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A. R. Luriya

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Topical and Theoretical Articles by Soviet Psychologists

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A. R. Luriya
(Moscow State University; RSFSR Academy of Pedagogical Sciences;
Burdenko Institute of Neurosurgery, USSR Academy of Medical Sciences)

BRAIN AND MIND

In the last few years great progress has been made in many fields of knowledge. Technology has moved forward with rapid strides, and with the appearance of self-regulating systems it has moved to a new stage. Significant progress has been achieved in physics and biology; new branches of medicine have been formulated and are being developed; and substantial changes have also been noted in a sphere of particular relevance and importance for each of us, in psychology, the science of man's mental life and the laws of his behavior.

First appearing as a branch of philosophy, psychology long ago became an independent study which began to acquire ever increasing importance with the development of technology, medicine, and the social sciences. Psychology has been confronted with entirely new problems: the development and further improvement of human abilities, the scientific basis of instruction and of the formation of moral qualities, and the problem of adapting the models of communications and the control of automatic technical systems to the peculiarities of human perception and thought.

Thanks to the progress of numerous scientific fields, the further development of psychology towards scientific and rational methods of forming and developing mental abilities is possible and assured.

Materialist philosophy has had a decisive influence on psychology. It made possible the rejection of the false isolation of mental from physiological processes, and it facilitated the understanding of mental phenomena as a product of social development. Russian and Soviet materialist philosophy has played an enormous role in the formation of the science of psychology. The classic works of I. M. Sechenov, I. P. Pavlov, N. Ye. Vvedenskiy, and A. A. Ukhtomskiy revealed the reflex nature of mental processes and assisted in understanding the human mind as a system of dynamic activity formed under the decisive influence of the external environment. Finally, contemporary medicine, especially neuromorphology, neurophysiology, and neurosurgery, has made it possible to approach the analysis of the workings of the human brain with accurate methods for the first time. As a result, a new branch of psychology has appeared, neuropsychology, which arose on the basis of the physiology of higher nervous activity, which studies the cerebral bases of mental processes, and whose practical significance in the recognition of the slightest sign of cerebral damage and in the restoration of functions destroyed by brain damage is as great as its theoretical importance.

1

For a long time there survived in psychology an incorrect, idealistic notion which maintained that mental processes such as speech, logical thought, the higher forms of memory, and so forth, were innate "abilities" or immutable "characteristics" of man's mental life. It was precisely these erroneous ideas that served the most reactionary theories justifying the existing inequality between nations and classes by reference to supposedly immutable

characteristics of their mentalities. The assumption that these innate mental characteristics were permanent and could be developed only to a very small extent has proved radically wrong. Contemporary science entirely rejects such reactionary theories.

The development of scientific knowledge of the structure of the higher, specifically human, mental faculties ended the attempt to regard them as immutable characteristics of mental life or as innate qualities of the brain cells given by nature once and for all. Karl Marx already demonstrated that the scientific approach requires another point of view, that man's mental peculiarities are formed in the process of historical social development, and that all five senses are a product of world history. I. M. Sechenov, who saw psychology as "the science of the formation of mental activities," considered all mental processes as determined reflex responses to the influence of external environment. These principles have been developed in Soviet psychology and have been further corroborated by the work of L. S. Vygotskiy, A. N. Leont'yev, and their associates.

The eminent Soviet psychologist L. S. Vygotskiy entirely refuted the old notions which viewed such processes of mental life as volitional actions or logical memory as inherent abilities of man or as "natural" innate properties of his brain. In a series of convincing observations and experiments, he demonstrated that these mental processes are formed during a child's development. They form under the influence of education, of association with adults and the acquisition of mankind's accumulated experience. They begin as forms of external behavior in the child, imitating the adult, and only later do they evolve into the complex forms of the internal mental life of man. As L. S. Vygotskiy said, action which was previously shared by two people becomes the internal means for oganizing the behavior of the child. (1) What were thought for centuries to be inherent forms of "mental life" have turned out to be in fact the result of a complex formation of mental activity in the process of the social development of the child.

