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A Neurophysiological Analysis of Human Behavior

by
P.V. Simonov

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INTRODUCTION

Characteristic of the Russian scientific tradition, associated with the names of M.Sechenov, I.P.Pavlov, A.A.Ukhtomsky, L.S.Vygotsky, A.R.Luria and their pupils and followers, is a strong connection between the study of brain function and psychology based on the principles of philosophical materialism. "The new psychology is closely connected with physiology," said V.I.Vernadsky (1975:104) with the shrewdness so characteristic of him. I.P.Pavlov wrote: "It seems to me that for psychologists... our research must have great significance, because in future work it will constitute the core of psychology... The basic laws underlying the immense complexity we see in human inner life will be discovered by physiologists in the not so distant future" (Pavlov, 1951:105-106).

The ideological basis behind the alliance of psychology and physiology is dialectical-materialistic monism, a heuristic definition of which was so brilliantly formulated by L.S.Vygotsky. "The inability of the old school of psychology to solve the problem of the psyche was basically due to its idealistic approach, in which the psyche was considered separate from the whole process of which it is a part; the psyche was held to be an autonomous process, existing apart from and on a level with physiological processes ... We must not study psychic and physiological processes separately and disjointly, lest they become incomprehensible; we must take the process as a whole, characterised by its subjective and objective sides simultaneously" (Vygotsky, 1982:137). The idea of dialectical monism is now supported by scientists from a wide range of disciplines engaged in the study of man: philosophers, psychologists, and researchers into the function of the brain. The psyche and its neurodynamic equivalent, according to the philosopher D.I.Dubrovsky (1982:69), "do not only coexist, but are inseparable in their existence." Quoting the well-known opinion of F.Engels, who said that movement in its broadest sense is a form of material existence and includes consciousness and thinking, the psychologist Y.A.Ponomarev concludes: "Engels ascribed the psyche to material interactions, and this is

the only correct and strictly scientific position leading to the consistent application of the principles of dialectical materialism in every area of knowledge. If only the science of psychology, guided by these principles of dialectical materialism, had concentrated all its efforts on the development of these principles, it would undoubtedly have gained greater success" (Ponomarev, 1983:113). At the VIIth International Congress on Logic, Methodology and Philosophy of Science in Salzburg (1983), K.V.Wilkis presented convincing arguments in favour of the idea that "pure psychology" ignoring the material basis of the psyche lacks a long-term future, and without the support of neuroscience it cannot develop a theory of intellect (Kelle, Naletov, and Sokolov, 1984).

At the same time the recognition of the integrative nature of psycho-physiological processes does not lead to the abandonment of a systems approach to the study of the psyche or those aspects of its analysis which characterise the psychology and physiology of higher nervous activity. I.P.Pavlov himself pointed this out: "First of all we have to understand things psychologically, and only then transfer this knowledge into the language of physiology (Pavlov, 1954:275). A similar view is also shared by A.R.Luria: "Before answering the question of what the brain basis of any psychic process is, we must carefully study the structure of the psychic process whose cerebral organisation we would like to establish, and identify those links within it which can more or less be associated with specific brain systems" (Luria, 1973:76).

The same methodological principles underpin our approach to the description of the fundamentals of general psychology, taking into account the present state of research into the science of higher nervous activity. What are the characteristic features of this field on the threshold of the 21st century? Which of its results offer the possibility of a solution to problems which are important to psychology? How do the theoretical baggage and methodological arsenal of this science differ from those at the time of Pavlov's death and immediately afterwards?

The most important difference is that the study of animal behaviour has left the realm of laboratory experiments and turned to the analysis of the complexity of behaviour of a wide variety of animals in their natural habitats. The study of brain mechanisms in the case of a small number of relatively simple forms of behaviour is increasingly becoming synthesised with the ethological analysis of complex forms of behaviour, as well as with the biology of evolution. These three fields, which were for a

long time developing almost independently of each other, have now been recognised as closely related and requiring interdisciplinary investigations (Marler and Terrace, 1984). The essence of such interactions was clearly formulated by R.Galambos: "It is possible to prove that the following three problems are closely interlinked: (1) how the nervous system is organised at the time of embryogenesis, (2) how it encodes the innate properties of all types of reactions, (3) how it eventually becomes reorganised as a result of life experience. If this is correct, then solving one of these problems would mean that the answers to the others will fall into our outstretched hands like a ripe plum" (Galambos, 1961).

The evolutionary aspect was accorded primary importance in the science of higher nervous activity under the influence of ethology and the biology of development. From the moment of its birth the physiology of higher nervous activity has been inseparable from Darwinism and evolutionary theory. It suffices to mention the names of I.P.Pavlov, L.A.Orbeli, Kh.S.Koshtoyants, E.A.Asratyan, L.G.Voronin and many others. The close attention of present research has been drawn to two problems: (1) the points of similarity between the regularities of individual learning and the development of the world of living organisms, and (2) the role of the individual activity of these organisms as links in the evolutionary process as a whole.

One of the first to express the idea of a similarity between the "creativity of nature" (the emergence of new forms of life) and the activity of the individual brain was K.A. Timiryazev (1939). The view that learning is a selection process was shared by I.P.Pavlov.

Pavlov wrote: "Those combinations of actions directed at objects (manipulations of objects) which achieve a goal become fixed and those which do not are discarded... At first a movement which produces the required alteration in the position of surrounding objects is accidental, but when it is repeated with continual approximation to the goal it becomes fixed and can be reproduced in reverse order by the animal itself, as in the case when a paw is raised and this is reinforced with food..." (Pavlov, 1975:93-94). Later the analogy between learning and evolution was studied by J.Pringle (1951), W.Russel (1961), P.V.Simonov (1966), A.A.Malinovsky (1969), K.Popper and J.Eccles (1977). "Obviously there is no principal difference between choice and natural selection, the only difference is that choice is a function of the brain," wrote Volkenstein (1970:71).

Recently this topic was fully discussed in a special edition of the journal Behavioral and Brain Sciences in

connection with the reprinting of B.F.Skinner's article "Selection by consequences" (Skinner, 1981,1984). The discussion produced both fervent supporters of Skinner's ideas, calling him "the Darwin of ontogenesis", as well as harsh critics of the concept which was proposed. The weakest point in this concept is the absence of any solid evidence for a mechanism which generates completely new material for the next selection, a consequence of which is that "the ability to create is no more than accidental variation of present experience" (Hallpike, see Skinner, 1984:489). As possible candidates for the role of "psychic mutations", authors have variously suggested the so-called substitute activity which arises in animals and humans when they are unable to solve a difficult problem (Dawkins, see Skinner, 1984:487), and the spontaneous discharge of neuronal complexes or the labile connections between them in developing organisms (Changeux, Heidmann, and Patte, 1984). In what follows we shall try to establish that the missing link in theories of learning as a process of selection can be successfully bridged by A.A.Ukhtomsky's theory of the dominant and its physiological mechanisms.

In contemporary views of the noosphere (in the terminology introduced by V.I.Vernadsky), individual learning and creativity are frequently presented as a link between genetic (biological) and cultural evolution (Plotkin and Odling-Smee, 1981; Lumsden and Wilson, 1982). Consequently, the evolution of nature is seen as a unified process in which, in the words of Karl Marx, "history is a *real* part of the *history of nature*, of human involvement in nature" (Marx and Engels, 1956:596). The success of ontogenetic adaptation to an altered environment, its direction and speed of phylogenesis are determined by feedback mechanisms (Gilyarov, 1981). For example, simple organisms are eliminated by predators in a non-selective manner, so their evolution is very slow. Higher organisms, which are capable of active resettlement and self-defence and the learning and development of skills are eliminated selectively according to the effectiveness of their actions, and consequently their evolution is faster. The dependence of evolution on events played out at the ontogenetic level led D.K.Belyaev to perceive stress (including emotional stress) not only as a factor of selection between stress-resistant and stress-prone individuals, but also as a factor enriching the diversity of material with which natural selection works and hence speeding up the process of evolution (Belyaev, 1979;1981).

Contemporaneously with advances in the conceptual basis of the science of higher nervous activity there occurred an

enrichment of the arsenal of methods by which brains, including the human brain, could be studied. By this we mean first of all the development of methods for recording a variety of electrical activities in the brain: cumulative EEGs, evoked potentials, and even single-cell activity, with computerised quantitative analysis. In some cases the application of stereotactic neurosurgery made it possible and clinically justifiable to utilise implanted electrodes for direct stimulation of brain structures during therapeutic-diagnostic procedures, a technique which enlarged our knowledge of the functions of deeper brain structures (Heath, 1963; Sem-Jacobson, 1968; Delgado, 1969; Bekhtereva, 1971; Smirnov, 1976). Finally, advances in neurochemistry and psychopharmacology bring us ever closer to an understanding of mental processes on a molecular-biological level. Higher nervous (psychic) activity and behaviour are no longer declared to be "a function of the brain as a whole": the analysis of specific manifestations of human higher nervous activity is being linked with ever increasing success to the interaction of specialised brain structures. However limited might be our knowledge of the structures and functions of the human brain and the laws which govern its activity, nevertheless with the support of this knowledge we can now use a new approach to a range of questions which lacked satisfactory answers within the bounds of psychology, or which were sometimes not even posed at all because their key importance and theoretical and practical value were underestimated. What questions are these?

1. While recognising the driving role of needs in human behaviour, we lack a sound classification of them, traditionally limiting ourselves to a division of needs into material and spiritual, natural (biological), and cultural (historical). Bearing in mind that all human needs are socially determined and that they are qualitatively different from the needs of animals, we are convinced that one of the reasons for this state of affairs is the failure to make "a systematic study of inborn reactions" (I.P.Pavlov). As a consequence, human needs are deprived of their natural prehistory in the prehuman period of evolution and the principle of *historicism* is violated - a fact which motivated V.I.Lenin to include the "history of mental development of animals" in the list of areas of knowledge on which the theory of cognition and dialectics should be based (Lenin, Complete Collection of Works, vol.29, 1963:314). "... The mere fact that human beings emerged from the animal kingdom," wrote F.Engels in "Anti-

Düring", "determines that human beings will never be able to free themselves completely from the characteristics of animals, and as a consequence we can only discuss whether these characteristics are present in greater or lesser degree, we can only discuss the different degrees of animality or humanity" (Marx and Engels, 1961:102).

2. As a particular example of this underestimation of the role of needs and their phylogenetic prehistory, we can cite the interpretation of will as conscious self-regulation by an individual of his behaviour and activity, as a capability which emerged solely at the human stage of evolution. In other words, will is described as a kind of "super-regulator" intervening in the competition of motives and determining which need will become the governor of behaviour. We must emphasise that this view of the will as a purely cognitive, rational process totally debilitates our attempts to develop practical methods for educating will; these methods are usually limited to appeals for "conscious self-regulation of behaviour".

