elementary or complex character of the sounds, their pitch and, lastly, the articulation of the noises and sounds in speech, form species. That is why by means of olfaction and taste we distinguish but a single indivisible attribute in any given object, whereas by means of vision we distinguish 8 *categories of attributes*, by means of touch and the muscular sense—11 *categories*, by means of hearing—4 *categories*. Each category in its turn embraces a series of individual attributes. For example, the category of colour includes all the basic colours of the rainbow with all of their intermediary hues and their various mixtures in pairs; the category of compressibility includes the attributes of softness, solidity, fluidity, fragility, etc.

Thus, from the point of view of the sensory perception of external objects by man, the indications of different sense organs are far from being equivalent: the role of the organs of olfaction and taste is so small compared with that of the other organs that only the latter, i.e., vision, touch and hearing, can be rightfully called "higher sense organs". For this reason, we shall dwell in greater detail on these senses.

The general significance of the higher sense organs can be defined as follows: the whole of man's conscious life is directly bound up with their activity. This can be illustrated by the well-known case of a patient who lost all his senses except vision in one eye and hearing in the contralateral ear. As long as these remaining ways of sensory communication with the external world were open, the patient was awake. But when the experimenters deliberately closed them, the patient fell into a state of profound sleep; he awoke only when his intact eye and ear were subjected to stimulation. My late friend Prof. S. P. Botkin told me of a similar case he had personally observed. The patient (an educated woman) was deprived of all senses except the sense of touch and the muscular sense in the right

Like the retina, it is a mosaic of elements also unevenly distributed over the receptor surface. Their number is greatest in the finger-tips (on the volar surface), where it reaches 20 per 1 mm². For this reason the finger-tips are most capable of sensing separately the stimulation of two adjacent points of the skin by the application of the legs of a pair of compasses (see the introduction to the sense organs). And for this same reason we are able to sense the slightest roughness of objects with the finger-tips, and the blind person feels the embossed letter with the finger-tips when reading. This means that these parts of the palmar surface correspond to the yellow dots of the retina.

Meissner's corpuscles are regarded as elements which respond to the tactile stimulations of separate points. So long as a tactile sensation is produced by a slight pressure on the skin, and this pressure can excite the nerve directly, it suffices to attribute to these corpuscles a sensitivity to mechanical shock only; and we see, in point of fact, that the skin reacts in the form of a slight itch even to such faint shocks as sound vibrations (for example, when we apply the shank of a vibrating tuning-fork to the skin).

Another point of analogy between the palmar surface of the hand and the retina of the eye is that in both cases the impression is objectivised, i.e., perceived not as a change in the state of the body, but as something external which comes into contact with the receptor surface. It might seem, for example, that if we touch the leg with the palm of the hand, we should obtain two impressions simultaneously—the sensation of the leg from its contact with the hand, and the sensation of the hand from its contact with the leg. In reality, we perceive only the latter; the part of the leg touched by the hand gives the impression of being an alien object, especially if we feel its shape (for example, its prominence). Further, if we move in the direction of one another, say, the forefinger of the right hand and each finger of the left hand in turn, we shall obtain contacts of equivalent tactile areas, but we shall not feel any shape. For this reason the sensation of an alien object will not emerge in the consciousness; we obtain only qualitatively (and, therefore, subjectively!) different sensations for the separate fingers.

Lastly, if we move the forefinger of the right hand towards the immobile forefinger of the left hand, at the moment when the tips of both fingers come into contact with each other (especially if the movement of the right finger is repeated several times) the left finger will seem to be the alien object. In this case the right finger does the touching, the left is merely the object touched; in the second of the foregoing examples these roles are not divided between the fingers of the right and the left hands, since both move in equal measure; but in the first example the sensation obtained by the hand from contact with the leg effaces the opposite sensation, because the skin of the leg distinguishes only faintly the shapes of objects, while their perception by the palm of the hand is, on the contrary, very keen.

From this it follows that

*the principal conditions for spatial touch are, as in the case of vision, the faculty of the sensory mechanism to project the impressions to the outside and the faculty to distinguish the tactile movements performed by it* (corresponding to the acts of looking!).

To avoid repetition in describing the tactile acts which enable us to determine the outlines and sizes of objects, as well as their planary and spatial position, I shall make a general survey of the response of the tactile apparatus to all the above-mentioned acts.

When speaking of the planary and spatial localisation of immobile objects by vision, we said that in such cases the determining factors are: the position (relative to our body) and the length of the straight line linking the centre of the imaginary cyclopic eye with the point regarded at the given moment. We pointed out that when the eyes follow a moving object this straight line is, as it were, a long tentacle extending from the cyclopic eye to the object; it contracts or lengthens when the object draws closer to the eyes or moves off; it follows the moving object upwards, downwards and sideways. But while this is but a figurative image of the optical axis of the cyclopic eye, in the case of planary and spatial localisation of objects *by touch the arm is a real tentacle extending from the body to* the object; it can be stretched to full length and can be shortened so considerably that it comes almost into contact with the body of the observer; it can also move upwards, downwards and sideways in order to determine the relative position of the parts of the object touched. In a word, no matter whether it concerns the outlines and sizes of objects, or their distance and relative position, the motor reactions of the eyes during the act of looking and of the hands during the act of palpation are absolutely equivalent: in both cases the determinants are the indications of the muscular sense accompanying the motor reactions of the perception of impressions. In all these cases the difference between the visual and tactile acts is expressed in the following three advantages of vision over touch: the hand does not perceive colours and shades; the sphere of its sensation is limited by the length of the arm (for the eye it extends to infinity); in the act of palpation the image of the object is not constantly in front of the hand as in the case of an object seen which is constantly in front of the eyes; the hand feels separate parts of the object in succession and the memory combines the different moments of the sensation into a single whole. The hand, however, feels the density of objects, the smoothness or roughness of their surfaces and their temperature.

The hands determine the volume of objects in a different way from the eyes; they do it more precisely, because with the palms of the hands we can touch the lateral surfaces of objects which are more or less concealed from the eyes, as well as the posterior surfaces wholly inaccessible to the eyes. We can feel all the sides of an object, and in doing so a very big role is played by the changes in the palmar surface which makes it possible to feel the angles, prominences, hollows, etc.

## THE ORGAN OF HEARING

*Of all the sense organs hearing is the one which provides us* with the greatest variety of impressions. In the vocabulary of any language there are tens of thousands of words that sound differently; a word of several syllables can form several different acoustic images if the pitch of the tone and the stress on the syllables are varied, i.e., if the utterance of some syllables is lengthened and that of others is shortened. The expressiveness of speech depends precisely on these stresses and the mute intervals between words and syllables. In music, too, we distinguish not only the intensity, pitch and timbre of the tones (hard, nasal, sonorous, soft, rasping, etc.) but also their combination into chords, their tempo, definite succession and mute intervals. If we listen attentively to the noises constantly vibrating in the surrounding air, the ear will discover, as it were, a new world of faint sounds which as a rule we never hear because we pay no attention to them. There is no doubt that each acoustic impression corresponds to a certain peculiarity in the external influence by which it is produced, i.e., in the character of the oscillatory movements transmitted to the ear by the sounding body through the medium of the air. What, then, is the structure of the organ of hearing which enables it to respond to the action of external influences in a million ways? The answer to this complicated question is facilitated, first of all, by physics which studies, so to speak, the composition of the acoustic influences and isolates the elements common to all of them. Thanks to physics, we know that the number of these common elements is comparatively small. Physics begins by dividing all sounds in two categories: musical and noisy—regular and irregular periodical vibrations of sounding bodies. It then goes on to show that the duration of a sound or noise corresponds to the duration of respective vibrations, their intensity—to the amplitude of the vibrating particles, the pitch of musical tones—to the number of vibrations per definite unit of time, and the timbre*—to the character of the particular vibration. Further, studying the sounds of various musical instruments, physicists found that the simplest form of vibrations (the pendulum-like form) is produced by the pipes of an organ and by tuning-forks. And so they named these sounds *elementary tones* to distinguish them from all other sounds which, composed of harmonious combinations of ele-

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* The term "timbre" implies the character of the musical tones by which tones of one and the same pitch are distinguished from one another in different musical instruments—the violin, the guitar, the clarinet, etc.

mentary tones of varying pitch, are complex. This explains the essence of timbre as a chord of elementary tones.