The instincts which are formed by the time a child is born (and which are themselves the product of long biological evolution, carried in hereditarily consolidated "codes") cannot by themselves lead to the appearance of the complicated mental "abilities" of the man. For the formation of these mental "abilities" the child must develop in a social environment, in a world of human relations and of things created by social history, in continual association with adults.

While still in its early stages, Soviet psychology proved in many studies that the basic mental processes were formed under the influence of activity in social conditions. L. S. Vygotskiy and A. N. Leont'yev demonstrated that active attention and conscious memory are formed in that manner.

While the child in the first stages of development only notices bright or novel objects, is unable to concentrate on them for long, and his attention does not go beyond what I. P. Pavlov called the simple "orienting reflex," later on the child begins to notice objects which appear in his association with adults and the orienting reflex becomes an intricately organized, conscious, oriented-experimental activity. The child discriminates those objects which are the purpose of his activity, he points to them and defines them by speech. External actions and speech are here auxiliary means of sustaining attention. Gradually their external form becomes unnecessary, and the objects that occupy the child are discriminated with the aid of inner speech. He steadily begins to control his actions, and the active attention which is specific to man arises, controlling the flow of his mental processes.

The complex forms of human memory follow a similar path in their development. It is well known that a child is born with a highly developed capacity for consolidating the impressions he receives from his external environment. However, this consolidation is initially involuntary; it is determined by the immediate impressions the child receives and by his emotional experiences; the child still cannot actively remember necessary material or consciously discriminate it from the total mass of impressions impinging upon him.

Only as the child develops, through his activity with objects and his association with adults, does the information reaching him begin to acquire an orderly character. From this information he distinguishes the object of his activity and what he must avoid. Whatever does not enter his activity is pushed aside and is not committed to memory. A special "activity of memory" appears and forms the active, selective memory which is specific to man.

As many experiments of Soviet psychologists (A. N. Leont'yev, L. V. Zankov, A. A. Smirnov, P. I. Zinchenko, etc.) have shown, the development of this active memory goes through certain steps.

In each of these cases there appears a system of internal mental processes, social in origin, mediated in structure, and relying on a system of verbal connections. It is precisely these processes, creating complex human "abilities," that distinguish

1) L. S. Vygotskiy, Izbrannye psikhologicheskie issledovaniya, Izd-vo Akad. Ped. Nauk, M., 1956; Razvitie vysshikh psikhicheskikh funktsiy, Izd-vo Akad. Pedag. Nauk., M., 1960.

the mental activity of man from the immeasurably simpler processes of animal behavior.

Research into the higher mental functions of man, demonstrating their social nature and complex mediated structure, began in the first decade of Soviet psychology. The results then achieved were generalized in such valuable works as Thought and Speech (1934) and The Development of the Higher Mental Functions (written in 1930, published in 1960) by L. S. Vygotskiy, and The Development of Memory (1931) by A. N. Leont'yev. The fundamental lines laid down by these works have been continued in many other studies. Thus the works of A. N. Leont'yev showed that all conscious human mental processes are not innate "properties" or "abilities," but complex forms of mental activity which evolve during the lifetime of the child as he masters the historical social achievements of mankind. Even such abilities, elementary at first glance, as the discrimination between speech sounds or musical tones are formed by man as he acquires language or reproduces music. "Only music," as Marx wrote, "awakens the musical sense of man."

These propositions served as the starting point for many Soviet psychological investigations. In recent years a whole series of experimental works by P. Ya. Gal'perin, A. V. Zaporozhetz, D. B. El'konin and others have appeared, showing that such complex mental phenomena and processes as abstract concepts and volitional actions are formed by the dynamic activity of the child. These phenomena, formed historically through social practice, appear in the child as he absorbs and masters social experience. Studies have demonstrated that such processes go through a series of steps: thus, what are initially practical actions later become, thanks to verbalization, those "internal" phenomena of consciousness or "mental operations" as we know them in the psychology of the adult.

The study of the history of human "mental operations" and the proof that they are the product of a long development of mental activity is one of the most important achievements of Soviet psychology. It provides a scientific basis to argue against the centuries-old and totally false ideas of mental phenomena as "inherent" properties or "immutable abilities" which are still the defense of idealistic, positivist psychology abroad.