3. The predominant notion of emotion as a unitary, indivisible psychic process leaves the question of the definition of "emotion" still open, even a hundred years since the question was posed by William James. In a comparatively recent article "Les théories des émotions", Bernard Rime expressed his view on the state of study of emotion as extremely unsatisfactory, as the study of "disparate pieces of knowledge unsuitable for the solution of real problems" (Rime, 1984). To this day emotion is regarded sometimes as a worthwhile goal that induces us to strive for "experiences" per se, including the experience of negative emotions, and sometimes as a subjective reaction to objective phenomena which does not reflect these phenomena, since there are no "stereotypes" for emotions in the objective world. The absence of a clear answer to what sort of objective reality is reflected by emotions is compensated for by the use of phrases like "value orientation", "meaningful experience", "personalised meaning", etc.

4. The physiology of higher nervous activity is the study of neurophysiological mechanisms of psyche and behaviour, based on the principle of reflexes. But the reflex theory of behaviour is sometimes rejected on the pretext that it is passive and unable to explain the active, creative character of human activity. It is forgotten that in its present state the reflex theory is a dialectic unity

of active and reactive, creative and reflective, relying on previously accumulated experience and using this as a basis for predicting future possibilities. The role of needs in initiating behaviour and the synthesis of the mechanisms of the dominant with the mechanisms of conditioned reflex formation account for the two factors which are necessary and sufficient in the organisation of purposive behaviour: its active, creative character (the dominant) and its precise correspondence with objective reality (the established and finely specialised conditioned reflex).

5. The slow progress of research into individual (typological) characteristics of higher nervous activity can be explained by the fact that this research was for a long time based on the analysis of properties of basic nervous processes - excitability and inhibition, i.e., it was directed towards the functioning of nervous activity at the cellular level. However the ineffectiveness of attempts to connect neurons directly with behaviour and psyche gradually became clear (Eccles, 1980). It is now obvious that between a cell and behaviour there is a layer of events which are the result of interactions between specialised macrostructures of the brain. The outlines of the new typology are being drawn on the background of the individual characteristics of these interactions.

6. The discovery of the functional asymmetry of the human brain, the use of the method of evoked potentials and the recording of the electrical activity of the brain while its functions are being restored after the comatose state have brought us significantly closer to the elucidation of the nature and neurophysiological basis of consciousness, as well as of unconscious manifestations of psychic activity. Consciousness has ceased to be an exclusively philosophical problem, having been transformed into an object for experimental neurophysiological analysis.

7. Research into the nature and interaction of conscious and unconscious manifestations of higher nervous activity has led to a fundamentally new approach to the problem of the dialectical contradiction between the determination of a human being's behaviour by his genetic predisposition, the social environment, and freedom of choice, on which is founded the existence of ethics and personal responsibility for one's own actions. A number of writers consider this contradiction to be the central problem of modern psychology and philosophy (Allport, 1964; Ayer, 1973; Sperry, 1980). Later we shall try to demonstrate that the decisive factor

in overcoming this contradiction is the use of the principle of complementarity.

8. It can hardly be disputed that while some preparatory work has been done on developing a theoretical foundation for *learning*, we almost completely lack a scientifically based theory of *education* in the generally accepted sense of "theory". Of course, the statement of this fact should in no way detract from the merit of distinguished pedagogues both past and present: Ya.Kamensky, K.D.Ushinsky, N.K.Krupskaya, A.S.Makarenko, K.S.Stanislavsky, Ya.Korchak, V.A.Sukhomlinsky and others. But their valuable practical experience and incisive generalisations have not yet served as a basis for the discovery of laws governing the formation of juvenile personality or the development of a set of rules with which to equip any teacher to give a course of lectures at pedagogical training institutes and schools.

We wish to maintain that the above-mentioned "blank spaces" on the map of the modern human sciences, debatable points and unresolved issues are organically interlinked and have a single historical source. The point is that for half a century following the death of I.P.Pavlov and L.S.Vygotsky the physiology of higher nervous activity has been developing primarily as the neurobiology of *learning and memory*, while psychology has been developing as the psychology of the *intellect*. Vygotsky himself at the end of his creative life saw the main task to be "the analysis of emotion and motivation, given that it is precisely through these that activity determines psychic processes and consciousness" (A.N.Leontyev, see Vygotsky, 1982:40).

As the organ of the psyche and the organisation of behaviour, the brain presents itself to us primarily as *the motivated brain*, stimulated into activity by the various needs of living organisms. Needs in their turn are a specific (essential) force of living organisms which links them with their environment for self-preservation and self-development, a source of activity for living systems in the surrounding world. The preservation and development of human beings are manifestations of this force, possible solely because the world contains objects which are attractive "as *objects* which are independent of human beings; however these objects are *objects* which human beings *need*; ...*objects* vital to the exercise and maintenance of their essential forces" (Works of K.Marx and F.Engels, 2nd Ed., vol.42: 163). Closely related to the concept of "need" is the phenomenon of motivation. A good understanding of the

history of research into motivation is provided by the collection of articles edited by W.A.Russell (Russell (Ed.), 1970). Motivation represents the second stage in the organisation of goal-directed behaviour in comparison with the satisfying of needs; it can be considered as "objectified need". Motivation is the physiological mechanism for activating traces held in memory (engrams) of those external objects which are capable of satisfying an organism's current need, and of those actions which are capable of leading to its satisfaction.

The phylogenetic prehistory of human needs can be discovered by an analysis of the most complex unconditioned reflexes of higher animals, qualitatively transformed in the subsequent process of cultural-historical development. It is with the analysis of these most complex unconditioned reflexes that we shall begin our exposition of the scientific basis of general psychology. This book continues the development, refinement and discussion of ideas contained in our previous work, The Emotional Brain (Simonov, 1981). The Motivated Brain is the second part of a trilogy which will include the planned The Creative Brain. It is hoped that this trilogy will permit us to demonstrate the fruitfulness and long-term viability of the need-information approach to the study of psyche and behaviour.

In conclusion, we must emphasise that a whole series of postulates contained in this book remain open to discussion. Above all, this applies to the analysis of the scientific basis of temperament, character, and personality. The state of this issue at the present time can be judged by the discussion contained in the journal Vestnik Moskovskogo Universiteta. Seriya Psikhologiya (No 4, 1985; No 1, 1986). "All existing and proposed definitions of personality and character, including correlative ones, not only lack a sufficient degree of cogency," said V.K.Vilyunas in the course of the discussion, "but in general fit badly into the system of psychological categories... Character and personality are 'intuitive' categories, used in the absence of a precise knowledge of the functioning of motivational, volitional and emotional processes" (ibid. No 4:63).

"When describing the character type of a human being on a scientific rather than an informal level," justifiably maintains A.A.Bodalev, "it is essential to precisely probe and outline the needs which 'feed' and determine the 'display of attitudes' that make up a concrete character type" (ibid. No 1:46).

This is the reason why we have concentrated our attention specifically on the role of needs in the structuring of character and personality, and singled out

from amongst the general properties of the nervous system those which form the basis of temperament: activity and emotionality.

As far as possible I have tried to continue the work of my teacher, Ezras Asratovich Asratyan, the creator of the reflex theory of motivation which enables the problem to be discussed within the framework of the Pavlovian legacy. I dedicate this work to his memory.

Chapter 1

THE MOST COMPLEX UNCONDITIONED REFLEXES OF HIGHER ANIMALS: THE PHYLOGENETIC PREHISTORY OF HUMAN NEEDS

> "...While studying comparative physiology, one feels the deepest contempt for the idealistic exaltation of man over the other animals."
>
> F.Engels (Letter to K.Marx)

> "There can be no doubt that a systematic study of the range of innate reactions in animals will maximally aid our understanding of ourselves and the development of our capability for personal self-regulation."
>
> I.P.Pavlov (1973:240)

The most essential characteristic of any unconditioned reflex is its innateness and its genetic immutability, in contrast to individually acquired ontogenetic experience. The classic example of purely innate behaviour is the action of a fledgling when hatching from the egg. Also innate is the stereotyped blow to the head performed by red-legged falcon fledglings when killing mice. Newly hatched chicks prefer to peck at three-dimensional objects, rather than flat discs. In some cases, the repetition of genetically determined actions not only does not facilitate their perfection, but even worsens task-solving. For example, the innate reaction in wild rats to extrapolate the movement of food platforms worsens by 34% after 80 presentations (Kuznetsova, 1982).

G.Miller, E.Galanter, and K.Pribram (1965) define the unconditioned reflex (instinct) as an inherited, immutable, involuntary Plan, carried out independently of its consequences for the organism. It should be noted that there is a tendency to exaggerate the inertness and mechanical nature of unconditioned reflexes, and their independence

from the attainment of an adaptive goal (satisfaction of a need). An early experiment by I.M.Sechenov showed that in decapitated frogs failure to remove an irritating stimulus with the leg results in a generalisation of the defensive reflex and subsequent involvement of new motor coordinations. Characteristic of many unconditioned reflexes is the phenomenon of extinction. In hoofed mammals the raising of the head when placed in darkness is an innate reflex; but if it is not reinforced with feeding it disappears.

The activation of any unconditioned reflex depends on the actual functional state of the animal as determined by the dominant need and the current situation. For example, in frogs the reaction of the leg to stimulation with acid depends on the original position of the stimulated extremity. When on alien territory, cichlid fish turn to flight, but when they reach their own territory, they attack a pursuer. Herring-gulls select green eggs as objects to incubate and prefer blue and red when stealing eggs to eat from alien nests (Menning, 1982). Painful stimuli provoke an aggressive reaction in dominant mice and a defensive reaction in subordinate mice (Legrand and Fielder, 1973). Even direct elecrical stimulation of the "aggression centres" in rhesus monkeys leads preferentially to an attack on those males which are subordinate to the stimulated one (Alexander and Perachio, 1973).

Unconditioned reflexes undergo major changes depending on the age of the animal. Bear cubs which have left the den at first display predominantly investigative behaviour, but three months after they leave the den their curiosity is replaced by wariness, and encounters with new objects, especially with large animals, begin to provoke fear. The smiling reaction in babies can at first be produced by a wide variety of stimuli, but later the child only responds with a smile to familiar faces (Hinde, 1975).

L.A.Orbeli (1964) has a structured and well-argued conception of the postnatal maturation of unconditioned reflexes under the influence of and in interaction with conditioned reflexes, a conception which largely anticipated the findings of contemporary ethologists. It has become clear that the innate and individually acquired components of goal-directed behaviour are related to each other in ways which are immeasurably more complex than was previously thought. For instance, the building of a nest by a rat is an innate reflex, but it can be destroyed by raising the rat in a cage with a mesh floor in which the animal's previous attempts to gather material for nest-building have ended in failure. A goldfinch raised in isolation preserves the

ability to sing, but its song is simplified and lacks the nuances which are acquired on hearing the song of other birds (Solbrig and Solbrig, 1982). Individual experience also enhances the innate ability of a bird to distinguish the song of its own species from the sound signals of other species (Maler, 1982). The famous experiments of Harlow and Harlow (1965) showed that dramatic changes take place in the maternal instinct of monkeys separated from their mothers in childhood, when they later acquire their own babies. These data have turned out to be valid for human beings as well. The research of the last few decades convincingly demonstrates the highly dangerous consequences of separating a child from its mother (especially during the first three years); such a separation leaves an imprint on the character and subsequent behaviour of a human being which is hard to compensate for, and may be totally indelible.