*Thus, thanks to physics, the physiologist, when studying the* aural sensations, does not have to deal with an infinite number of facts; all he has to do is to reveal in the structure of the *aural apparatus the conditions which make possible the per*ception of musical tones and noises with their common properties—duration, intensity, pitch and timbre. Human speech is no exception in this respect, because it is also a mixture of noises (consonants) with musical tones of varying pitch, intensity and timbre (vowels).

But before passing to the structure of the organ of hearing, I shall try, for the sake of simplicity, to elucidate theoretically the significance of its principal components depending on the basic properties of the aural sensations.

An essential *part of the aural apparatus, as is the case with* the other sensory apparatuses, is the surface that perceives acoustic vibrations, i.e., the entire peripheral apparatus at the end *of the aural nerve, the conductors leading from it to* the centre, and the centre itself. As in the physiology of vision, we shall examine here only the functioning of the components of the *peripheral mechanism.*

In normal hearing the sounds are transmitted to the ear through the air;* the acoustic vibrations of the air, then, act as *impulses which excite the ends of the aural nerve.* These vibrations, however, act on the nerve only as mechanical shocks; generally speaking, the nerves are excited by in*fluences of this kind only if the intensity of the shocks corre*sponds to the innate sensitivity of the particular nerve. Consequently, it can be assumed *a priori* that the ends of the aural *nerve are not supplied with transformers of the excitatory* movement (indispensable in the case of the optic nerve). We shall soon see that this is really so.

*When the aural nerve is excited by mechanical shocks, only* one of the two possible structures of the ends of the aural nerve can ensure the capacity of our ear to distinguish musical

* The bones of the skull also transmit sounds, but only when we hear our own voice.

tones of varying pitch: either each tone is perceived by a nerve fibre (or fibril) the end of which vibrates in unison with the exciting sound; or the tones are perceived by a small number of nerve ends and each fibre has at its end a special appendage which transforms the pitch of the vibration produced by the nerve end. The microscope does not reveal any such appendages at the ends of the aural nerve; on the other hand, the number of nerve ends in the part of the aural apparatus which is believed to perceive the musical tones amounts to several thousands—a number which, as we shall see shortly, is sufficient to explain the limits of our sensitivity to tones of different pitch. These limits lie between tones of 16 vibrations per second (the lowest audible tone of the pipe of the organ) and 40,000 vibrations; this adds up to approximately 11 octaves. If the discrimination of tones were equally fine within these limits, then, even taking the smallest of the numbers observed for separate ends of the cochlear nerve, namely, 3,000, we would get 270 differently vibrating fibres for each octave, i.e., 270 different tones, while the piano has only 13 keys for each octave, i.e., 13 tones differing in pitch; moreover, the highest tones used in music never exceed 5,000 vibrations per second, and beyond this limit the sensitivity of the pitch discrimination declines considerably.

Let us imagine for a moment that in the part of the aural organ which perceives musical tones the end of each fibre of the cochlear nerve is connected with a string tuned to a tone of definite pitch. In this case each string, together with the corresponding fibre, would act as an element for perceiving tones of the pitch to which the string is tuned; this element would be capable of vibrating (of becoming excited) not only under the influence of a tone of its own pitch transmitted by the air, but even under the influence of a complex acoustic movement when the tone of the element enters this complex sound as one of its components. Thus, if we sing the vowels *a, o, e, i* and *u* in one and the same tone in front of a piano with the top and pedal raised, not only the string of the given tone will respond (resound) in the instrument to each of the vowels (except *u*), but also a number of other strings, namely, those whose tones enter into the composition of the particular vowel as overtones. The ear has the same property. When we hear a chord, we perceive it as a single whole; at the same time, however, we feel that it differs from each of the component tones and the keen musical ear clearly distinguishes these tones in the chord. In other words, the ear is capable not only of discerning a long series of tones according to pitch, but also of decomposing a complex acoustic movement into its component elements, i.e., to distinguish in a complex sound the elementary tones of which it consists.

Another important property of the aural sensations, which is reflected in the structure of the sound-receiving apparatus, is the conformity between the duration of the sensations and that of the impulses. This property is manifest in the capacity of the ear to catch abrupt sounds as well as the length of the mute intervals between them. How this is accomplished can be best explained by describing the structure of the aural mechanism, which is what I now propose to do.*

Thus, every time a particular sound acts on the ear, in the form of regular or irregular periodical particles of the air, its vibrations are transmitted from the tympanic membrane to the fluid of the labyrinth. This, so to speak, is the first half of the role played by the sound-conducting mechanism in the acts of hearing; this role was demonstrated long ago by experiments which permitted direct observation of the vibrations of the tympanic membrane under the action of sound. The second half of this role is the conduction of the acoustic movements from the air into the cavity of the labyrinth without any modification of the intensity, rhythm and character of the vibrations, no matter how complex the acoustic movement may be. This aspect of the activity of the sound-conducting mechanism was fully revealed with the invention of the telephone, and especially with Edison's phonograph. The two instruments reproduce with greater or lesser precision the most complex acoustic movements and noises—the words of human speech, the sounds of singing, the playing of musical instruments, coughing, sneezing, etc. In both instruments the acoustic vibra-

* Here follows the description of the structure of the "aural mechanism" which we omit.—Ed.

tions are perceived by a metallic plate which *of necessity is of small dimensions*. This plate responds to the acoustic impulses by movements of a very small amplitude; the movements rapidly fade when the impulses cease to act, because the latter have to overcome a fairly considerable resistance. The same thing is observed in the case of the tympanic membrane. The dimensions of this membrane are very small: its major axis being 9.5 or 10 mm. and the minor axis—8 mm.; it does not vibrate freely, but in conjunction with the aural ossicles; besides, the displacements of the latter are impeded at the opposite end—where the stapes enter the round window—by the membrane surrounding its base and by the mass of the shifting labyrinth fluid. It is clear that this system, together with the rapid extinction of the effects produced by each air impulse, reacts with corresponding vibrations to any series of these impulses, i.e., reproduces the air vibrations from the point of view of their frequency, character and amplitude—the latter, of course, in greatly reduced dimensions. Further, Edison's phonograph shows that the vibrations of the tympanic membrane are faithfully transmitted to the system of the aural ossicles, because in the above-mentioned instrument the receiving plate also transmits vibrations to a tiny lever set against it, and the latter records the vibrations of the plate on a revolving drum. Thus, faithful transmission of the acoustic vibrations into the cavity of the labyrinth has been proved. But once the acoustic movement has been communicated to the fluid, the latter reproduces it without any modification.

Along with these analogies, however, the aural apparatus has a big advantage over the phonograph of Edison in its musculo-nervous appendage which varies the tension of the tympanic membrane.*

* The chapter ends with an exposition of some further details relating to the structure of the aural apparatus and with certain conclusions concerning the functions of the organ of hearing ensuing from this structure.—*Ed.*

# NOTES

## REFLEXES OF THE BRAIN

1. The history of the "Reflexes of the Brain" and the difficulties associated with the publication of this work, were described in detail by Sechenov in his *Autobiographical Notes*:

"I returned to Petersburg in May 1863 and spent the summer writing a treatise which played a definite role in my life. I have in mind the 'Reflexes of the Brain'. The dissertation which I wrote for my doctorate in 1860 contained the following two theses:

"'All the movements known in physiology as voluntary movements are reflex movements in the strict sense of the word', and 'the most general feature of the normal activity of the brain (expressed in the form of movement) is the disproportion between the excitation and the effect (movement) engendered by it'.