The new materialist ideas of human mental activity give scientific psychology enormous practical significance, for they allow us to work out a scientific basis for the formation of human mental properties or faculties in the process of rationally constructed education. In our socialist society, organized instruction and education are widespread in all aspects of life, and they are continually acquiring a more scientifically based character. The science of psychology has begun to play an ever increasing role in the scientific foundation of forming human capabilities.

There is no longer any doubt now that the inborn "properties" of higher nervous processes (their strength, equilibrium, mobility), which I. P. Pavlov indicated and which have been successfully studied in recent decades by B. M. Teplov and his associates, are merely "instincts," merely the internal conditions vital to the development of the higher forms of mental activity. These higher mental processes (conscious perception, dynamic attention, logical memory, volitional action), just as the complex forms of abstract conceptions and habits, are formed in the course of mastering social and historical experience through the influence of training and education. B. M. Teplov and his associates have shown that this is the reason people with different innate properties of the nervous system, with unequal strength and mobility in their neural processes, using different methods of work can still achieve successful results in learning and working. Among the pace-setters in production, science, or culture, one can meet people with the most varied temperaments or the most diverse innate properties of their nervous system.

By assiduously studying the main laws and stages of the formation of mental processes, Soviet psychology provides us with the opportunity to control these processes on a scientific basis.

A series of special investigations has shown that such processes as learning to read or count, the formation of geometric concepts or productive habits (conducted by P. Ya. Gal'perin and others), go through a progression of successive stages, from extensive material actions to intensive mental actions. Soviet psychology has worked out a system of "programmed mastery" of such knowledge, abilities, and habits. By doing so, it has also proved that conditions can be created which will give instruction a scientific foundation and will ensure a significantly faster, more consistent, and more solid formation of knowledge and habits than was true before.

The role of new scientific ideas in the practice of forming human mental processes testifies to the boundless possibilities opening up before us. We are beginning to approach the solution to a complicated task, the formation of human capabilities on a scientific basis.

2

The radical change of our notions of the essence of mental processes led inevitably to a radical reconstruction of our conceptions of the material substratum of the mind, i.e., the human brain as the

organ of mental life, its structure and methods of functioning.

When human mental processes were regarded as innate and immutable "abilities," students tried to find their substratum in permanently fixed parts or centers of the brain which were supposedly the carriers of these "abilities." It was widely considered that if people had these "abilities" in varying degree, then the difference lay in the cerebral convolutions. These mistaken ideas were used by reactionary anthropologists who spoke of "higher" or "lower" races, and about the "intellectual inferiority" of Negroes, the American Indians, or members of the yellow race. Attempts were frequently made to show that representatives of these people had smaller brains, that the cerebral convolutions of Negroes were different from those of whites, and so forth. All these efforts, devoid of any confirmation, (2) originated in the antiquated notion of the human mind as the manifestation of innate "abilities."

Representatives of the reactionary wing of foreign psychiatry and neurology have even tried to find a base in natural science for religious feelings. They strove to isolate this complex social-psychological phenomenon in particular portions of the cerebral cortex; the famous German psychiatrist K. Kleist attempted to indicate the cerebral convolution which controlled the religious "ego" of man.

Scientific ideas of the nature of mental processes reject such fantastic conjectures, whose reactionary substance is evident. They allow a new approach to the problem of the brain's functioning as the organ of human thought. The notion that the basis of mental activity is the work of innate "centers," fixed forever, has proved untenable. Science has clearly shown that the human brain is a system combining different parts of nervous tissue, whose joint work allows very complicated analysis and synthesis of the phenomena of reality and regulates the most complex forms of active human behavior.

This is the core of contemporary scientific study of systematic or dynamic localization of functions in the brain; the bases of this study were established by I. P. Pavlov, and it has been powerfully furthered in the last decade.

In every age the study of the brain and its workings has been connected with the notions which predominated in the science and technology of the time.

Three centuries ago, as a result of the major achievements in mechanics and hydrodynamics, the mechanical model of the world was dominant. Descartes thought the material basis of mental life lay in a special liquid secreted by the pineal gland which circulated through the neural channels.

Electricity occupied a leading place in nineteenth-century science, and the brain was considered as a central station which worked like a telephone switchboard. The predominant idea in all physiological constructions of the last century was the "reflex arc," by which excitations from outside reached the brain, where they were "switched over" to new routes and were directed to the periphery.