Although the construction of an "inventory" of unconditioned reflexes was considered by Pavlov to be the most important task facing the science of higher nervous functions, we lack to this day an even partially complete and generally accepted classification. Pavlov himself based his own classification on the anatomical principle: which part of the central nervous system was the locus of the central component of the given innate reaction? Accordingly, Pavlov made the following divisions: (1) simple unconditioned reflexes (spinal cord), (2) complicated unconditioned reflexes (medulla oblongata), (3) complex unconditioned reflexes (midbrain), and (4) most complex unconditioned reflexes, occurring in the higher regions of the brain (Maiorov, 1954:187-188). However, the systematic investigations by E.A.Asratyan (1959) and his collaborators convincingly demonstrated that the central component of the arc of an unconditioned reflex cannot be treated as monolinear: the central component does not pass simply through one level of the brain, but rather consists of many branches, each of which passes through each of the basic sections of the central nervous system (the spinal cord, medulla oblongata, etc.). The highest branch of the arc passes through the cerebral cortex, is the cortical representation of a particular unconditioned reflex, and embodies the corresponding function of the organism at the cortical level. The existence of a cortical representation for practically every unconditioned reflex creates anatomical precursors for the formation of first-order conditioned reflexes as a synthesis of two or more unconditioned reflexes.

J.Konorski (1970) divided the plethora of unconditioned reflexes into two basic categories: preparatory (drive,

motivational) and executive (consummatory). Within the process by which a new stimulus is perceived, Konorski distinguished between the targeting reflex (targeted at the better analysis of the stimulus), and the orienting reflex per se (oriented towards its novelty). The preparatory exploratory reflex, according to Konorski, is initiated by sensory hunger, the need for new stimuli. The preparatory alimentary unconditioned reflex (hunger) manifests itself in motor unease and the activation of sensory systems. Fear is the preparatory defensive unconditioned reflex, and rage the preparatory offensive unconditioned reflex.

I.P.Pavlov (1973:339) based his classification of the most complex special unconditioned reflexes (instincts) on needs and motivations. He distinguished between (1) individual unconditioned reflexes: the food reflex, the aggression reflex, the active and passive defence reflexes, the freedom reflex, the investigatory reflex, the play reflex, and (2) species-related unconditioned reflexes - the sex reflex and the parental reflex.

According to Pavlov, the first set of these reflexes provides for the self-preservation of the individual, while the second set provides for the preservation of the species. The activation of the most complex unconditioned reflexes is subjectively reflected in the shape of emotionally-tinged experiences. "Who would separate the physiological and somatic aspect of the most complex unconditioned reflexes (instincts)," wrote Pavlov, "from the psychic aspect, i.e., from the experience of mighty emotions such as hunger, sexual attraction and anger?" (Pavlov, 1951:335). Similar conceptions were supported by J.Konorski: "The subjective experiences corresponding to particular drives (familiar to us from introspection) we refer to as emotions. It may be assumed that they are also present in the higher animals" (Konorski, 1970:41).

It is obvious that when we speak about the most complex unconditioned reflexes (the nest-building reflex, the parental reflex, the play reflex, etc.), we have in mind not just a single "reflex arc" with its afferent, central, and effector components, but an integrated behaviour complex, a systems type morphofunctional structure, i.e. a *system* of reflexes, just as any conditioned reflex can be considered a synthesis of at least two unconditioned reflexes (Asratyan, 1959). Accordingly, motivations and emotions are in no way components of even a very complex "reflex arc", but arise as a result of the interaction of at least two reflexes. Thus, the unconditioned food motivation presupposes activation through the hunger stimulus of genetically determined engrams of those external objects which are capable of

satisfying the corresponding need according to the scheme: effects of metabolic changes on interoceptors; activation of engrams (afferent models) of the food object; food-seeking activity. Similarly, the innate emotional reaction to food results from the convergence of hunger excitation produced by the initial unconditioned stimulus (metabolic changes) and the afferentation from the reinforcing unconditioned stimulus (food present in the mouth). Even the innate reaction to painful stimulation has two components: the sensory component, linked to such characteristics of the stimulus as its localisation, sharpness or dullness, extent of generalisation, etc., and the emotional colouring of the pain stimulus through extent of suffering and level of tolerability (Val'dman and Ignatov, 1976). The presence in the structure of the pain reaction of a "cognitive" sensory component creates the potential for the conversion of the pain stimulus into a conditioned signal of emotionally positive food reinforcement, as was demonstrated in the famous experiments of M.N.Erofeeva (1912).

Thus, in what follows we shall not discuss the whole infinite variety of innate reactions, but rather concentrate on the type of innate reaction which Pavlov called "most complex unconditioned reflexes (instincts)". In doing this, we do not accept the thesis that the biological significance of such reactions reduces entirely to *self-preservation* of the individual and the species, since the progress of nature presupposes the dialectically opposed interaction of the drive for self-preservation and the drive for self-development; the ability to preserve oneself and one's offspring, population and species is rather a precondition for development, and in no way the sole factor determining the dynamics of the evolutionary process.

Of fundamental significance for us are the ideas of V.I.Vernadsky on the continual expansion of the frontiers of the biosphere and its population by living organisms. "Living organisms are *plastic*," wrote Vernadsky, "they alter and adapt to changes in the environment, but it is possible that they also possess their own processes of evolution, represented by changes on a geological time-scale which are independent of changes in the environment. This can perhaps be seen in the constant, step-like growth throughout geological time of the central nervous system of animals, the significance of the central nervous system in the biosphere and the depth of impact of living creatures on their surroundings" (Vernadsky, 1977:18).

Vernadsky's ideas are in tune with those of A.A.Ukhtomsky, who thought that "the basic tendency in the development of motives is expansion, by which is meant the

subjugation of the environment on an ever-increasing spatio-temporal scale (the "chronotope"), rather than reduction in the form of a drive towards "defence" against the environment, equilibrium with the environment, or the release of inner tension" (Yaroshevsky, 1975:15). Vernadsky and Ukhtomsky prophetically anticipated the conclusion of modern evolutionists that progress is a gradual conquering of the environment, that progressive evolution is adaptation to "a succession of environments further and further removed from the original environment inhabited by the ancestors" (Grant, 1980:333). The degree of adaptation to an environment cannot be a measure of evolutionary progress, since the highly successful adaptation of parasites is achieved by a clear regress in their organisation compared with ancestral forms, and many arthropods have adapted to extreme conditions incomparably better than mankind. But not one living creature is capable of extending its area of habitation from the south pole to the north pole, and then adding extraterrestrial cosmic space to its territory (physically), or the depths of the Universe (intellectually).

These ideas of two of the giants of early Russian science, Vernadsky and Ukhtomsky, appear to us as the *classification principle* by which we can group the most complex unconditioned reflexes (Simonov, 1983). These reflexes were shaped by evolution in such a way that when a living organism appeared, it was capable of occupying a place amongst other creatures of the same or another species in (a) the geosphere (by physically populating it), (b) the biosphere and, in the case of mankind, also (c) the sociosphere, as well as (d) the noosphere (the intellectual mastery of the world). Phylogenetic precursors of the latter can clearly be seen in higher mammals. With the control of each of these spheres we can match vital unconditioned reflexes, role (zoosocial) reflexes and self-development unconditioned reflexes. It is to a more detailed description of each of these that we shall now turn our attention.

1. *Vital unconditioned reflexes* provide for self preservation and species preservation. They include the hunger (food) reflex, the thirst reflex, the regulation of sleep, defence reflexes (including the orienting defence reflex of "biological caution", the economy of effort reflex, and many others. Two indices may serve as defining criteria of a vital unconditioned reflex: (i) failure to satisfy the corresponding need results in the death of the organism, and (ii) the activation of the unconditioned

reflex does not require the participation of another organism of the same species.

The innateness of food (hunger) reflexes is shown by the genetic determination of the parameters which external objects must possess in order to satisfy the corresponding need. This phenomenon is fully present in man, as is demonstrated by experiments in which maternal milk is suddenly replaced by another liquid (Shuleikina, 1971). Bear cubs identify edible objects (ants, wasps, berries, snails) immediately, without training, whilst methods for gathering them (how to catch frogs, etc.) are discovered gradually, without the help of the mother. The innate reaction of puppies to meat appears at a strictly determined age (20-21 days) and is extinguished at 8-9 months if not reinforced (Slonim, 1967).

Many defence reflexes also have an innate character. Apes display an innate reaction to heights (emitting cries, grasping for the arm), even when they have never been faced with heights in their individual experience. The concrete form in which a defence reflex is manifested largely depends on particular circumstances (in cornered rats, flight is replaced with aggression), and on interactions with other unconditioned reflexes. For example, aggressive animals can coexist peacefully when this becomes necessary for the rearing of offspring. Stimulation of the lateral hypothalamus in rats can elicit aggressive behaviour towards a subordinate rat, but fails to elicit it towards a dominant animal or a female (Koolhaas, 1978). If the aggressive behaviour of a cat, provoked by electrical stimulation of the hypothalamus, is met by aggression on the part of the attacked animal, further stimulations of the brain begin to elicit defensive behaviour rather than aggression (Belenkov, Shalkovskaya, and Gonzalez, 1982).

Aggression (the active attack reflex in Konorski's terminology) must be distinguished from the food-gathering behaviour of predators. The essential difference between these two forms of behaviour is clearly revealed when particular brain structures are destroyed. After injury to the medial hypothalamus, 8 out of 11 rats started to kill mice, but their intraspecies aggression did not increase (Albert and Welsh, 1982).

The hunting behaviour of predators, including its innate components, is a more complex form of food-gathering activity than the passive consumption of food from a dispenser. Bilateral destruction of the amygdala in cats leaves unimpaired those conditioned motor food reflexes which were previously developed, but removes the hunting reaction to live mice or birds (Cherkes, 1967). Destruction

of the ventromedial section of the amygdala in cats temporarily removes the killing of mice but preserves eating from a saucer (Zagrodska and Fonberg, 1977), while lesions of the dorsal and dorsolateral section result in hypophagia and preservation of hunting behaviour (Zagrodska and Fonberg, 1978). In rats, when the killing and eating of mice is combined with an injection of lithium chloride, this leads to a reduction in the eating without affecting the act of killing (Berg and Baenninger, 1974). Although lesions of the medial section of the amygdala destroy mouse-hunting in cats regardless of the experimental situation, after destruction of the dorsal section of the amygdaloid complex cats continue to hunt alone. Hunting difficulties are observed in the presence of other members of the group, when the operated animal loses its hierarchical rank (Zagrodska, Brudnias-Stepowska, and Fonberg, 1983). These data point to the importance of the amygdala in the organisation, hierarchical interaction and dynamic coordination of a number of unconditioned reflexes.

In the experiments of Frank and Stutz (1982), rats were given three levers to press in order to receive food, water, and stimulation of the posterior hypothalamus. Under these conditions the rats used all three levers and their weight remained constant. When stimulating electrodes were implanted in the basolateral section of the amygdala, the consumption of food and water was sharply reduced. Even when they pressed the "food" lever, the rats did not touch the food. Their aggression increased sharply. These experiments again demonstrate that in distinction to stimulation of the hypothalamus, electrical stimulation of the amygdala destroys the balance between coexisting and competing motivations.