"The first of these theses is quite clear, the other requires a certain explanation. In the absence of any influence of the brain, the sensory stimulations and the reflex movements caused by them correspond to each other in intensity, i.e., weak stimulations evoke weak movements, and vice versa; but given the influence of the brain, no such conformity is observed: a weak stimulation may evoke a very strong movement (for example, the whole body starts at a sudden light touch) and, conversely, a very strong stimulation may not evoke any movement at all (as in the case of a person suffering acute pain and remaining outwardly immovable). If to this we add that at the time I was preparing my dissertation I could not but be aware of the three elements which comprise the reflex acts, and of the psychological significance of the intermediate members of the acts which end in voluntary movements, it will be clear that the idea of establishing the physiological substratum of the psychical phenomena with regard to the mechanism of their formation had come into my mind already at the time of my first visit abroad; this is all the more so, because in my student days I used to study psychology. There is no doubt that ideas of this kind were maturing in my mind also during my stay in Paris, because there I was engaged in experiments directly connected with acts of consciousness and will. In any case, upon my return to Petersburg from Paris these ideas took the shape of the following, partly unquestionable and partly hypothetical propositions: in his everyday conscious and semi-conscious life man is never free from the sensory influences exerted by the environment through his sense organs, as well as from sensations ensuing from his own organism (his own feelings), it is these factors which maintain his entire psychical life with all of its motor manifestations, because psychical life is inconceivable when the senses are lost (this supposition was confirmed twenty years later by observations on very rare cases of patients who had lost almost all their senses). Just as man's movements are determined by the indications of the sense organs, his mode of behaviour in psychical life is determined by desires and wishes. Both the reflexes and psychical processes resulting in action, are of an expedient character. The beginning of the reflex is always caused by a certain external sensory influence; the same thing takes place—often imperceptibly—in the whole of our psychical life (since in the absence of sensory influences psychical life is impossible). In most cases the reflexes end in movements; but there are reflexes which end in the suppression of movement; the same thing can be observed in psychical acts; most of them are manifested in facial expressions and actions, but in very many cases their ending is suppressed, with the result that instead of three members the act consists only of two; the meditative mental side of life takes on this form. Emotions are rooted, directly or indirectly, in the so-called systemic senses which can develop into strong desires (sensation of hunger, instinct of self-preservation, sexual desire, etc.) and which are expressed in impetuous actions, for this reason they can be included in the category of reflexes with an intensified ending.

"These considerations formed the foundation of a small treatise to which I gave the title 'An Attempt to Establish the Physiological Basis of Psychical Processes'. The editor of the medical journal to whom I submitted the manuscript informed me that the censor's department insisted on a change of title (I rather think that the editor himself thought the title was not quite suitable for a purely medical journal). So I changed the title to 'Reflexes of the Brain'. This earned for me the charge that I was an involuntary propagator of immorality and nihilistic philosophy. Unfortunately, the censors' regulations of that time prevented me from publishing an explanation which would have easily dispelled the misunderstandings. Indeed, my sternest opponents can accuse me of asserting that every action, irrespective of its content, is predetermined by the nature of the given individual; that any action is caused by a certain, sometimes insignificant, external stimulus; that the action itself is inevitable and, that being so, even the worst criminal is not responsible for his crimes They can say, moreover, that my teaching gives the green light to shameful deeds by persuading depraved persons that they are not responsible for what they do, seeing that they cannot help doing so.

"This last charge is due to an obvious misunderstanding.... There was no need to discuss in my treatise the matter of good and evil, my object was to analyse actions in general, and my point was that, given certain conditions, not only actions but also their inhibition are inevitable and obey the law of cause and effect. Is this an apology for immorality?" (*Autobiographical Notes by Ivan Mikhailovich Sechenov*, U.S.S.R. Academy of Sciences, Moscow-Leningrad, 1945, pp. 113-16; see also pages 153-54 of the present volume.)

Sechenov sent his manuscript to the magazine *Sovremennik*, the views of which were similar to his own. However, the censor's department banned it, and for this reason the treatise had to be published serially in the weekly *Meditsinsky Vestnik* (Nos 47 and 48, 1863). Three years later, in 1866, this classical work—partly revised—was published in book form after traversing a long and thorny path of censorial persecution.

A study of the archives has made it possible fully to reproduce all the stages of Sechenov's struggle to overcome the difficulties associated with the publication of his "Reflexes of the Brain".

Of particular interest is the indictment formulated by the St. Petersburg Censors' Committee when bringing an action against Sechenov. In a document addressed to the attorney of the District Court on June 9, 1866, the Censors' Committee motivated its charge and described the "Reflexes of the Brain" as follows: "This materialistic theory reduces even the best of men to the level of a machine devoid of self-consciousness and free will, and acting automatically; it sweeps away good and evil, moral duty, the merit of good works and responsibility for bad works; it undermines the moral foundations of society and by so doing destroys the religious doctrine of life hereafter; it is opposed both to Christianity and to the Penal Code, and, consequently, leads to the corruption of morals."

The publication of the "Reflexes of the Brain" made a tremendous impression on the progressive circles of Russian society. It became the handbook of the young people of the eighteen-sixties. People were deeply stirred by it, and it was the subject of lively discussion; and while it won many friends, it also made many enemies in the camp of the reactionary idealists. The book played a decisive role in the education of that generation of Russian physiologists who are regarded as the glory and pride of Russian science.

Pavlov had high praise for this book (see, for example, Pavlov's *Complete Works*, Vol. III, Book I, published by the U.S.S.R. Academy of Sciences, 1951, p. 249, and also Pavlov's address at a Sechenov memorial meeting on March 22, 1907, published in the *Proceedings of the Russian Medical Society*, St. Petersburg, March-May 1907).

I. Mechnikov, K. Timiryazev, A. Samoilov, N. Wedensky and other scientists referred in their reminiscences to the scientific and social value of this book.

The "Reflexes of the Brain" was violently attacked by the idealists the moment it appeared and throughout the subsequent years (N. Strakhov, E. Edelson, whose pen-name was "E. E-n", K. Kavelin, M. Ostroumov, Z. Radlov, G. Chelpanov, A. Stadlin, and others). However, among Sechenov's critics were some who belonged to the democratic movement of the sixties. The magazine *Russkoye Slovo* edited by D. Pisarev reacted to the "Reflexes of the Brain", not with a review, but with an article headed

"The Last Philosopher-Idealist", written by V. Zaitsev and devoted to Schopenhauer. The author of this article, while acknowledging the importance and theoretical value of Sechenov's views on the complex philosophical questions concerning the origin of the concepts of time and space, misunderstood Sechenov's teaching as a whole and wrongly interpreted it. M. Antonovich, a friend of Chernyshevsky, published in the *Sovremennik* a reply to Zaitsev in which he supported Sechenov's views p. 31

2. In the first edition of the "Reflexes of the Brain" the word "psychical" was absent. Introducing this word in the second edition, Sechenov deemed it necessary to emphasise that his purpose was to make a physiological analysis of the psychical activity of the brain, not its activity in general. p. 32

3. Eduard Friedrich Weber (1806-1870)—author of the *Mechanism of the Human Body* written jointly with his brother, Wilhelm Eduard Weber, physiologist (1804-1891). A third brother, Ernst Heinrich Weber (1795-1878), was a well-known physiologist and anatomist, professor of the Leipzig University and the author of a number of works on psychophysics (the famous Weber-Fechner law was named after him) p. 43

4 Eduard Pflüger (1829-1910)—German physiologist; was professor of physiology of the Bonn University. p. 43

5. Claude Bernard (1813-1878)—outstanding French physiologist—was member of the Academy of Sciences and Head of the Chair of Physiology, Sorbonne. Bernard greatly influenced the development of physiology in the second half of the nineteenth century. At one time Sechenov worked in his laboratory p. 43