Currently the study of self-regulating systems, of systems of automatic control, is being developed. The work of such systems, constructed on prepared programs given to them, does not require the constant transmission of external signals. Through feedback they can regulate the processes going on within them. The ideas at the base of self-regulating systems gave an impetus to the re-examination of old concepts and the elaboration of new ones concerning the most complex forms of brain function, which, as I. P. Pavlov defined it, is "the highest self-regulating system."

More and more the brain has come to be considered a very complicated system of separate parts, or "blocks," each of which has its designated function. Their joint work allows us to receive information from the external world, to create a subjective image of the objective world, to predict the future, to evaluate the results of our actions, and to regulate our behavior. This conception has been formed by the achievements in the precise anatomy of the brain in contemporary physiology, psychology, neurology, and neurosurgery. Observations of the workings of the human brain and of the changes resulting from injuries to it gave us the opportunity to compare our notions of its workings with precise anatomical data.

Let us briefly examine the basic systems on which the workings of the brain rely.

The first system, or the first "block," that makes up the complex apparatus of the brain, has been studied in detail only in the last ten to fifteen years. Its fundamental function is the maintenance of a certain alert condition in the cerebral cortex, to make it an apparatus capable of receiving information and regulating active behavior.

This system maintains the cerebral cortex at a working level, but it is not in itself an apparatus to receive information from the outer world and to realize a directed regulation of behavior. This is

2) Many studies by progressive psychologists and anthropologists have convincingly demonstrated this. For instance, the prominent American psychologist O. Klineberg, in recent years the president of the International Association of Scientific Psychology, cited a case where similar prejudiced conclusions on the part of reactionary scholars were easily exploded by objective verification. Vide O. Klineberg, Social Psychology, N. Y., 1948.

not an autonomous system. It is constantly under the regulating influence of higher systems of the cerebral cortex, which receive and process information from the external world, and which determine the program of man's dynamic activity. Other sections of the cerebral cortex, more complicated in their structure, fulfill those functions.

The bulk of these sections can be conditionally called the second system (or the second "block") of the brain. They serve to receive, process, and store information reaching man from the external (and partially from the internal) environment. This system is distributed over the anterior sections (occipital, parietal, and temporal) of the cerebral cortex. I. P. Pavlov called these sections of the cortex the cortical ends of separate analyzers, or, to put it differently, of the instruments ensuring the analysis and synthesis of signals arriving from the external world.

The structure of these cortical sections of the different analyzers is now well known.

The cortical sections of the visual analyzer are located in the occipital sections of the cortex, of the cutaneous in the parietal (post-central), and of the auditory analyzer in the temporal sections.

The precise anatomical construction of these sections of the cortex is of special interest. In each of them the primary, or projection, zones occupy first place; here end the fibers that proceed from the peripheral apparatuses — the eyes, skin and ears — and bring information from these instruments to the cerebral cortex. The primary zones of these regions of the brain consist of a highly developed fourth (afferent) layer of minute nerve cells which receive incoming excitations and transmit them both to neighboring cells and to the more complicated secondary zones of the cerebral cortex. The bulk of these zones consists of special nerve cells of the upper layers of the cortex; they receive impulses from the primary cortical areas and ensure a protracted circulation of spheres of excitation within the cerebral cortex. These dynamic systems of excitation, circulating in the cortex and themselves under the constant tonic effect of the reticular formation, form the basis for processing (by analysis and synthesis) of information received, and for storing the "short-term" and "long-term" memory traces evoked by it; their biochemical mechanisms are now under careful study by several Soviet and foreign investigators.

Above the secondary zones of the cerebral cortex are yet more complex tertiary zones, or, as they are commonly called in modern science (by G. I. Polyakov and others), the "reclosure zones" of the cortical sections of the analyzers. These zones, distributed between the visual, auditory, and general sensory sections of the cortex, mature later than the rest. They consist for the most part of associative neurons, nerve cells with short endings that are based in the second and third layers of these areas. The nerve cells of these sections consolidate the excitations coming to the cortex from the perceptual instruments. This permits complex cognitive processes which require the simultaneous participation of several analyzers.