The individual characteristics of a particular animal play an important role in the interaction of unconditioned reflexes. It is possible to find rats which will die of hunger rather than kill live mice, even if they have previously been fed on dead mice. At the same time there are rats which will continue to kill even when they are completely satiated. It is probable that such an independence of hunting behaviour from the need for food was developed in the course of evolution in order to provide a reserve of excess food which could be used to feed animals which were young or less successful at hunting. It is also probable that the brain substrate which determines individual differences in the relationship between hunting behaviour and the satisfaction of the need for food is to be found in the motivational structures of the amygdaloid complex. According to the data of Vargens (1980), the

central nucleus of the amygdala and the ventral amygdalofugal pathway in rats facilitate the mouse-killing reaction, whereas the medial section and the stria terminalis inhibit it. The way in which the consequences of lesions of the amygdala depend on the individual characteristics of particular animals is shown by changes in the threshold of the aggression reaction elicited by stimulation of the ventromedial nucleus of the hypothalamus. After bilateral destruction of the amygdala, the threshold increased in 12 cats, decreased in 1, and remained unchanged in 7 (Maeda Hisao, 1976).

It can be considered proven that animals possess aggressiveness not as an end in itself. The more so, this is true of human beings. The myth of an innate aggressiveness in human beings is disproved by the lack of any aggressiveness in certain isolated tribes, for example the eskimos (Eccles, 1980). Aggressive (active attack) behaviour in animals is always based either on the defence reflex of self-preservation (as in cornered rats), or on the struggle for a mate, position in the group hierarchy or territory. Only in pathologic cases does aggression lose its biological purpose. For example, rats with lesions of the hypothalamus continue to attack dead mice, balls of cotton wool, wooden bars, etc. (Albert, Walsh, Ryan, and Siemens, 1982). The relative independence of different types of aggression is also shown by the consequences of lesions in different brain structures. Lesions of the medial hypothalamus increase a rat's struggle when its legs are subjected to painful stimulation, but has no effect on the defence of territory against other rats. Territorial aggression is impaired by the destruction of the lateral hypothalamus (Adams, 1971). On the basis of the territorial defence reflex, a conditioned instrumental reaction can be developed: a mouse will press a lever which releases another mouse into its cage, this mouse then immediately becoming an object of attack (Connor and Watson, 1977). It may even be true that the reinforcement of this peculiar conditioned reaction is linked to the involvement of emotionally positive brain structures: it is well-known that the phenomenon of self-stimulation can be elicited by the implantation of electrodes in structures which produce aggressive behaviour (Val'dman, Zvartau, and Kozlovskaya, 1976).

In general, it would be rash to identify unconditioned reflexes with emotions, since one and the same motor stereotype can either be accompanied by the involvement of brain mechanisms of emotion, or be realised without them: for example, a lion on the hunt shows no signs of rage before leaping on its victim. The electrical stimulation of

various points in the hypothalamus in cats is capable of eliciting an angry attack, a "cold attack" with no signs of emotional excitation, or an expression of rage without an attack (Wasman and Flynn, 1962). Bilateral destruction of the basal nuclei of the amygdala depresses the emotional reaction of rage in rats without affecting the development of conditioned defence reflexes or the latency period of previously developed conditioned links (Allikmets and Ditrikh, 1965). In the same way as the emotional colouring of one and the same foodstuff depends on the level of motivation towards food, it is necessary for a number of supplementary factors to be present in the process of aggressive behaviour before brain mechanisms of negative emotions (anger, fear) or positive emotions (satisfaction) are involved.

From the extensive literature on vital unconditioned reflexes, we wish to single out behaviour which satisfies the *need for economy of effort*, since it is usually not given the attention it deserves.

If a chamber is set up with two levers which need a different amount of effort for their operation, but give an equal quantity of food, rats prefer the easy lever (Greene, 1969). Rats continue to press a lever even when food is present in the chamber, if the food is relatively inaccessible. Making access to the food-receptacle easier immediately leads to a reduction in the operation of the "food" lever (Mitchell, Fish, and Calica, 1982). As the number of lever-presses necessary for access to a food-receptacle increases, polecats and cats use the lever less frequently, and when they obtain food they eat significantly more. This economy of time and energy is characteristic of many species (Kaufman, 1980; Kaufman, Collier, Hill, and Collins, 1980). A vivid demonstration of the need for economy of effort is provided by the interaction within a single population of so-called workers and parasites, the former obtaining food by lever-pressing and the latter preferring to eat already obtained food. It must be emphasised that in isolation from each other rats from either group operate the lever with equal success, but when they are transferred to a common cage, they immediately divide into workers and parasites (Masur, Candida, and Pestana, 1978). If two workers are selected from a population and placed together, one of the rats may become a parasite (Masur, Aparecida da Silva, and Radicchi, 1977). The division into workers and parasites does not depend on the sex of the animals or on their position in the group hierarchy, while the consumption of food is totally determined by zoosocial rank both in rats (Anthouard, 1970)

and in monkeys (Firsov, 1977). In 11 out of 13 pairs of rats, the worker carried out 80% of the lever-presses and consumed 20% of the food and water obtained. For parasites the position was reversed. Workers were more aggressive, a fact explained by their experience of fighting in order to control the lever (Masur and Aparecida da Silva, 1977). The isolation of baby rats from their littermates and from their mothers from the age of 25 to 65 days facilitates the formation of a future parasite (Masur and Struffaldi, 1974). Initially, parasitism is passive in character, but subsequently it becomes active: parasites encourage workers to press the lever by biting at them and pushing them towards it. In a community of monkeys, encouragement to obtain food (through play or pushing) is gradually replaced by more determined coercion through threats and aggression (Firsov, 1977). In animals isolated in childhood, the change from passive to active parasitism is slowed (Anthouard, 1971).

The fact that parasitism is based on economy of effort is demonstrated by the rapid extinction of instrumental reactions in parasites when they are given free access to food and water. Instrumental reactions in workers are extinguished significantly more slowly (Capriglone, Flavio, Moreir, and Masur, 1979). The independence of parasitism from the position of an animal in the group hierarchy shows that the need for economy of effort belongs to the vital (purely biological) unconditioned reflexes rather than to the zoosocial ones.

2. *Role (zoosocial) unconditioned reflexes* can be activated solely through interaction with other individuals of the same species. These reflexes underlie sexual, parental and territorial behaviour, the phenomenon of emotional resonance ("co-experience"), and the formation of group hierarchies in which a particular individual constantly plays the role of mate, parent or infant, owner of a territory or new-comer, leader or subordinate. Tinbergen is justified in considering any interaction between two or more individuals of the same species as "social behaviour" (Tinbergen, 1953). Grant (1980) distinguishes the following forms of community in lower and higher primates:

(i) the maternal family: mother and infants (lemurs, aye-ayes)
(ii) the family with two parents (gibbons)
(iii) the herd with a single male hostile to other males (sacred baboons)
(iv) the herd with many males and a hierarchy

corresponding to age (capuchins, gorillas)

(v) the multi-male herd with a system of flexible oligarchy, with the phenomena of co-dominance and collaboration (chimpanzees).

This phylogenetic series convincingly shows that the socialisation of animals and their group organisation were developed to a significant extent on the basis of conjugal and family relationships, in which the functions of fatherhood (motherhood) were exceptionally tightly interwoven with the functions of group leadership or subordination. The father-leader is truly a key figure in the history of zoosocial interrelationships.

The simplest example of a role relationship seems to be the interaction of sexual partners, but even this is far removed in its developed forms from primitive notions about the "animal sexual instinct". It is sufficient to recall that the longer is the period between the beginning of courtship and intimacy (coitus), the more prolonged is the subsequent existence of a pair formed for the production of a single litter or maintained for the whole life-span of the particular species (Lorenz, 1970).

Concern for offspring is positively correlated with level of socialisation. Young hyenas are fed solely by their mother, resulting in only a 5-10% survival rate amongst the offspring. In more socialised hyaenidae with a relatively stable group composition, communal food-gathering and territorial defence, the pups are fed by all members of the group. As a result, 35% of the offspring survive (Bulger, 1975). Despite its great importance, the paternal instinct is controlled and sometimes suppressed by other motivations. The dominant males in a herd of lemurs, macaques, baboons, gorillas or chimpanzees sometimes kill the offspring of a former leader: this apparently aids the improvement of the gene-pool. Even more decisive is the behaviour of a dominant sacred baboon, capable of killing its own heir if the latter distracts too much attention and thereby destabilises the group (Rijksen, 1981).

The research of the last few decades has convincingly shown the enormous significance of early childhood for the subsequent socialisation of young animals and the dramatic consequences of separation from the mother. It has been convincingly demonstrated that the need for social contact, communication and affection has an independent, genetically predetermined origin and is not a secondary corollary of early sexuality, as Freudians would have it, or of the need for food (Masson, 1976). The characteristic posture of separated young monkeys (grasping the head and body with the

arms) is in essence a reaction of self-contact, compensating for the lack of contact with other individuals (Ponugaeva, 1973). The consequences of separation to a certain extent depend on the individual characteristics of the particular animal. In 168 rhesus monkeys reared in isolation from their mothers and tested for a response to a new, unknown animal, three types of response were displayed: (i) the friendly communicative response, (ii) the hostile response, and (iii) the timid response (Chamove, Eysenck, and Harlow, 1972). These data demonstrate the fundamental importance of three types of emotions: joy, anger and fear, correlated (as was noted by Pavlov) with traits of the sanguine, choleric and melancholic temperaments (Simonov, 1966). According to the data of Scott, Stewart, and De Ghett (1973), the consequences of separation in puppies are displayed through two basic emotions: the state of distress (frustration) and the reaction of fear towards any unfamiliar object.

The similarity of biochemical changes in the brain-tissues of separated animals and humans in a state of depression, and the improvement in their condition under the influence of exactly the same drugs, demonstrates the commonality of the ultimate biochemical mechanisms in different species, including man. The existence of periods of heightened receptivity is something that must be taken into account whether we are dealing with the training of dogs, the adoption of children, second language learning, changes of abode, etc. (Scott, 1979).

Emotionally negative experiences (hunger, fear, pain, loneliness) increase the need for contact and quicken the process of socialisation. A jet of compressed air from a soft toy monkey does not frighten off young monkeys, but causes them to become even more closely attached to it and to press up to it. Electric stimulation of ducklings as they approach a model duck strengthens the phenomenon of imprinting, the drive to follow the model. In the experiments of Scott (1962), isolated puppies were released to communicate with the experimenter. One group was encouraged with play when it approached the experimenter, a second was alternately encouraged and punished, and a third only punished. Feeding all three groups was achieved mechanically without the participation of the experimenter. It turned out that the puppies which became most attached to the experimenter were from the second group, and those which were least attached came from the first. The importance of attachment as an independent zoosocial need is demonstrated by the possibility of developing instrumental conditioned reflexes in dogs which are reinforced solely by petting and verbal encouragement (Fonberg, Kostarczyk, and Prechte,

1981). These instrumental reflexes are impaired by lesions of the lateral hypothalamus and the dorsomedial amygdala, and indeed to a greater extent than reflexes developed under food reinforcement.