6 I Rosenthal (1836-1915)—professor of the Berlin Physiological Institute, author of the book *General Muscular and Nervous Physiology* translated into Russian by I. R. Tarkhanov. The first edition of the "Reflexes of the Brain" did not contain any reference to the work of Rosenthal; neither was there any graphical scheme of the "reflex machine" nor any mention of the experimental data obtained by Berezin (see note 7) This is explained by the fact that in the interval between the publication of the first and the second editions, i e., between 1863 and 1866, Sechenov and his pupils had accumulated new data concerning the mechanisms which inhibit reflex movements, and introduced greater clarity into the anatomical concept of the peripheral and central apparatuses participating in the formation of reflex arcs at different levels of coupling. This explains why in the second edition the end of §4, beginning with the reference to Rosenthal's work, differs from the first edition, though the basic ideas are unchanged. p. 44

7 I. G Berezin (1837-1866)—Russian physiologist and pupil of Sechenov. In 1863 Berezin graduated from the Medico-Surgical Academy, remained in the Academy and did physiological research in Sechenov's laboratory. p. 45

8 Here the term "conscious sensation" is used by Sechenov for the first time. Later, developing his views on the nature of sensations, he differentiated them according to the degree of their perceptibility. Sechen-

ov identified the concepts "perceptible sensations" and "conscious sensations". p. 49

9. See Note 7. p 50

10. V. V. Pashutin (1845-1901)—a patho-physiologist and pupil of Sechenov and Botkin, who raised pathophysiology to the level of an independent experimental discipline and created the first Russian school of pathophysiology.

11. The question of the influence of "the physiological state of the nervous centre" on the nature of sensation, posed here by Sechenov, acquired in physiology the significance of an independent subject which gave rise to a special trend in physiological investigation. Sechenov's pupil N. Wedensky should be regarded as his direct continuer in this branch of research. p. 53

12. Sechenov was the first to use the term "vague" in characterising the muscular sense; sometimes he also used the term "obscure". These concepts became firmly established and widespread; they gave an impetus to many investigations which were specially aimed at ascertaining the role of the muscular sense in human behaviour. By means of these figures of speech Sechenov emphasised the important idea that the signals emanating from the muscular sensations leave a vague impression in the consciousness, and sometimes even do not reach it at all. Sechenov reverted to the question of muscular sense in many of his works. When substantiating his theory of locomotion, he devoted much attention to the analysis of muscular sense as a regulator of movements. The physiologist A. Samoilov, one of Sechenov's pupils, characterised the importance acquired by this aspect of Sechenov's teaching (A. F. Samoilov, *Selected Articles and Speeches* published by the U.S.S.R. Academy of Sciences, 1946). The significance of Sechenov's works in this field was elucidated also by K. Kekcheyev who devoted a special investigation to proprioceptive sensations and showed that the modern teaching on proprioception is based on Sechenov's principles concerning the muscular sense (K. Kekcheyev, *Interoception and Proprioception and Their Clinical Significance*, State Medical Publishing House, 1946). p. 67

13. The striking cases described here by Sechenov can be fully explained by the operation of the conditioned-reflex mechanism. Over the years firm connections are established between definite parts of the day and the sensations invariably accompanying these parts (partly reaching the consciousness and partly not), on the one hand, and definite actions—on the other. Thus, definite parts of the day become, as it were, conditioned stimuli. In the case of the cook, the movements were performed automatically, but at one time they had been acquired by learning. The same conditioned reflex mechanism explains the second case described by Sechenov. p. 69

14. Sechenov's idea that "persons who are deaf from birth never learn to combine sounds into words" cannot be regarded as conforming to reality. Actually the training of deaf-and-dumb persons is based on the fact that in this case "the muscles participating in speech" (which Sechenov mentions in his work) establish a connection not with the aural but with

visual sensations (watching the movements of the teacher's lips), tactile and muscular (feeling the cervical muscles of the teacher while he pronounces separate sounds), olfactory, gustatory and others, for example, the sensation of vibration which adequately compensates for defects of hearing This fact was, apparently, unknown to Sechenov, because the training of deaf-and-dumb people made considerable headway (especially in the U S S R.) long after the appearance of his "Reflexes of the Brain". This, however, does not refute Sechenov's basic idea of the importance of hearing for the development of speech, especially since in his subsequent article "Who Is to Elaborate the Problems of Psychology, and How?" he somewhat changed his original viewpoint by acknowledging the possibility of training deaf-and-dumb persons to speak. p. 81

15 When using the expression "decomposition of concrete impressions" Sechenov implied under the term "concrete impression" a non-differentiated reflection of an object caused by the activity of the sense organs Decomposition is, in Sechenov's opinion, an analysing activity. Here Sechenov's view on the sense organs as analysers begins to take shape. The connection between his views and those of Pavlov on the essence of analysers is quite obvious. Sechenov's research paved the way for Pavlov's thorough and profound substantiation of a teaching on the sense organs as analysers (I. P. Pavlov, *Complete Works*, Vol. III, Book I, 1951). p. 85

16. Sechenov explains the difference between the visual, aural and tactile perception of the various properties of external objects not only by the different "analytical power" of the corresponding "sensory apparatuses", but also by the uneven development of the visual, aural and tactile faculties, depending on man's requirements and social activity. This point of view, and especially the fact that Sechenov emphasised the role of man's requirements and exercise in developing his analytical faculties, is fully in accord with the present-day materialistic approach to the laws of development of the sense organs. In his interpretation of the problem of requirements and exercise Sechenov rehabilitated the remarkable (both for his time and for ours) ideas of Lamarck which had been misunderstood by many people and undeservedly forgotten. In Sechenov's interpretation these ideas appeared in an entirely new light due to the fact that he could free himself from the naïve mechanistic conception of the nervous fluid—the cornerstone of Lamarck's psycho-physiological views—and rise to the level of strictly materialistic physiology. p. 87

17 Sechenov's idea that "the number of psychical acts is increased many thousand times" as a result of countless associations of notions "from all sensory spheres" is close to the teaching of Pavlov who proved that any external agent can be a conditioned stimulus, and that the number of temporary links, especially in man, can, therefore, be unlimited (I. P Pavlov, *Complete Works*, Vol IV, pp. 52-53). p. 91

18. Jan Purkinje (1787-1869)—outstanding Czech anatomist and physiologist. His scientific activity was extremely broad. His fundamental physiological works were devoted to the study of the sense organs. The change which takes place in the brightness of coloured objects in con

ditions of reduced illumination is known as "the Purkinje phenomenon" p. 99

19. Sechenov opposes fractional sensations to concrete sensations. By concrete sensations he implied those which produce an integral image combining all the diverse attributes of the object. In these cases, psychology generally uses the expression "perception of an integral object". Sechenov, who actually attaches a broad sense to the concept of sensation, does not use the term "perception". p. 101

20. According to Sechenov's interpretation, the traces which persist in the brain as a result of the action of the stimulus on the sensory apparatus are material phenomena the nature of which is wholly subject to physiological study, though it cannot always be determined. The theory of traces or so-called engrams was used also by the idealist psychologists who divorced the trace processes from the changes in the material substratum accompanying each sensation. Sechenov imparted to the theory of traces a definitely materialistic character. p. 102

21. The question of various physiological viewpoints concerning the process of "perception of colours" was thoroughly elucidated by S. V. Kravkov (1894-1951), an expert in the psycho-physiology of vision. Kravkov expounded the history of the controversy between Helmholtz, who held that there were three kinds of nervous apparatuses in the organ of vision and advanced the trichromatic theory of colour vision, and Hering who sought for the physiological substratum of the six basic colour sensations (the red, yellow, green, blue, white and black colours) in special chemical reactions of dissimilation and assimilation of substances. The original investigations carried out by Soviet scientists, and above all by S. V. Kravkov, have greatly clarified the theory of colour vision and enriched it with new experimental facts (S. V. Kravkov, *The Eye and Its Functioning*, 4th ed., 1950, pp. 299-334). p. 102