Special experiments and observations, possible thanks to contemporary neurosurgery, have shown the role that these areas of the cortex play in the reception, processing, and storage of information.

Scientific observations indicate that while the human brain is the organ of our feelings, it is itself indifferent to painful sensations. It can be touched, stimulated by an electric current, even cut, but the person on the operating table feels no pain. This circumstance allowed a series of observations of patients under brain surgery for epilepsy, tumors, and cerebral injuries. The observations confirmed that stimulation of various parts of the cortex gives different results.

If the primary (projection) zones of the occipital region of the cortex are stimulated by an electric current, the patient begins to feel that there are sparks or tongues of flame before his eyes, or that the air takes on some kind of color. But he does not see any formulated images. If the secondary portions of the occipital region of the cortex are stimulated in the same way, then matters change. Complex, formulated, sensible visual hallucinations arise before the patient; he begins to "see" objects, familiar people, and sometimes whole scenes.

Similar phenomena occur when different parts of the temporal region are stimulated. When the primary sections of the temporal cortex are stimulated, the patient hears separate tones. Stimulation of the secondary areas of the temporal cortex produces complex auditory hallucinations (and sometimes visual, as well). Still more complex mental phenomena arise by stimulating the tertiary areas of the cortex.

Thus, the primary zones of the cerebral cortex really do play an essential role in receiving, and the secondary and tertiary in processing (by analysis and synthesis) and storing, information coming from the sense organs.

Equally valuable are observations of patients with brain damage (injuries, tumors, hemorrhage) that upsets the normal functioning of the cerebral cortex.

All this testifies that very complex mechanisms control the reception, processing, and storage of information in the human cerebral cortex. This complex of areas of the cerebral cortex which has just been described, and which is the basis of complicated cognitive processes, does not, however, exhaust all the cerebral apparatuses that

make up the material substratum of mental activity.

There is also a third system (or third "block") which plays a very special role in the accomplishment of mental processes. This area relies on the working of the frontal zones of the brain (especially the frontal lobes), and handles the processes of programming human activity, collating the effect of action with the initial intention, and regulating and controlling mental processes.

Human actions, like those of animals, are always deliberate, directed towards a specific goal. The fundamental difference between the two cases is that an animal's actions are determined by its biological requirements, while human actions are guided by conscious (i.e., formed in the process of social life) intentions and complex social motives.

Two conditions are important to maintain deliberate behavior, directed towards a definite purpose. First, a behavioral program, formed by these motives and intentions and usually formulated in external or internal speech, must be firmly fixed in the memory and direct the course of actions. Secondly, the effect of these actions must be collated with the initial intentions. If the result of the action corresponds to (agrees with) the initial intention, the tonus of the cortex drops and the action ceases. If the result of the action does not correspond to the intended aim, the cortical tonus rises and the action continues until the required aim is achieved. This process has been dubbed by P. K. Anokhin, prominent Soviet psychologist, the "action receptor" mechanism; it is reminiscent of the processes in quick operating electronic structures, for it ensures the self-regulation of human behavior.

In the early stages of animal evolution (among the lower vertebrates), where behavioral processes are mainly of an instinctual character, this self-regulation is realized by apparatuses of subcortical formations and ancient (so-called limbic) sections of the cerebral cortex. (3) Man's behavior is guided by socially formed motives and relies on a system of speech signals which I. P. Pavlov called "the second signal system of reality"; the major role in regulating human behavior is played by the most intricately constructed regions of the cerebral cortex, especially the frontal lobes.

Anatomical and electrophysiological studies have shown that the frontal lobes of the brain have intimate connections with all the other parts of the cerebral cortex and the subcortical formations. Information that has already been processed in the other regions of the cerebral cortex is fed into them. At the same time the frontal lobes enter into the composition of those apparatuses of analysis and synthesis of our voluntary movements that I. P. Pavlov called the cortical ends of the motor analyzer, and they are closely connected with the speech zones of the cerebral cortex. Finally, they are very closely tied with the reticular formation and the autonomic nervous system which permits them to assess signals from the internal environment of the organism. This also allows the frontal lobes of the brain, the most intricately constructed and the youngest apparatuses of the cerebral cortex, to ensure the synthesis of incoming information, to create complex behavioral programs, and to collate the results of completed actions with the initial intentions.