The importance of social factors in the behaviour of dogs was emphasised and properly valued by I.P.Pavlov when he wrote: "... in our dog we encountered a distinctly social reflex, the action of an agent in the social environment. The dog, like its wild ancestor, the wolf, is a herd animal, and human beings through long historical ties have become its 'socius'... This experiment in conjunction with some earlier ones finally pushes us into the sphere of social reflexes, which we shall now include in the programme of our future research" (Pavlov, 1973:313).

One factor which exercises a pronounced influence on the behaviour of animals is the use of signals to indicate the emotional state of another individual of the same species: vocalisations, specific odorous substances, behavioural characteristics of the partner, etc. We have called this the phenomenon of *emotional resonance*, distinguishable from imitative behaviour because the observing animal does not repeat the actions of its partner, but is motivated by its partner's signals. For example, rats avoid the corner of a chamber which preserves the smell of rats subjected to painful stimulation (Mackay-Sim and Laing, 1980). Rats and monkeys reduce the number of lever-presses to obtain food if these presses are accompanied by painful stimulation of an individual of the same species (Masserman, Wechkin, and Terris, 1964; Greene, 1969). Sensitivity to signals of defensive arousal in a partner increases in rats which have experienced the effect of a painful stimulus (Church, 1959). Rats refuse to drink when housed with other rats which have previously experienced poisoning by lithium chloride after using a saccharin solution (Danquir and Nicolaidis, 1975). If a mother rat is given a substance with a new taste, and the baby rats poisoned, the mother then rejects this substance. The danger signal for her is the smell indicating the pathology of the baby rats' gastrointestinal tracts. A similar effect could not be achieved in females which had not given birth (Gemberling, 1984). Finally, rats recognise dead individuals with some accuracy and speed, and bury them. Anaesthetised but living kin are also buried after they have been sprayed with cadaverine or putrescine (Pinel, Gorzalka, and Ladak, 1981).

On the other hand, the presence of a hungry rat in a neighbouring compartment of the chamber will stimulate a satiated rat to press the "food" lever more frequently (Strobel, 1972). On the basis of food reinforcement,

comparatively complex forms of interaction can be developed, for example, the simultaneous approach of two rats to a signal lamp, and subsequently to a milk dispenser. Bilateral destruction of the lateral hypothalamus prevents the development of such synchronised actions, although the individual training of each of the two mice is not hindered (Berger, Mesch, and Schuster, 1980).

The presence of a second cat increases the alcohol consumption of a cat which is individually disposed to the drinking of ethanol, and what is more this effect is dependent on the presence of a particular partner preferred by the given cat (Wyrwicka and Long, 1983). In the experiments of Beck (1978), two differently sexed rats were allowed to meet only if each opened its own door by means of a special lever. The synchronisation of their actions depended not only on training, but also on the hormonal cycle of the female.

Cessation of the defensive arousal of another individual of the same species can act as a sufficient reinforcement of an instrumental conditioned reflex in a certain proportion of rats, dogs and monkeys (Rice and Gainer, 1962; Simonov, 1976). In our experiments, 77 out of 247 male white rats (i.e., 31%) were relatively quick to develop the conditioned reaction of avoiding the painful stimulation of a partner. 111 (45%) developed this reaction after being used for a few times as the "victim". In 59 (24%) the conditioned reflex of avoiding a partner's cries of pain could not be developed (Simonov, 1981).

The reaction under analysis is highly sensitive to the effects of pharmacological substances, including alcohol. The reaction of avoiding a partner's cries of pain is depressed by giving the rats a dose of 32 mg/kg of ethanol, while their "own" conditioned defence reflex is suppressed only with a dose of 2.25 g/kg, i.e. a dose 70 times greater than that required to block emotional resonance (Burov, 1980). The effect of a partner's cries of pain over a number of days provokes neurosis in rats which are capable of the development of a stable avoidance reaction (Burov and Speranskaya, 1977). Rats in the middle group which have difficulty in developing this reaction are more sensitive to the effects of additional neuroticising factors (the development of their "own" conditioned defence reflexes with the random use of differentiating signals) than rats which are highly sensitive or insensitive to the cry of pain of another rat (Airapetyants, Khonicheva, Mekhedova, and Vil'yar, 1980).

Local lesions of the brain structures of rats reveal:

(i) brain formations in which lesions have no certain influence on the avoidance reaction: the cingulate and entorhinal cortex, the hippocampus, the septum and the mammillary bodies

(ii) structures in which the effect of lesions is clear-cut and at the same time does not depend on individual characteristics of the animal: the frontal area of the neocortex

(iii) structures in which the consequences of lesions are determined by individual characteristics of the animal prior to operation: the amygdala, the central gray matter and the hypothalamus. It can be supposed that it is precisely these structures which are the neuroanatomical substrate for the individual variation in the reactivity of rats to signals of defensive arousal in a partner, as well as for a variety of other forms of behaviour in the given animal.

It should be noted that the structures in group (iii) above belong to the need-motivation system, which is connected with the qualitative appraisal of external stimuli. Lesions of structures belonging to the so-called information subsystem, which evaluate the probability of reinforcement of conditioned signals, either have no effect on the avoidance of cries of pain (the hippocampus), or have an effect which is independent of individual characteristics of the animal (the frontal areas of the cortex). However, the inactivation of a whole hemisphere by the spreading depression method has a different effect on the behaviour of rats which easily develop the avoidance reaction to cries of pain and those which develop it poorly. In rats of the first group, the time spent on the pedal increased when the right hemisphere was switched off, and in rats of the second group the time increased when the left hemisphere was switched off (Bianki, Filippova, and Murik, 1985). Experiments with localised brain lesions demonstrate that the conditioned avoidance reactions we have observed depend primarily on the individual characteristics of an animal's motivational sphere, rather than on its learning abilities. This explains why amongst animals which occupy different levels of phylogenetic development (rats, dogs, monkeys) there are individuals which show different sensitivities to signals of defensive arousal in another member of the same species.

This ability to react to the emotional state of another individual, which is very old in evolutionary terms, led to the development of two basic varieties of motivation: "for

self" and "for others". On the other hand, the intellectual mastery of the world which was achieved by the development of human *co-knowledge* (i.e., knowledge which can be passed on and shared with other members of the community) was supplemented with a mechanism of *co-experience*, co-feeling, the ability to enter the internal world of another by "transferring" it onto one's own emotional experience. It is no accident that a brain formation such as the central gray matter, which gives an emotionally negative colouring to the individual's perception of its "own" stimuli (sounds, tactile stimuli, temperature, etc.), should be absolutely essential for reactions to signals of the emotionally negative state of a partner.

An exceptionally important role in the life of living creatures is played by their *hierarchical* (strictly zoosocial) behaviour. The mechanisms which underlie social organisation often turn out to be stronger than hunger, sexuality, aggressiveness and fear. Even after three days of food deprivation, sacred baboons keep distributing food according to hierarchical rank. Only later do they begin to fight for each scrap of food (Dzhalagoniya, Uzunyan, Vavilova, and Baboyants, 1983). It appears that the well-known aphorism "love and hunger rule the world" does not even do animals justice, let alone mankind. It is incorrect, according to K.Lorenz (1967), to think that the forces which oppose aggression are a consequence of the development of the intellect. Their origin should be sought in the social instincts of animals. The ethologists' conclusions recall to mind the profound idea of V.I.Lenin that "in reality 'zoological individualism' was not bridled by the idea of God, but rather by the primitive herd and primitive commune" (Lenin, 1963:232).

The problem of the innate components of hierarchical behaviour is complex and little-studied. Even in insects the importance of ontogenetically formed influences is quite large. In bees, wasps and termites all eggs are identical. Workers emerge from those larvae whose rations are limited. In termites there are both male and female workers and soldiers. Only those males which impregnate a female (drones) form a special caste. In relation to the higher animals one can hardly talk about "leadership genes" and "subordination genes", although a whole range of inherited (typological) traits of a particular individual are highly relevant to the position that individual will occupy in the group organisation.

The presence of a hierarchy stabilises and organises group behaviour. High-ranked birds are aggressive only to those birds closest to them in the hierarchy. When fights

occur, they intervene on the side of the weaker individual (Lorenz, 1970). The importance of hierarchical behaviour is simply demonstrated by the fact that the fighting and panicking which arises in a group of rats stimulated by an electric current results in the loss of the avoidance habit in rats previously trained in this habit (Burov, Kampov-Polevoi, and Salimov, 1977). In a group of 10-14 mice, the dominant animals in 70% of cases attack the closest and most aggressive subordinates. This lessens conflicts between the subordinates and stabilises the group. Another form of stabilisation is the emigration of high-ranked subordinates (Novikov, 1979). When a group of mice first occupy a new territory, their aggressiveness is suppressed by investigative activity. Then begins a process of "clarifying relationships" and the emergence of a dominant; this process is difficult for mice reared in isolation (Poshivalov, 1977). During the period of group formation, the rise in blood pressure was higher in dominant mice from a genetic line with a clear hierarchical structure (i.e., with a powerful zoosocial need), than in mice belonging to a genetic line with unstable organisation (Lockwood and Turney, 1981). These data once again demonstrate that the strength of a need can be judged according to the magnitude of an emotional reaction (rise in blood pressure). Within limits, a hierarchy can be maintained by conditioned reflexes. For example, a dominant mouse which is subdued by tranquilisers will preserve its position in the group for some time on the basis of its appearance, smell, etc. (Poshivalov, 1979).

Like many other biological phenomena, hierarchical behaviour has its weak spots. The motivation of a rat to follow its leader in choosing a door in a maze seems to be stronger than its own experience of the correct choice. As a result, rats with no leader find the right door in 66% of cases, while rats with a leader which chooses the wrong door manage only 40% (Konopasky and Telegdi, 1977).

L.M.Baskin (1975) distinguishes in high-ranked hoofed mammals between leaders and dominants. The leader protects the herd, defends it against predators, intervenes in fights and looks after foals and sick animals. The dominant has control over the mares and their behaviour, drives off rival males, marks out territory and maintains the hierarchy. It is interesting that in extreme situations (overflowing rivers, deep snow-drifts in the path of the herd, etc.), the dominant becomes passive and a way of escape is sought by the leader; however, when the obstacle is overcome, the dominant immediately reassumes his proper position. D.Dewsbury (1981) defines leadership as the ability of an

individual to influence the character of the group's movement, its timing, speed and direction. The leader does not have to be the dominant: the leader's influence on the group is determined by experience rather than by physical strength.

High rank in a group guarantees priority in access to food, resting-places and females. When male rats were placed in different branches of a maze, females preferred the dominants. Thus the advantaged position of dominants in reproductive behaviour is a result not only of the suppression of rivals, but also of attractiveness to females (Carr, Kimmel, Anthony, and Schlocker, 1982). Manifestations of dominance differ from species to species. For example, in a group of 6 chimpanzees, rank did not influence the frequency of pairings with females (Coe and Levin, 1980). The approach of a dominant individual forces a monkey to stop eating and turn to the grooming of its own or the dominant's fur. Only when a subordinate monkey is shown definite signs of a positive attitude towards it does it resume eating in the presence of a dominant (Kryazhev, 1955). In rhesus monkeys, the sons of high-ranked mothers have a chance of occupying a higher rank. It must be emphasised that highly-ranked animals not only compete with each other, but also unite in order to maintain their position in the group. As a result of such interaction, it is not a single animal that heads a colony of sacred baboons (hamadryads) and wild baboons, but a group of the elder males (Menning, 1982).