22. Sechenov regards as subjective those sensations which are caused by the action on the sense organs of stimuli located in our organism, or by changes taking place within it (at present these sensations are known as interoceptive and proprioceptive). Sechenov, therefore, includes the muscular sensation in the category of subjective sensations. For Sechenov the visual and aural sensations are objective because the stimuli which engender them are objects situated outside the organism (in modern terminology these sensations are called exteroceptive). p. 103

23. In the first edition of "Reflexes of the Brain" between the words "muscular" and "memory" Sechenov inserted (in brackets) the words "modified tactile". The absence of these words in the second edition shows that Sechenov was not inclined to interpret muscular memory only as modified tactile memory. By designating aural and muscular memory as memory of time, the visual and tactile memory as memory of space, Sechenov merely emphasised the specific features of the muscular and aural sensations, on the one hand, and of the visual and tactile ones, on the other. Actually Sechenov tended against drawing a strict demarcation line between these two kinds of sensations; in his works he repeatedly pointed out that in man's concrete activity they are often associated

and, acting reciprocally, ensure a more perfect knowledge of the objective world p. 104

24. This example illustrates in the best possible way the formation of a temporary connection or a conditioned reflex. Here, as on other occasions, Sechenov described in full and correctly characterised the formative process of a temporary connection. Not being able at the time to investigate and reveal this connection by way of experimentation, he had to limit himself to a description. It was left to Pavlov to raise the solution of this problem to the level of an extremely important scientific discovery which marked a turning-point in materialistic physiology. p. 111

25. Sechenov skilfully discloses the reasons for the widespread and erroneous view that thought is the cause of action. He ascribes this error to the illusion of self-consciousness and to the fact that the sensory stimulation, which determines the beginning of each action, often remains unnoticed by the mind, or, as he stated later, "the visible links between thinking and its sensory prototype is completely lost" ("The Elements of Thought", pages 265-266). This proposition, directed against idealist indeterminists, should be regarded as a powerful and effective argument in support of materialism. p. 118

26. In his analysis of the process of development of "lofty moral motives" and "deep convictions", Sechenov confined himself to disclosing the physiological mechanisms of the origin and development of definite associations. It is in this sense that we should interpret his words "their activity [Sechenov has here in mind the "noble types" of people] is the inevitable result of their development". p. 126

27 Friedrich Eduard Beneke (1798-1854)—German philosopher and psychologist who eclectically combined Kantianism with sensualism and empiricism. Beneke regarded psychology as "internal natural science". He is the author of numerous works on psychology, logic and ethics Beneke's principal work, mentioned by Sechenov, is *Lehrbuch der Psychologie als Naturwissenschaft* (1833). p. 138

28 Referring to the French sensualists, Sechenov had in mind Helvetius, Holbach, Diderot, and especially Condillac—one of the most consistent sensualists, author of the famous *Treatise on Sensations*. p 138

## OBSERVATIONS ON MR. KAVELIN'S BOOK THE TASKS OF PSYCHOLOGY

29. This article was first published in 1871 in the magazine *Vestnik Yevropy*, No. 11. In 1873 it was reprinted in Sechenov's *Psychological Studies*

K. D. Kavelin (1818-1885)—writer and lawyer; lectured at the Moscow University on the history of Russian law and on the philosophy of history. p. 140

30. When speaking of the modern physiologico-psychological school" Sechenov had in mind those physiologists and psychologists who studied

the problems of psychology on the basis of physiological facts and by means of the objective method. Actually, this school did not unite any definite group of researches, it simply reflected the tendency that began to manifest itself at the time to bring psychology closer to the natural sciences and to liberate it from metaphysical philosophy. p. 140

31. "Self-consciousness" and "introspection" are identified by Sechenov in this case, as in all other cases, when these concepts characterise the methods of psychology. p 140

32. The example of a physician who demonstrated his capacity to evoke "goose-flesh" on his arm exclusively by power of imagination was cited by Sechenov in the "Reflexes of the Brain" (see p. 107). Not satisfied with the usual explanations of these phenomena and repudiating their idealistic interpretation, the materialist physiologists gradually elucidated this "mysterious domain". I. P. Pavlov, who was not specially concerned with the study of the influence of notions on the soma, expressed casually some highly important views on this subject He stated. "In the Odessa laboratory one of Sechenov's assistants (his apparatus is available in the laboratory of our institute) proved that when we think of a certain movement, we actually perform it. When, for example, I think of a circle, my hand performs a circular movement and the apparatus can record it. This movement is the obvious consequence of an afferent stimulation produced by the subjective idea of a circle, a consequence of our thought. Sechenov was the first to demonstrate that the stimulation of afferent cells is inevitably transformed into a corresponding movement. This is a laboratory fact." (See *Pavlovian Wednesdays*, published by the U.S.S R. Academy of Sciences, 1949, Vol. II, 481-82.) p 147

33. Wilhelm Max Wundt (1832-1920)—German psychologist, idealist philosopher, representative of experimental psychology. p. 152

34. Johann Friedrich Herbart (1776-1841)—German psychologist and pedagogue. Herbart, whose philosophical and psychological views were based on metaphysical idealism, was a typical representative of intellectualism in psychology. Sechenov subjected his concepts to severe criticism. p. 156

35. The concept "analyser" is used here by Sechenov not in the physiological sense as in his other works (see, for example, page 89 where he speaks of the "analyser of time"). Here the concept "analyser" means "the analysing subject". p. 156

36. H. Le Hon (1809-1872)—historian, archaeologist and geologist. His work, to which Sechenov refers and from which he draws facts concerning the rudiments of psychical life in the so-called fossil man, is a circumstantial monograph published in 1867 and subsequently reprinted many times. p 159

37. Edouard Lartet (1801-1871)—French archaeologist who initiated the study of monuments of art of the paleolithic period in the valley of the river Vézère (excavations in the Moustier, Madeleine, d'Aurignac, Cro-Magnon grottos, etc.); the important stages of the development of the paleolithic culture are designated by their names, Lartet originated the

chronology of the Quaternary and proved that man already existed at that period. p. 159

38. Edward Tylor (1832-1917)—English anthropologist and archaeologist. Tylor introduced into science the concept of animism as the essence of primitive religion, but being an idealist he could not solve the problem of the origin and forms of primitive religion. Sechenov, who upheld the evolutionary view on the development of human psychical activity, utilised some of the facts communicated by Tylor to confirm this viewpoint. p. 161

39. Luigi Galvani (1737-1798)—Italian physician and physicist—the first to observe the influence of electric current on the contraction of the muscles of a frog. p. 165

40. Volta Alessandro (1745-1827)—Italian physicist, famous for his discoveries in electricity; founder of the theory of galvanism. p. 165

41. Hermann Ludwig Ferdinand Helmholtz (1821-1894)—naturalist. Sechenov characterised the personality of Helmholtz and his work in a speech delivered on November 16, 1894 at a meeting of the Imperial Society of Friends of Natural Sciences, Anthropology and Ethnography. In his speech Sechenov expounded Helmholtz's theory of acoustic sensations and explained his idea of spherical resonators (see pp. 467-478). p. 167

42. The psychological experiment proposed by Sechenov to Kavelin with a view to proving the determinability of the processes of thought and the dependence of the arising associations not on "thoughts evoked at will", but on definite objective and subjective conditions, was subsequently widely applied in experimental psychology and is used to this day in the study of associative processes, both normal and pathological. p. 174

43. While firmly denying the possibility of "evoking thoughts at will", Sechenov does not, of course, contest the facts of everyday life, but, a confirmed determinist, he refused to regard a psychical act as a phenomenon without any cause.