The functions of the frontal lobes of the brain are shown with special clarity in observations of the changes that occur in human behavior when they are disturbed as the result of some pathological process.

As a rule in such cases the sight, hearing, and cutaneous sensitivity of the patient remain unchanged. He can still speak, write, and read, but his behavior as a whole is profoundly disturbed. Such patients cannot create and maintain complex behavioral programs. They have no fixed purpose and are easily distracted by any minor irritation. While remembering instructions given to them, these people do not regulate their behavior by means of speech, and even while repeating verbally the instructions they have grasped, they do not execute them by a series of consecutive actions. They cease to collate the completed action with the initial intention, they neither notice nor correct their mistakes, and they are deprived of the chance for self control which is the most important condition of the normal determination of behavior. As a result of all this, their actions lose deliberateness and fall under trivial extraneous influences.

It is easy to see the significance of each of the three systems of the brain: the first maintains the necessary tonus of the cortex; the second receives and processes incoming information; and the third acts as the programming and checking mechanism to ensure the intentional and goal-directed nature of behavior.

Such are the basic conceptions of the structure of the main systems of the human brain on which contemporary science bases its understanding of the material foundations of human mental activity.

3

The new knowledge of the structure and function-

3) This term applies to those sections of the cortex found on the internal surface of the hemispheres and which are well developed even in the lower mammals. The eminent Soviet neurologist I. N. Filimonov has devoted many years to their investigation.

ing of the brain permits substantial advances in resolving the most important theoretical and practical problems of psychology and medicine that scientists are pressingly faced with.

First comes the problem of the concrete analysis of the material bases of mental activity and of the factors contributing to separate mental processes.

Psychologists have closely studied human mental activity and have made significant progress in the investigation of the basic stages of its development. However, both the cerebral bases of concrete mental processes and the physiological factors that determine their course are still insufficiently clear.

Which mechanisms of the brain are responsible for voluntary movement, speech, human reasoning? Which factors (or physiological components) are they comprised of? The new conception of the brain as a complex, self-regulating system allows a direct approach to the solution of these problems. Now it is quite evident that there are no special "centers" in the cerebral cortex that could be considered as the material substratum of complicated mental "abilities." The complex processes that form the basis of mental activity always rest on a whole "functional system" of cerebral zones working in cooperation, and each zone has its own specific role in this working partnership of "centers."

In order to complete a voluntary movement or to form a habit of movement it is imperative to create the spatial "matrix" within which the movement should flow. This is ensured by the secondary and tertiary fields of the occipital-parietal cortical areas, which are the cortical ends of the visual-spatial analyzer. If these portions of the brain are destroyed, the spatial schema of movement disintegrates.

However, the participation of the above mentioned systems of the cerebral cortex is not sufficient to ensure the proper flow of movement. The prominent Soviet physiologist N. A. Bernshteyn has devoted many years to the study of human movement, and he has shown that its proper organization requires the constant input of impulses of deep sensitivity that signal the position of extremities in space; without them movement becomes uncontrolled. The analysis of such signals received in the brain from the muscles and joints is performed by another system of zones in the cerebral cortex, found in the posterior region of the hemispheres (the cortical apparatus of muscular-articular sensitivity). Therefore, damage to these areas of the cortex not only reduces sensations of the position of the body's extremities but also causes uncontrolled movements.

But even these cortical systems are insufficient to ensure well organized movement and a properly formulated motor pattern. A system is also needed that switches one link of movement to another and ensures the formulation of a planned series of movements comprising a motor pattern. Research in our laboratory in recent years has shown that this is ensured by other portions of the cerebral cortex, found in front of the central anterior convolutions (the so-called pre-motor zone) and closely connected with the subcortical motor ganglia. If these sections of the cerebral cortex are disturbed, it becomes more difficult to switch from one link of movement to another, coordination is impaired, and movement sometimes becomes a chain of separate, isolated motor fragments.