Research shows that dominance is determined not so much by the individual qualities of the leader, but by the manifestation of signs of subordination on the part of subordinate individuals (Rowell, 1974; Dlag, 1977). This reminds one of the old theatrical rule that the king is played by his retinue! An increase in the size of a population at first makes the hierarchy more rigid, but subsequently leads to its dismantling. What is more, this depends not on the density of population, but on the growth of the community in absolute numbers (Alexander and Roth, 1971). It is interesting that in the case of the Yanomami Indians, who live according to the primitive communal system, the emergence of new "daughter" settlements is not connected with any lack of food on the territory they occupy. The growth in the population of the commune leads to an increase in intrafamilial and interfamilial conflicts. It is this interpersonal tension which is the cause of dispersal.

Higher apes display a characteristic instrumentalisation of hierarchical behaviour. A case has been described of a

young male chimpanzee becoming a dominant by frightening the other members of the group with blows from a stick on an empty petrol can. This leader was immediately "overthrown" as soon as the experimenters removed his "instrument of power" (Lawick-Goodall, 1971). In an experiment with two levers, one of which gave food only to the monkey working it, and the other providing food for two monkeys, only the dominant monkey preferred the lever "for two". The subordinate male invariably used the lever "for self". Two other monkeys chose the lever "for two" after the use of this lever started to be reinforced with double portions of food (Colman, Liebold, and Boren, 1969). This experiment shows how complex the relationships are in the satisfaction of needs "for self" and "for others", and the extent to which they are individualised in different members of the same species.

Enormous importance must be attributed to the need *to follow norms* and the reflexes which satisfy this need. Any infringement of the behavioural norms which are characteristic of a given species provokes a marked aggressive reaction on the part of other, primarily high-ranked members of the group. As a rule, the "infringer" is expelled from the group. Comparable reactions can be observed in young children who unconsciously behave in a hostile manner towards their peers who have any defects or abnormalities (Lorenz, 1967).

Two brain formations are most closely linked with zoosocial behaviour: the frontal sections of the neocortex and the nuclei of the amygdaloid complex. Changes in social behaviour are observed in rats after destruction of the orbital (but not medial) sections of the frontal cortex. These rats became more aggressive when subjected to nociceptive stimuli and when encountering a rat of the opposite sex. At the same time, they could not be distinguished from control animals in territorial and food-gathering aggressiveness (Koeb, 1974).

After destruction of the basolateral nucleus of the amygdala, guinea pigs lost their hierarchical status, and never regained it. After a lesion of the lateral septum, status was impaired as a result of hyperactivity, but restored after a certain period (Levinson, Reeves, and Buchanan, 1980). Destruction of the amygdala and the orbital section of the frontal cortex changes many forms of social behaviour in hamsters: aggression provoked by nociceptive stimuli, territorial and sexual behaviour. Lesions of the hippocampus and the medial frontal cortex do not affect these forms of behaviour (Shipley and Koeb, 1977). Monkeys with amygdaloid lesions lose their rank as a result of

lowered aggressiveness and fear of other members of the group (Kling, 1972). It would be an oversimplification to imagine that "centres of social behaviour" are localised in the amygdala. As we have already seen in the case of the phenomenon of emotional resonance, the amygdala is connected with organising the interaction and coexistence of a variety of motivations. This is the reason why the consequences of amygdalectomy depend on the individual characteristics of a particular animal: bilateral destruction of the amygdala suppresses the aggressive behaviour of dominant hamsters and the subordinate behaviour of low-ranked animals (Bunnell, Sodetz, and Shalloway, 1970). If in an experimental situation there is no competition of motivations and reactions are more or less stereotyped in character, damage to the amygdala may have no effect on behaviour, just as a bilateral amygdalectomy does not impair the aggressive reaction of male rats to the incursion of a strange male rat (Busch and Barfield, 1974).

To conclude this short review of hierarchical behaviour, let us recall the words of F.Engels in a letter to P.L.Lavrov: "... I cannot agree with you that 'the struggle of all against all' was the first phase of human development. In my opinion, the social instinct was one of the most important keys to the development of man from the apes" (K.Marx and F.Engels, 1964:138). Primitive human communities were in no respect communities of "free and equal men". The invention of tools, the distribution of communally gathered food and other characteristic features of humanisation were without doubt "superimposed" on the rather complex and rigid group organisation of our animal ancestors, transforming it from its original state.

3. *Self-development unconditioned reflexes* include exploratory behaviour, the resistance (freedom) unconditioned reflex, and the preventive "preparedness" reflexes: the imitation and play reflexes. The most important characteristic of self-development reflexes is the fact that they are not connected with individual or species-related adaptation to situations prevailing *at a given moment in time*. Metaphorically speaking, self-development unconditioned reflexes look to the future: in the sense of Vernadsky and Ukhtomsky, they are oriented towards the mastery of new spatio-temporal environments.

A second characteristic of this group of unconditioned reflexes is their independence: the fact that they cannot be derived from other needs of living organisms or reduced to other motivations. For example, the reaction to obstacles (the reflex of freedom, in Pavlov's terminology) is

activated independently of which need first initiated the behaviour and which goal lies at the end of the blocked path. It might seem that the play behaviour of animals, which often requires a partner, should be included in the role (zoosocial) reflexes. However, in play, hierarchical tendencies are absent. The playful fighting of a young animal contains no elements of competition and is completely free of aggressiveness (Lorenz, 1967). Its sole purpose is the training of those skills and abilities which will be needed at a later stage for the satisfaction of a number of vital and zoosocial needs.

At the present time it can be properly considered that the *exploratory behaviour* of animals is aroused by an independent need to obtain information, i.e. new stimuli with unclarified pragmatic significance (Eisenberger, 1972; Berlyne, 1974;1979). On the basis of this unconditioned reflex, conditioned instrumental reactions can be developed in which the sole reinforcement is the possibility of carrying out exploratory activity. For example, rats can be taught to exit from a maze in order to investigate new territory, while dogs and rhesus macaques will press a lever which opens a window to a neighbouring compartment (Dewsbury, 1981). The proposition that normal life activity requires a flow of information from the environment as well as a flow of matter and energy is supported by experiments which demontrate the dramatic consequences of "information hunger", especially in developing brains. Enrichment of the environment (keeping rats in a group, the presence of a large number of objects for them to investigate, etc.) affects brain weight, the thickness of cortical matter and brain chemistry. These effects are not connected with stress, handling (holding young rats in the hand) or physical load, but depend on the level of exploratory activity. In the experiments of Huntley and Newton (1972), young rats spent the first 105 days of their life under the following conditions: (i) isolation and restriction of movement, (ii) isolation without restriction of movement, and (iii) maintenance in a complex habitat. Statistically valid differences were obtained in the brain weights of rats from groups (i) and (iii). Group (i) showed maximal weight of subcortical structures and minimal weight of the cortex. In group (iii), opposite relations were observed. Thus, the decisive factor was the complexity of the environment rather than the physical load. An enriched environment increases the synthesis of DNA in brain cells, while sensory deprivation suppresses it (Vygvitskaya, 1983).

I.Schneirla (1959) provided experimental support for the universal law that relatively weak unknown stimuli elicit in

young animals and children the exploratory reaction of approach to the stimulus, while stronger stimuli elicit avoidance and fear. The biological significance of such a law is obvious. Exploratory activity correlates negatively with aggressiveness in rats from different genetic lines (Shtemberg, 1982). The strongest exploratory activity is found in middle-ranked animals. When a new lever for obtaining food is set up in a cage full of rats, the dominant male tries to bury it, and proximate females imitate him. The first to master the new lever are the middle-ranked rats. Low-ranked animals fear the unknown and are therefore passive. They begin to use only an already mastered lever (Anthouard, 1971). Exploratory activity can alter under the influence of hierarchical relationships. When rats are united in a group and the group hierarchy is stabilised, exploratory activity is increased in the dominant animals and suppressed in the subordinate animals (Summerlin and Wolfe, 1971).

Essential to full exploratory behaviour is the intactness of the frontal sections of the neocortex and the nuclei of the amygdaloid complex. The exploratory activity of monkeys weakens after bilateral removal of the frontal cortex (Deets, Harlow, Singh, and Blomquist, 1970). As far as the consequences of lesions of the amygdala are concerned, these depend on the relationships between the exploratory drive and those needs which facilitate or compete with it. In the experiments of White and Weingarten (1976), satiated rats with a destroyed amygdala displayed greater exploratory activity than the control animals. When subjected to food deprivation, amygdalectomised rats surpassed the control animals in alimentary behaviour but were inferior to them in exploratory behaviour. This means that destruction of the amygdala strengthens those behaviours which are connected with a dominant need.

The research of the last few years has shown that the reinforcement of exploratory behaviour is closely connected with the mechanisms of positive emotions. When the neuronal activity of the anteromedial cortex was recorded in rats, it turned out that those neurons which show increased activity in response to the stimulation of emotionally positive points in the brain also increase their activity in orienting and exploratory behaviour (Kanui, Martin, and Sinnaman, 1983). The rewarding effect of the satisfaction of the exploratory need involves the participation of endogeneous opiates (Katz and Gelbart, 1978).

The satisfaction of a whole variety of needs would have been impossible if in the course of evolution a specific

overcoming reaction had not arisen and undergone further development. This reaction was discovered by I.P.Pavlov and named by him the reflex of freedom. In the resistance of an animal to attempts to restrict its motor activity, Pavlov brilliantly saw incomparably more than a variant of the defence reflex. The freedom reflex is an independent form of behaviour for which obstruction is no less an adequate stimulus than food for the food-gathering quest, pain for the defence reaction or a new and unexpected stimulus for the orienting reaction. "Without it [the freedom reflex - P.S.]," wrote Pavlov, "the slightest obstacle in the path of an animal would completely interrupt the course of its life" (Pavlov, 1951:343).

Pavlov's idea was elaborated in the concept of "stimulus-obstacle situation" developed by V.P.Protopopov (1935; 1950). He showed experimentally that the overcoming reaction, which arises in the presence of an obstacle and is supplementary to the need which originally initiated the behaviour (alimentary, sexual, etc.), plays an important role in the determination of adaptive actions. It is the nature of the obstacle and not the original motive which determines the set of actions to be selected in the process of organising behaviour capable of achieving the goal.

The Pavlovian freedom reflex was reinvented many times by other researchers. In the English-language literature it is described as the drive to resist compulsion, most clearly displayed in wild animals for whom it appears to be stronger than sex, hunger, and thirst (Kavanau, 1967; Seligman, 1975). There are grounds for considering that the state called animal hypnosis, which arises in animals of a variety of species when they are forcibly restrained, results from acute extinction of the freedom reflex. Special experiments have shown that the inhibition recorded in this state is not transmarginal, but is most close in its characteristics to internal inhibitory extinction (Simonov, 1963). The long history of the unconditioned reflex of freedom has reached its apex in man with the formation of neurophysiological mechanisms of will (Simonov, 1970).