## WHO IS TO ELABORATE THE PROBLEMS OF PSYCHOLOGY, AND HOW?

44. The article "Who Is to Elaborate the Problems of Psychology, and How?" was conceived by Sechenov long before his controversy with Kavelin; the controversy impelled him to expound possibly earlier not only his critical but also his positive views on the science of psychology and on the ways of its development. The article was first published in the *Vestnik Yevropy* in April 1873. In the same year it appeared in his book *Psychological Studies*. Later, this work was included in the second volume of Sechenov's posthumous *Complete Works* published in 1908. This article, which is one of the most fundamental and original of Sechenov's psychological works, is imbued with the spirit of militant materialism. p. 179

45. The prefix "iatro" is derived from the Greek word *iatria* meaning healing, medical treatment. p. 183

46. This idea expresses one of the basic principles of Sechenov's views on psychology; Sechenov, as is clear from the essence of his statements on consciousness, is far from denying the role of consciousness in psychical life, on the contrary, he stresses it in every possible way (see page 481) He is against the "separation of the element of consciousness from its source", against any isolation of consciousness as an independent "spiritual essence"; he considers as profoundly erroneous the separation of consciousness, as a part of the integral whole, from the other parts, from the action of the external or internal stimulus with which any psychical act begins, as well as from the movement (or inhibited movement) in which it ends. The purpose of his struggle was to prove that scientific psychology was incompatible with any counterposing of the psychical to the material. p. 196

47. Sechenov repeatedly raised the question of the relation of physiology to psychology. Somewhat earlier he pointed to the necessity of entrusting "physiology with the analytical study of psychical phenomena" Characteristic in this respect is the original title of his "Reflexes of the Brain"—"An Attempt to Establish the Physiological Basis of the Psychical Processes". From these formulations many concluded that Sechenov denied psychology as a science and regarded the study of all psychical phenomena as belonging to the province of physiology. It would be wrong, however, to infer conclusions of this kind from the substance of his views Actually Sechenov, and subsequently Pavlov, regarded psychology as a branch of science, on the condition, however, that it should be provided with a firm physiological basis and that the "isolation of the psychical" from the material be renounced. p. 198

48. The term "physiologico-psychologist" is used by Sechenov to designate a new type of scientist who studies psychical phenomena from the physiological point of view. p. 199

49. "Common psychology" means psychology based on introspection. p. 203

50. The term "pure reflexes" is no longer used. Sechenov used it to characterise the elementary reflex acts not complicated by any "psychical elements". p. 212

51. The term "notion" is mostly used by Sechenov in the sense in which it is generally accepted in psychology, i.e., as images of former objects of perception. But in the given case Sechenov imparts to the term the sense of "concept" just as the French word *idée* may simultaneously have these two meanings. p. 227

52. This idea of Sechenov retains its theoretic and practical value to this day. Indeed, the diversity of voluntary movements performed by man in every-day life derives from exercise or training stimulated by definite vital purposes (labour activity, sports, art, etc.). Hence, vital necessity should be regarded as the decisive factor determining the development of voluntary movements. In another of his works Sechenov shows how the movements are perfected under the influence of necessity and exercise (see "The Part Played by the Nervous System in Man's Working Movements", pp. 481-483). Modern pedagogics, especially the pedagogics of

labour and sports, can fully rely on these ideas of Sechenov, and also on his criteria for the classification of movements. In this respect his views are a long way from being outdated, on the contrary, they should be regarded as essential, as fully retaining their validity. p. 244

53. Sechenov's view that even the most habitual movements are controlled by the consciousness is now being corroborated to an ever-increasing extent.

Sechenov states that "will" does not interfere with the mechanisms of movements, but this means that it interferes with other aspects of movement. This becomes obvious when for some reason or other movement is impeded, or when its regularity is broken. p. 246

## A FEW WORDS IN REPLY TO MR. KAVELIN'S "LETTERS"

54. This article, which brings the controversy between Sechenov and Kavelin to an end, was published in the magazine *Vestnik Yevropy*, No. 7, 1874. p. 261

## THE ELEMENTS OF THOUGHT

55. The article "The Elements of Thought" was first published in the magazine *Vestnik Yevropy* for 1878 (Nos. 3-4). In it Sechenov realised a long cherished idea to analyse the origin of the act of thinking, beginning with elementary reflex processes and ending with abstract thought.

"The Elements of Thought" can, therefore, be regarded as the generalised and strictly systematised result of his many years of work in the sphere of psychology, as the fruit of his long and persistent research aimed at finding the answers to the questions in which he was profoundly interested. Moreover, even after the publication of this work, Sechenov continued his study of the still unresolved questions and accumulated additional material in order to clarify and supplement those parts of his article which did not satisfy him. It was no accident, therefore, that in 1903, at the age of 74, he reverted to "The Elements of Thought" and, anxious to make up for the deficiencies of the first edition, decided to revise it.

In its revised form "The Elements of Thought" appeared in the magazine *Nauchnoye Slovo* in 1903. It is this text we reproduce here in the present volume. A comparison of the two texts shows that the basic ideas and formulations of the 1878 edition remain unchanged. Many of the corrections relate to matters of style, and only a few passages were appreciably revised. Consequently, we are entitled to consider this work as written in 1878 and not in 1903, chronologically, it should precede those of Sechenov's works which were written later. p. 265

56. On pages 286-288 Sechenov explained the difference between the views of the nativists and those of the empiricists on the problems of visual sensations and visual notions. To this explanation it should be

added that broadly speaking nativism was a philosophical and psychological trend the adherents of which—nativists—regarded the concepts of time and space as being innate, not as products of experience, as it was asserted by their adversaries, the empiricists. Subsequently, Sechenov rejected the views of the nativists, but did not accept Helmholtz's views on this question either. He explained the transformation of sensations into notions by the "interaction of external influences and the innate neuro-psychical organisation" which, in his view, should be considered not statically, but in the process of development. p. 289

57. Here Sechenov lays the foundations of the physiological interpretation of the act of attention and anticipates the trend of further research in this sphere aimed at elucidating the mechanism of the orienting reactions (Pavlov) and of the dominant (Ukhtomsky). In defining the principle of the dominant, Ukhtomsky recognised the existence of a direct connection between it and Sechenov's ideas. According to Ukhtomsky, recognition of the external objects, for each of which there is a definite dominant, is simply the reproduction of these dominants (see A. A. Ukhtomsky, *Works*, Vol. I, 1950, pp. 169-70). Pavlov had definite ideas about the physiological phenomena of nervous processes which take place in the cerebral hemispheres at the time of conscious activity. For Pavlov this was "nervous activity of a certain part of the cerebral hemispheres which at the given moment and under the given conditions manifest optimal excitability". All the other parts of the hemispheres are at the same time in a state of reduced excitability. In Pavlov's view the parts with optimal excitability are the creative area of the cerebral hemispheres, the area in which conditioned reflexes and differentiations are easily elaborated. Under the influence of external stimuli, and of the links between the various centres of the hemispheres, the state of optimal excitability is shifted from one point of the hemispheres to another. "The area of reduced excitability varies" accordingly. Thus, it is not difficult to see a direct connection between the ideas of Sechenov and Pavlov in this respect. (See I. P. Pavlov, *Complete Works*, Vol. III, Book 1, 1951, pp. 247-48) p. 297

58. Sechenov's views on the evolution of memory represent a pronounced advance compared with the concept of memory as an isolated faculty which prevailed at that time. True to the desire to analyse psychical phenomena as processes, Sechenov in this case, too, links the evolution of memory with the "evolution of what is memorised", and included in this concept the "modifications of the nervous organisation" resulting from the accumulation of more and more traces and imprints. From this standpoint, Sechenov is consistent in giving preference to adult memory rather than to that of the child. According to him, the advantages of adult memory consist in a more perfect arrangement of the material, which is determined by the richness and variety of the associations. p. 302

59 Franz Cornelius Donders (1818-1889)—Dutch physiologist and ophthalmologist who established a number of essential laws in the domain of physiological optics. p. 306

60. Olfaction is also regarded by Sechenov as a higher sense organ (see page 539 of the present volume, the first lecture delivered at the Moscow University in 1889). p. 321