Finally, it is known that the flow of movement, or a complex motor pattern, is subordinated to a corresponding program, which regulates the order of motor acts and prevents us from slipping into additional acts that are not part of the program. The formulation and storage of such a program, and also the collation of completed actions with the initial intention, are the function of the frontal areas of the brain, whose significance in the flow of processes in the higher nervous system has just been explained. Damage to this system makes the program of deliberate, goal-directed motor acts uncertain and they are replaced by accidental additional movements without meaning.

Thus, it would appear, a simple motor function is actually a complicated functional system, resting on a complex of cooperating cortical zones.

The analysis of the functions of the separate systems of the cerebral cortex that participate in the completion of complex mental processes does more than merely show what an intricate combination of cerebral instruments is involved in the normal completion of voluntary action, active perception, or directed, logical thinking. It also allows us to trace the factors which lie at the base of different forms of mental activity and at the same time to distinguish between externally similar forms of mental processes and to find common aspects in those processes that seem at first completely different.

Such an opportunity is provided by the analysis of alterations in mental processes from limited (local) damage to the brain, which is possible by the progress of modern neurosurgery.

We have already said that the different parts of the cerebral cortex are the "cortical ends" of different analyzers and that each has its own strictly specialized function.

Observations have shown that if any portion of the cerebral cortex maintaining one of the special conditions for the normal flow of mental processes is destroyed, then all forms of mental activity into which the corresponding factor enters are disturbed. Those forms of mental

activity which do not contain this factor are preserved.

For example, if the occipital-parietal sections of the left hemisphere of the cerebral cortex are damaged, then not only is spatial orientation disturbed, but also operations with geometrical relations, mental counting, and the analysis of some grammatical constructions (all of them must maintain simultaneity of spatial syntheses). However, fluency of speech and the perception of musical tones remain intact (for this factor does not enter here). On the contrary, these latter processes are disturbed if the temporal sections of the cerebral cortex are damaged (for they depend on the synthesis of elements in consecutive series), but the earlier mentioned spatial operations remain intact.

Such neuropsychological observations are of great importance for the analysis of the structure of mental processes. They enable us to move forward in that field of scientific psychology known as "factor analysis." This field is devoted to the study of the internal composition of complex mental processes; before, it only used the involved methods of mathematical statistics, but now, thanks to the achievements of neuropsychology, new, supplementary paths are opening up.

Progress in neuropsychology does not merely present new opportunities for further advances in materialist psychology. It also contributes to the solution of important practical problems of contemporary medicine, especially in neurosurgery.

It is well known how tremendously important it is in neurosurgery to make a precise and quick diagnosis of the location of a brain tumor or cerebral hemorrhage; the patient's life often depends on it. However, such diagnosis is often very difficult. Often standard neurological examination cannot indicate with sufficient precision the location of damage to the cerebral cortex. In these cases neuropsychological examination acquires great importance. Methods of such examination have been worked out over the last decade as part of the general clinical analysis of the patient; they establish the character of disturbance in one or another mental process, caused by local damage to the brain, and improve the topical diagnosis of the cerebral damage.

A second practical field that has undergone considerable development as a result of the progress in contemporary neuropsychology is the creation of new ways and methods to restore functions disturbed by local damage to the brain. By tracing the structure of complicated mental functions, and by observing how such processes as speech, writing, reading and counting are redistributed after disturbances as a result of crucial damage to the brain, neuropsychology can indicate possible ways for their restoration, and can work out scientifically based techniques for the compensation of defects.

Work on the restoration of cerebral functions disturbed by local damage to the brain is one of the most difficult tasks in medicine and pedagogy. The development of materialist neuropsychology is giving this important field its scientific basis.

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This article has dealt with only a few aspects of the development of modern Soviet psychology and its practical applications. However, in addition to general and neural psychology, other important branches of Soviet psychology have been developing recently. Rapid strides have been made in engineering psychology — the study of the activity of an operator and of the interrelations of man and machine. Educational psychology has been moving forward, promoting the programmed assimilation of knowledge, and greatly improving the processes of instruction. Wide horizons are being opened by the study of creating models of mental processes; such work resolves the problem according to the different level of their construction, and even goes to the level of examining the properties of separate neurons. Soviet psychologists studying the phenomena of "set" [ustanovka] have come up with original ideas.

There is no doubt that progress in these fields will make important contributions to the development of Soviet science, and that its achievements will be of use in the practical building of communism.

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