The research of ethologists has demonstrated the presence in animals and in man of a specific need (more precisely a group of needs) to master events. This need is most often transformed into the need to be able, the need to be prepared in the widest sense of the word, the need to be competent (the competence drive). The independence of this need explains the puzzling fact that an animal will repeat many times an action which continually fails to be reinforced. For example, the pecking actions of a chick become more and more precise even though it does not receive

food reinforcement (Tinbergen, 1985). In the case of the motivation of being "prepared", the perfecting of a skill stimulated by the Pavlovian goal reflex becomes its own reinforcement. The need for preparedness is satisfied with the aid of two basic unconditioned reflexes: the imitation and play reflexes.

Imitative behaviour ensures that experience is transmitted from one generation to the next, and is the basis of the phenomenon referred to by M.E.Lobashev in 1967 as "signalling (not genetic) inheritance" (see Slonim, 1976). "The study of the imitation process," wrote L.A.Orbeli, "must now become one of the most important elements in the study of higher nervous activity in man and animals" (Orbeli, 1964:295). By imitation, young animals master a mass of essential skills, for example the ability to graze in hoofed mammals. In laboratory experiments, chicks were shown a mechanical pointer which "pecked" at a button of a particular colour. This led to a preference for this colour even after the pointer had been removed from the experimental chamber (Suboski and Bartashunas, 1984). The effectiveness of imitative influences depends crucially on age and on periods of heightened sensitivity to such influences. Adult anthropoid apes uninstructed at the proper time in the construction of nests lose the ability to learn, no matter how long they observe the actions of other individuals (Firsov, 1977). Naturally, imitative learning is widely found in animals which lead a group lifestyle (for instance rats), and less common in hamsters, which live alone (Fabri and Filippova, 1982). In addition, great importance attaches to the rank of the animal whose behaviour is to be imitated. Danger signals emanating from a high-ranked bird are more effective than the signals from a young bird. Chimpanzees only copy the behaviour of high-ranked individuals. In order to train a whole group, it is sufficient to train the leader (Lorenz, 1967).

Each time we speak of imitative behaviour, we mean the reproduction of the *actions* of the "demonstrator", whether this be the trainee's parents or other members of the group. For this reason it is incorrect to treat as imitation the development of the classic secretory alimentary conditioned reflex in a dog which observes its partner eating (Kryazhev, 1955). L.A.Orbeli (1964) correctly saw in V.Ya.Kryazhev's experiments the development of a natural conditioned reflex to the sight of food, the champing of a partner, and similar signals.

Imitative behaviour, which is statistically advantageous and therefore reinforced by natural selection, nevertheless has a negative aspect in the form of phenomena like mass

panic. Blind imitation is invariably opposed by individually acquired experience. For this reason, frontal lobectomy in dogs strengthens imitative behaviour, whereas imitative behaviour in a child is gradually transformed into a conscious urge to "follow suit" (Orbeli, 1964). Because of innate ability to imitate, a child unconsciously masters the rules of a language long before it learns these rules at school. It is possible to say that the imitative learning of stereotyped behaviour and moral codes provides a direct route into the subconscious world, a route which to a significant extent evades the control of logical thought and obviates any critical evaluation of the actions reproduced.

As we have already noted, it is *play behaviour* that enables animals to acquire the skills which they will subsequently need. Play ensures physical training, the acquisition of skills in fighting, hunting and using tools, contact with other individuals of the same species, and the acquisition of group behaviour patterns. For example, young polecats acquire skills in rat-hunting while playing with each other. When young rats aged 25 to 45 days are deprived of the opportunity for play, they become less capable of developing complex skills. Moreover, contact with partners inhibited by chlorpromazine does not remove this defect (Einon, 1980). Manipulative play with objects arose only in higher primates and facilitated the formation of symbolic reasoning (Smith, 1982). Indeed, this was a phylogenetic prototype for the role later played by the use of tools in the development of speech and conceptual thought.

During the early stages of ontogenesis, play is "selfless" and free from the influence of other motivations, for example, the hierarchical relationships between the players. As young animals learn the norms of group behaviour, play becomes a method of training corresponding behaviour patterns. For example, "daughter-mother" role behaviour is learnt by children in the course of play. The change in motivations is reflected in the function of brain structures: in young rats, damage to the septum increases playful fighting, but in adult rats it increases aggressiveness (Beatty, 1982).

The independence of play need is demonstrated by the existence of the phenomenon of deprivation: isolating hamsters from each other on alternate days doubles the time of play at the subsequent encounter (Slonim, 1976). Careful study of children's games has revealed the existence of a specific play motivation, distinct from biological and social needs. In the English-language literature, this need is defined as the competence drive, the urge to acquire and perfect a multiplicity of skills: it is a specific variety

of developmental need (White, 1959; Severova, 1982).

Play has a major role in the development of fantasy and creativity. The profusion of trial actions and the unexpected associations justify the drawing of an analogy between play and the variability of genetic material which underlies natural selection (Smith, 1982).

At this point we conclude our brief survey of the most complex unconditioned reflexes (instincts) in animals in order to investigate their subsequent fate in the qualitatively new, socially determined higher nervous (psychic) activities of man.

Chapter 2

ATTEMPT AT A CLASSIFICATION OF HUMAN NEEDS

> "The concept of need must occupy an important position as a counterweight to the concept of instinct in Marxist-Leninist psychology, and be included in the inventory of its basic concepts. On the basis of the concept of need, the entire theory of the motivation of human behaviour is placed on a radically new footing compared with its usual formulation on the basis of instincts and inclinations."
>
> S.L.Rubinshtein (1976:40)

If we accept the proposition that needs are the basis, the driving force, the stimulus, and the objective of human behaviour, and that an individual's motives, urges, wishes, interests, goals, aims and values derive from and are generated by his needs (Diligensky, 1977), then knowledge of these needs becomes of paramount theoretical and practical importance, especially for the theory and practice of education in the widest sense of the word. Admittedly, the idea of need as the sole source of behavioural activity is by no means shared by all authors. For example, E.N.Bakanov and V.A.Ivannikov (1983) consider the term "need" to be inapplicable to the so-called process activities (exploration, play), on the grounds that the carrying out of such activities is unaccompanied by such characteristic features of needs as the strengthening of drives according to the growth of deprivation, the existence of an object of need, and the phenomenon of satiation. However, the research into the exploratory and play behaviour of animals which we discussed above, as well as experiments with sensory (information) deprivation in humans, the consequences of social isolation and similar phenomena, all show that what underlies any ideas concerning the role of other factors above and beyond needs in the initiation of behaviour is the

extreme limitation of our knowledge about the multiplicity of actually occurring needs.

When classifying needs, the majority of authors go no further than a division into the material and the spiritual, the natural (biological) and the cultural (historical). G.G.Diligensky (1982) limits himself to two basic groups of needs: needs of physical existence and needs of social existence. In the latter group are included not only needs for recognition, love, prestige, etc., but also ethical, creative and cognitive needs. Clearly such globally generalised classifications are hard to use in everyday educational practice.

Another difficulty is to be found in the infinite variety of "quasi-needs" which are secondary and derivative in origin. For example, the biological need to maintain a comfortable temperature generates the need for clothes. This in turn gives rise to the need to fabricate materials for making clothes, to create the necessary technology, to organise a production system, etc. Evidently, it only makes sense to classify those groups of needs which are primary and which cannot be deduced from each other or reduced to each other. The criterion is that an arbitrary degree of satisfaction of one group of needs should not simultaneously result in the satisfaction of other groups.

Several years ago, P.M.Ershov and I presented a classification of human needs in which we distinguished between vital (biological), social, and ideal needs (Simonov, 1975; Simonov and Ershov, 1984). Our classification totally coincides with the classification of activities according to V.Afanas'ev (1977), in which he distinguished between material (productive), socio-political, and spiritual types.

The justification for the assertion that the above three groups of needs have an independent origin is to be found in the results of research into the most complex unconditioned reflexes in animals (the topic of the first chapter), and in observations of the first stages of child development.

In the history of needs over millions of years, the most interesting, important, and complex point to explain is the transition from the needs of animals (and the instincts which fulfil these needs) to the socially determined needs of man. One of the leaders of modern population ethology (otherwise called sociobiology), E.Wilson (1983), emphasises that the social qualities of man differ in principle from the qualities of other living creatures and that analogies can only be made with extreme caution.

On this question are focussed the interests of a whole range of sciences: theoretical biology, evolutionary theory,

comparative physiology of higher nervous functions, anthropogenesis, and psychology.

In the case of man, it is incorrect to talk of the biological and the social as if they are present both in animals and in man, or in man alone. If the newborn state and severe brain pathology are excluded from consideration, in man there are no purely biological needs, inasmuch as the satisfaction of such needs is mediated by the influence of the social environment and humanised from very early childhood. On the other hand, the social and the ideal in man have their phylogenetic precursors and their prehistory in the prehuman stages of evolution. The idea that behaviour might be acquired without any innate basis at all, however remote, is incompatible with the science of higher nervous functions. The essence of the interaction between the innate and the acquired in human higher nervous functions was excellently described by D.K.Belyaev: "... the forms and norms of social consciousness, which are totally determined by the form of social production and by ideology (not biology!)... are differently acquired and realised as essential forces in the social practice of each individual depending on his natural strengths: inclinations, abilities, bents ... There are, for example, no special genes for humanism or altruism, or genes for antisocial behaviour. However, there are genetically determined psychic properties which, refracted through particular social conditions, combine together to form either a highly conscientious person who is repelled not only by criminal activities but also by careerism and avarice, or a person who has a poor conception of what conscience means, with all the consequences which follow from this" (Belyaev, 1981:5,15).

In the process of anthroposociogenesis, progress was made primarily in the direction of perfecting the means for satisfying needs. Communal labour, the development of language and conceptual thinking, and art (closely connected with language despite using a different semiotic system) led to the emergence of cultural inheritance, which is qualitatively different from the "signal inheritance" of animals, the transfer from parents to younger animals of such skills as hunting, nest-building, and singing. "Cultural inheritance," writes the evolutionist B.Grant, " - or the inheritance of traditions - is the totality of knowledge, ideas, crafts, customs, and technological skills possessed by a particular human community at a particular moment in its history. The sum total of knowledge and traditions is the result of discoveries and inventions made by preceding generations. It is and will continue to be

transmitted from generation to generation through instruction in the widest sense of the word" (Grant, 1980:351).

The development of production skills and culture had a powerful retroactive effect on the expansion, transformation and elevation of human needs, since "the satisfied initial need itself, the act of satisfaction, and the already acquired instrument of satisfaction lead to new needs, and this generation of new needs is the first historical act" (K.Marx and F.Engels, Collected Works, vol.3:27). "The fact that he [man - P.S.] arms himself with tools in advance," wrote L.S.Vygotsky, "is indubitably connected with the beginnings of culture. The act of a human being, arising in the course of the cultural-historical development of behaviour, is a free act, independent of the immediately prevailing need and the immediately perceived situation: it is an act aimed at the future" (Vygotsky, 1984:85). It should be noted that this "independence" of an act from a need is only apparent, since the act is still prompted by a transformed, derived *need*, standing at one, two or more removes from the initial need. Although the grain which a man sows in a field will satisfy his (or other people's) need for food only several months later, the need which prompts the sower to act does not lose its "alimentary" origin.