61. Here the word "sign" is equivalent to the word "signal". Subsequently, Sechenov uses the term "sensory sign", having in mind the signalling function of sensations (see, for example, the section "Control of Movements by Sensation" in the article "The Part Played by the Nervous System in Man's Working Movements", p. 479 as well as the subsequent pages). p. 335

62. See Note 81. p. 373

63. In his "Reflexes of the Brain" Sechenov wrote: ".... The muscular sense itself can analyse its sensations only in time...", and a little below: "The following well-known facts show that the muscular sense cannot analyse its sensations in space (see pp. 89-91 and Note 73)." But as the analysis of the muscular sense was becoming more profound, Sechenov changed his viewpoint somewhat, because he had obtained new facts proving that the muscular sense is capable also of spatial analysis. Hence, he arrived at the following conclusion: "... We now see that the same muscular sense, being divisible in the course of periodical movements, acts as a differentiating analyser or as an instrument for measuring space and time." In subsequent works, especially in the article "The Part Played by the Nervous System in Man's Working Movements" and in the book "Physiological Studies", Sechenov reverted again and again to the role of the muscular sense. In the aggregate, his ideas concerning the muscular sense form a harmonious and original theory. p. 389

64. George Henry Lewes (1817-1878)—English philosopher and writer, follower of positivism, author of the books *The Problems of Life and Mind and Physiology of Common Life*. A Russian translation of the latter appeared in 1861 p. 391

65 See Note 81. p. 391

66 Urbain Jean Joseph Leverrier (1811-1877)—French astronomer who discovered the planet Neptune in 1846, by way of calculations and logical deductions It was this Sechenov had in mind when he stated that "the human mind does not stop at experimentation". p. 397

67. Faraday rejected the concept of "action at a distance" which predominated in physics, he was guided by theoretical considerations subsequently confirmed by facts concerning the ultimate rates of propagation of electromagnetic waves. p. 397

68. James Clerk Maxwell (1831-1879)—English physicist, professor of experimental physics at Cambridge University, one of the founders of the theory of electricity and magnetism. p. 397

69 Heinrich Rudolph Hertz (1857-1894)—German physicist; he worked as Helmholtz's assistant between 1880 and 1883. p. 397

70 Julius Robert Mayer (1814-1878)—physician and physiologist, famous for his works *Quantitative and Qualitative Determination of Forces* (1841), *Remarks on the Forces of Inanimate Nature* (1842), *Organic Movement and Its Connection with Metabolism* (1845), *Remarks on the Mechanical Equivalent of Heat* (1847). p. 397

## THE THEORY OF NON-FREEDOM OF WILL CONSIDERED FROM THE PRACTICAL ASPECT

71. The article "The Theory of Non-Freedom of Will Considered from the Practical Aspect" appeared in 1881 in the magazine *Vestnik Yevropy* (No. 1). The direct cause of its appearance was the criticism to which Sechenov's "Reflexes of the Brain" had been subjected, and its persecution by the censors. Sechenov considered it his duty to protest against the false interpretation of the "Reflexes of the Brain" and against the practical conclusions which, it was alleged, would be drawn from it (see Note 1).

The article was Sechenov's reaction to the reproaches hurled at him to the effect that he had undermined the moral foundations of society and almost justified any crime by denying the criminal's responsibility.
p. 402

72. N. S. Tagantsev (1843-1923)—Russian criminologist, Professor at Petersburg University. p 412

## IMPRESSIONS AND REALITY

73. In his *Autobiographical Notes* Sechenov relates the history of the article "Impressions and Reality". "I recall," he writes, "one of my public lectures delivered in Moscow and subsequently published in the *Vestnik Yevropy* under the title 'Impressions and Reality'. The subject was the degree to which the visible and the real coincide; a topic which at first glance might seem useless, since sensation and reality are separated by an unbridgeable gulf. But this truth is not fully applicable to visual sensations, because they are objectivised, i.e., externalised in the shape of a definite figure, size, distance from the eye, and colour. Consequently, as far as visual impressions are concerned, the question is how to establish the degree to which this or that aspect of the objectivised sensation coincides with reality. As regards planary figures of objects the outlines of which can be drawn, the question is solved in the following way. Although we receive only sensory signals from the external objects, experience incontestably shows us at every instant that the identity or similarity of these signals always corresponds to the identity or similarity of the external influences which produce them. Hence, if the planary figure of an object and its image on the retina are identical, and if the retinal image is identical with the corresponding objectivised sensation, then the latter is identical with the planary figure of the object. The first of these propositions does not require any proof; as to the similarity between the images on the retina and the objectivised sensations, it is best proved by the phenomena of diffusion of light in the eye, when the object seen *deviates from reality, and coincides with what is pictured on the retina.* Thus, an external object appears to us with a vague outline if its image on the retina

is diffuse; if we place before the eyes a screen with cuts in it not bigger than the pupils and having the shape of two orifices, a triangle, a cross, etc., then a luminous point will have the appearance of being divided into two, or the shape of a triangle, cross, etc. This occurs at once, when the eye has not yet adapted itself to the distance of the luminous point; but diffuse images will also appear on the retina in the shape of two points, a triangle, a cross, etc. Otherwise, what would be the use of the refracting medium in the eyes of human beings and of numerous animals which forms the planary images of external objects?" (*Autobiographical Notes of Ivan Mikhailovich Sechenov*, published by the U.S.S.R. Academy of Sciences, Moscow and Leningrad, 1945, pp. 174-75.)

This article was first published in 1890 in the magazine *Vestnik Yevropy* (No. 5). In 1896 Sechenov reprinted it in the *Papers of the Physiological Institute of the Moscow University* (Vol. 4, No. 1) after making some changes in the original text. The revised article is published here. p. 422

## OBJECT THINKING AND REALITY

74. The article "Object Thinking and Reality" was published in 1892 in the scientific and literary volume of collected articles *Aid to Victims of the Famine*; subsequently two reprints appeared in Volume II of Sechenov's *Works* (1908) and in the special volume *The Elements of Thought* (1943). In this article Sechenov goes on with the elaboration of the question posed by him in the article "Impressions and Reality" and elucidates the mechanism of the transmutation of impressions into thoughts expressed in words. p. 438

## THE PHYSIOLOGICAL ASPECT OF OBJECT THINKING

75. The article "The Physiological Aspect of Object Thinking" appeared in the *Russkaya Mysl* in 1894. Subsequently, it was reprinted twice without alteration, in Volume II of the posthumous edition of Sechenov's *Works* (1908) and in the special volume *The Elements of Thought* (1943). p. 457

## HERMAN HELMHOLTZ AS A PHYSIOLOGIST

76. The article "Herman Helmholtz as a Physiologist" is the printed text of the paper read by Sechenov at a meeting of the Imperial Society of Friends of Natural Sciences, Anthropology and Ethnography, in November 1894. In the same year it was printed in Russkaya Mysl (No. 12) and was included in Volume II of the posthumous edition of Sechenov's *Works* (1908). p. 467

77. Alexander Humboldt (1769-1859)—*German geographer and naturalist.* p. 468

78. Emil Du Bois-Reymond (1818-1896)—German physiologist and agnostic, Professor at Berlin University. p. 468

79. Alfonso Corti (1822-1876)—Italian histologist, famous for the discovery of the so-called Corti organ—the terminal apparatus of the aural nerve in higher vertebrates.

80. Johannes Peter Müller (1801-1858)—German scientist, Professor, first in Bonn and later in Berlin, physiologist, zoologist, morphologist and embryologist. p. 473

81. In order to prove that the mechanism of conditioned reflexes lies at the base of these "unconscious conclusions", Pavlov examined, from the physiological point of view, the process of perception of the size and volumetrical properties of objects. Summing up, Pavlov said: "Strictly speaking, perception is simply a conditioned reflex, and since Helmholtz had no idea of conditioned reflexes, he referred to them as 'unconscious inferences'. "(See *Pavlovian Wednesdays*, Vol. 2, published by the U.S.S.R. Academy of Sciences, pp. 566-67, and also p. 220 of the present volume.) p. 478

82. In recent years Sechenov's attitude towards the views of Helmholtz has been investigated by Soviet scientists who proved that, notwithstanding the terminological similarity, Sechenov essentially disagreed with Helmholtz on the basic philosophical question and, unlike Helmholtz, he took a firm materialistic stand in the theory of cognition. (See K. S. Koshtoyants, "Sechenov", 1950, M. A. Sverdlin, "Sechenov and Helmholtz's Theory of Symbols". *Papers of the Stalingrad Medical Institute*, Vol. VII, Stalingrad, 1948; V. M. Kaganov, *Sechenov's World Outlook*, 1948, and also page 422, the beginning of §2, and p 455 of the present volume) p. 478

## THE PART PLAYED BY THE NERVOUS SYSTEM IN *MAN'S WORKING MOVEMENTS*

83. This article appeared in 1900 in the magazine *Narodnoye Blago* and was included, without alteration, into Volume II of the posthumous edition of Sechenov's *Works* (1908). p. 479

84. S. P. Botkin (1832-1889)—outstanding Russian clinician and therapeutist. From 1860 to the end of his life Botkin worked at the Petersburg Medico-Surgical Academy. For the first time in the history of Russian medicine he defined the foundations of clinical medicine from the standpoint of natural science. Pavlov was one of Botkin's pupils. Sechenov was a close friend of Botkin, and dedicated many pages of his *Autobiographical Notes* to him. p. 480

## THE PART PLAYED BY THE SENSE ORGANS IN THE WORK PERFORMED BY THE HANDS OF PEOPLE WITH AND WITHOUT SIGHT

85. This article was first published in 1901 in the volume of collected articles, *Aid to the Jewish Victims of the Famine*. It was included in Volume II of the posthumous edition of Sechenov's *Works* without alteration. p. 456

86 The "predetermined harmony of hand and eye movements" of which Sechenov speaks here, is to be understood as a definite co-ordination of the movements of the arms and eyes, which is a vital necessity and develops in man chiefly in the process of labour and is influenced by it. p. 489

87. Sechenov illustrates the possibility of substituting the muscular sense for vision by the example of an ataxic patient. Abundant material has now been published confirming that the functions of some organs can be replaced by those of other organs. These points were convincingly explained from the physiological point of view in the works of Pavlov and his school who specially studied the problem of compensation and who could rely on abundant experimental material in this work. Sechenov's merit is that he was the first to place the question of compensation of the functions of different organs on a strictly physiological basis. p. 490

## TWO CONCLUDING LECTURES ON THE ROLE OF THE VEGETATIVE ACTS IN ANIMAL LIFE

88. *In 1860, shortly after his return from abroad and after defending* the dissertation for his doctorate, Sechenov began his course of lectures at the Petersburg Medico-Surgical Academy. Before the end of the academic year, Sechenov delivered a cycle of lectures on animal electricity. As stated in the *Autobiographical Notes* (1905 edition, p. 106), his "real professional work began at the Medical Academy", in the autumn of the same year. At this time Sechenov always wrote out the text of his lectures and subsequently published some of them. The two concluding lectures, published in 1861 in the *Meditsinsky Vestnik*, are of special interest. In them Sechenov substantiated the link between the organism and the environment, and gave the classical definition of the concept of organism in its unity with the environment which, as we know, is the basis of Michurinist biology (see the last paragraph on page 500). The following names are mentioned in the lectures: Boussingault J. B. (1802-1877)—French chemist and agronomist; Quetelet L.A.J. (1796-1874)—Belgian mathematician and statistician; Bischoff Th. L. (1807-1882)—German physiologist, Dulong P.L. (1785-1838)—French chemist and physicist; Despretz C.M. (1789-1863)—French physicist; Barral J. (1819-1879)—French chemist and agronomist, Regnault H. (1810-1878)—French physicist and chemist, Béclard J (1817-1887)—French physiologist; Traube L. (1818-1876)—German clinician p. 492

## PHYSIOLOGY OF THE NERVOUS SYSTEM
### (Selected Chapters)

89 *Physiology of the Nervous System* is a remarkable work, original in structure and replete with profound physiological ideas. In the preface to this book Sechenov wrote: "What mainly prompted me to write the *Physiology of the Nervous System* was the fact that in all the textbooks on physiology, even in the best of them, the description of nervous phe-

nomena is based on the purely anatomical principle, i.e., the description begins with the functions of the nerve trunks, after which follow the functions of the spinal cord, medulla oblongata, cerebellum and other parts of the brain, and then, in the form of a supplement, the functions of the sympathetic nerve. This method of describing the nervous phenomena suffers from such grave shortcomings that already in the very first year of my teaching nervous physiology I chose a different way: in my lectures I described the nervous acts as they develop in reality. My attempt was successful, and now I submit it in book form to the public for judgement. It was impossible, however, to confine the book to the description of the nervous processes; in this case, its importance for students would be considerably reduced, because along with the nervous phenomena, the students should be acquainted with the general laws governing the nervous processes in the organism. Therefore, in the interests of the students, I have added a general part to the special physiology of the nervous system, the latter constituting the second part of the work. The new in the general part is the attempt to elucidate the way of studying the nervous centres from the general point of view, and, perhaps, the attempt to speak as briefly as possible about matters that are little known to us." *The present volume of Sechenov's Selected Works includes only those parts (§§78,79,80) of the Physiology of the Nervous System which* bear a direct relation to his theory of the "sensory apparatuses" and of their regulatory role in movement co-ordination. The names Matkevich and Türck are mentioned in §80. F. Y. Matkevich (born in 1832)—Russian physician and physiologist, author of a thesis for a Doctor's degree obviously influenced by Sechenov's work and entitled: "Concerning the Action of Alcohol, Strychnine and Opium on the Centres Inhibiting Reflex Movements in the Brain of the Frog" (*Meditsinsky Vestnik*, 1864, Nos. 1-5); Türck L. (1818-1876)—Austrian clinician. p 511

## PROF. SECHENOV'S FIRST LECTURE IN THE MOSCOW UNIVERSITY

90. Sechenov moved from St. Petersburg to Moscow after thirteen years of professorial work at the Petersburg University (1876-1888).

He began his course of lectures at the Moscow University with the theory of the central nervous system, which resulted in the publication in 1891 of his book *The Physiology of the Nervous Centres*.

The first lecture of this cycle was delivered in September 1889 and printed in the magazine *Russkaya Mysl*, 1890, Vol. I, pp. 1-15. p 526

## *PHYSIOLOGICAL STUDIES*

*[Selected passages from separate chapters]*

91. The first edition of the *Physiological Studies* appeared in 1884. This book was rightfully considered, and is still considered, a model of scientific popularisation. Sechenov wrote the following preface to the first

edition (dated September 1, 1883): "The present book is simply a revised and extended edition of public lectures published under the title 'Physiology of the Vegetative Processes'. The new edition differs from the previous one neither in volume, nor in the general character of the exposition. I have only made up for some deficiencies and introduced some changes which reflect the progress of knowledge during the last decade." For the second edition, which appeared in 1898 in St. Petersburg, entire chapters had to be written anew and many parts completely revised. The exposition of the chapter on the sense organs is more complete and profound in the second edition; here Sechenov's interpretation of the sense organs is the same as at the time when he wrote his "Reflexes of the Brain" when he first advanced the concept of analyser. The present volume includes corresponding passages from the *Physiological Studies*, which supplement and develop Sechenov's basic views on the role of the central nervous system, especially of the cerebral cortex, in the vital activity of the organism, as well as his original views on the linkage between sensations and movements, views that retain their validity to this day. G. Valentin mentioned in the chapter "The Sense Organs" was a German physiologist (1810-1883); F. Goltz mentioned in the chapter "The Functions of the Hemispheres" was likewise a German physiologist (1834-1902). p. 545

# NAME INDEX

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