In the course of their historical development, human needs acquired features which were qualitatively novel. In order to convince oneself that this is so, it is sufficient to compare the human need for knowledge with the exploratory behaviour of animals, or the hierarchy of the herd with human social relationships, themselves based on functions in relation to the means of production and the distribution of the social product. An equally great distance stands between ritual "dances", bird-song and the play behaviour of animals on the one hand, and human art on the other, a specific branch of the need for knowledge and the capacity for co-experience, the distant roots of which can be discerned in the phenomenon of emotional resonance.

The discovery and subsequent investigation of the phylogenetic links between the most complex unconditioned reflexes (instincts) of animals and the needs of man (despite their qualitative differences) serves to confirm the materialistic approach to the study of human brain activity, its higher (psychic) forms, and the motive forces of behaviour. This line is a continuation of the approach to modern science that we connect with the names of Darwin, Sechenov, Pavlov, Ukhtomsky, and Vernadsky, and which leads to an understanding of the great transition from the

biosphere to the noosphere on our planet. If phylogenetic roots are severed and a "hiatus" opens between the biosphere and the noosphere, sometimes papered over by obscure allusions to an all-explaining "sociality", this leads invariably to idealism. A clear example of this is the pessimism of such a renowned expert on brain activity as J.Eccles. Eccles unexpectedly concludes a brilliant exposition of the results of modern neurophysiology and an analysis of the role of social environment in the formation of a child's psyche with the following remark: "It might be thought that I have arrived at a purely materialistic position, in which biological evolution on the one hand and cultural evolution on the other fully explain human personality... I maintain that we must understand the uniqueness of personality as the result of a supernatural creation on the part of what in religious terms is called the soul" (Eccles, 1979:144).

It is said that by his discovery Copernicus halted the sun and caused the earth to revolve. Having discovered the significance of needs as the specific (essential) force of living organisms including man, as the source and motivation for the active mastering of the surrounding world and the development of self-consciousness, science has materialised the soul and spiritualised matter. The highest forms of motivation in animal behaviour, i.e., the zoosocial reflexes and self-development reflexes (exploratory, imitative and play reflexes), turn out to be the phylogenetic precursors on the basis of which labour and cultural inheritance lead to a qualitative leap in the development of the natural world, the emergence of the noosphere.

Thus the following needs have characteristics which enable us to consider them as primary, independent in origin, and basic:

1. *Vital* (biological) needs for food, sleep, a comfortable temperature, protection from external harm, etc. These serve to guarantee the existence of individuals and the human species as a part of the natural world at the highest stage in its development. They give rise to a multiplicity of material quasi-needs for clothing, housing, the technology essential for the production of material goods, the means of protection against harmful influences, etc.

Included in the category of biological need is also the need for economy of effort, which motivates human beings to search for the shortest, easiest, and simplest method of achieving their goals. The principle of economy of effort lies at the basis of invention and the perfection of skills, but may also assume a self-contained significance when it is

transformed into laziness.

2. *Social* needs in the narrow, proper sense (inasmuch as all human motives are socially mediated), including the need to belong to a social group (community) and to occupy a definite (not necessarily leading) position within this group, to enjoy the affection and attention of all around, and to be an object of respect and love. V.A.Yadov (1979) classifies social needs according to the sphere in which social relationships operate, i.e. the family, the collective, the social system as a whole. If a tribe, a nation or an ethnic group acts as such a community, a complex of needs arises which can be called ethnic. Here it must be said that the role of such needs in the modern world is clearly underestimated. It is claimed that, in interacting with a group, an individual aims at two goals: fusing into the community and at the same time distinguishing and distancing "the self". We consider these two tendencies as the desire to belong to the group, and to occupy a definite position within it which corresponds to the individual's conceptions of justice.

The concept of justice is a reflection in the individual consciousness of the historically determined correspondence between rights and obligations, represented in the motivational sphere of the individual by the needs "for self" and "for others". The correspondence between these needs is defined by B.F.Lomov (1984) as orientation of personality, the relationship between what a person receives and takes from society (both material and spiritual values are intended), and what he or she gives to society as a contribution to its development. It should be noted that it is meaningless to set needs "for self" against needs "for others", not only because they objectively coexist, but also because each has its own socially useful function. The need "for self" generates a sense of individual worth, independence of judgement, and freedom of thought. The need "for others" makes an individual benevolent and capable of sympathy, compassion and collaboration.

Amongst social needs, we wish especially to emphasise the need to follow the norms accepted in a particular society. Without this need, the existence of social systems would be totally impossible. G.Gegel' (1968) treats it as the need for religion, although it would be more correct to give it a wider interpretation as the need for ideology, normalising the satisfaction of all other vital, social and spiritual human needs. Norms are formed as a result of the highly complex interaction of historical, economic, national and other factors; they are reflected in social

consciousness and reinforced by the prevailing ideology, morality, and legislation. Nevertheless, the observation of norms is based on the social need present in members of the society to follow behavioral, moral, aesthetic and other similar standards.

Well consolidated norms become habitual, "second nature", and at a particular moment cease to be consciously controlled, entering the sphere of the subconscious.

Human beings no longer ponder on how to behave in particular circumstances. Deeply ingrained norms make our behaviour automatic and instinctive, although of course it is strictly speaking impossible to use the term "instinctive" in this case, since "instinctive" means "innate". Instincts are not initially a product of the conscious mind, and therefore cannot be transferred to the subconscious. Norms are acquired in the process of education, the fact that we are incognizant of them is historically secondary, and they do belong to the subconscious.

Evidence for the independent origin of human social needs is provided by the development of children. Careful observations have shown that the need manifested in social interaction which causes affection and the fear of loneliness is derived neither from the need for food nor from early sexuality, as was claimed by Sigmund Freud. Moreover, if two people share the functions involved in satisfying a child's vital needs (feeding, nursing, changing nappies, etc.) and in socialising with the child by means of smiles, "conversation", and play, the child is more attached to the person who enters into contact with it. At the same time it remains indifferent to the adult dispassionately satisfying its most important vital needs. The remarkable observations of A.I.Meshcheryakov on the development of children born blind, deaf and dumb have shown that the early socialisation of children is based on "mutually shared activities" (c.f. the role of labour in anthropo-sociogenesis!), because of which the child is tranformed from an object of care into an active individual and gradually progresses from the "language" of object manipulation to the language of speech (Kondratov, 1982).

The third and final group of primary needs consists of *ideal* needs for knowledge of the surrounding world and the place of the individual within it, and for knowledge of the meaning and purpose of existence on earth, both through the acquisition of already existing cultural values and through the discovery of what is new and unknown to previous generations.

Yet again we must emphasise that the need for knowledge

is not derivative from biological and social needs, although of course it has very close secondary connections with them. The need for knowledge has its origin in the universal need for information which, together with the need for an influx of matter and energy, is a primordial attribute of all living creatures. The satisfaction of any need requires information on the means and methods by which the goal can be achieved. Moreover, the need for information exists as an aspiration for what is new and unknown, regardless of its pragmatic contribution to the satisfaction of a variety of biological and social needs. This view of the nature of epistemological needs is gaining increasing support (for example, Shcherbitsky, 1983).

Insisting on the independent origin of social and ideal (spiritual) needs, we naturally cannot support the thesis that these are secondary with respect to material needs, as proposed, for example, by B.F.Lomov: "Of course, the whole multiplicity of human needs is based on so-called material needs (for food, clothing, housing, etc.). On this basis, in the course of the historical development of society, there develop, in the widest sense of the word, spiritual needs" (Lomov, 1981:12).

Taking cognizance of reality, man attempts to discover the rules and regularities which govern the surrounding world. He finds the mysteriousness of the world so difficult to bear that he is prepared to impose a mythical, fantastic interpretation on it rather than suffer the burden of incomprehension, even if this incomprehension directly threatens him neither with hunger nor with danger. When man comprehends the laws of his surroundings, he places them at the basis of models of the world, whether scientific theories or works of art.

When they become part of the general treasury of human cultural heritage, ideas, theories and works of art begin to live lives of their own, often outliving their creators by centuries. "No, not all of me will die. The soul in the legacy of my lyre will outlive my ashes..." (A.S.Pushkin). Ideas, theories and perceptions of works of art continue to evolve, undergo modification and be enriched by representatives of successive generations. The discovery of objective reality and the relative autonomy of the so-called "third world", the world of ideas, does not belong to Karl Popper (1968); it was clearly formulated by V.I.Lenin: "Here we *really*, objectively have *three* elements: (1) nature, (2) human knowledge, = the human *brain* (as the highest product of nature), and (3) the form in which nature is reflected in human knowledge, i.e., concepts, laws, categories, etc. (Lenin, Complete Collection of Works, vol.29, 1963:164).

Vital, social, and ideal (epistemological) needs can in their turn be divided into two varieties: the needs for *preservation* and *development* ("necessity" and "growth" needs in the terminology of English-speaking authors). These two varieties represent the dialectically contradictory character of the onward march of nature at the level of individual behaviour. The progress of nature cannot simply be reduced to the "struggle for survival", to maintenance of equilibrium with the environment, but presupposes the mastering of the environment on continually increasing spatio-temporal scales. One characteristic which can be used to distinguish the two varieties of need is their relationship to prevailing socio-historical norms of satisfaction. Needs for preservation are satisfied within the norm; needs for development exceed the norm, inasmuch as man is distinguished by "the boundlessness of his needs and their capability for expansion" (Archives of K.Marx and F.Engels, vol.2/7, Moscow, 1935:235). In the sphere of social needs, the need for development "for self" is manifested as the drive to improve one's social position. The need for development "for others" is satisfied by an advancement of the norms themselves or an improvement in the position of a particular social group. In ideal needs, the norm is the knowledge that has been accumulated up to the present time. The ideal need for preservation is satisfied by the acquisition of this knowledge, but the need for development motivates the drive towards what is novel and unknown.

It is precisely the activity of the need for preservation and the need for development which gave rise to the two basic forms of emotion: negative and positive. The preservation (survival, equilibrium) mechanism has no need for positive emotions. It can function on the basis of negative emotions alone, since the very removal of a distressing condition via the satisfaction of the corresponding need is a reward for the individual. Positive emotions are the instrument of the need for development, and this is why their importance increases in line with the transition to ever more complex and elevated forms of motivation.

The special relationship between emotions and the needs for preservation and development is of major importance for educational practice. Folk wisdom has long observed that "wish is greater than force", i.e. the desire to be rewarded is stronger than the desire to avoid punishment. Experiments on animals and observations on children have shown that punishment for carrying out a particular act does not preclude a repetition of the same act in the future. For the

reliable prevention of undesirable acts, it is essential that they lose their attractiveness to the individual and cease to give rise to positive emotions.

The negative emotion which arises when there is a threat that needs for preservation will not be satisfied is experienced as anxiety, while the failure to satisfy needs for development gives rise to what is called frustration. Both states are negative and depressing for the individual, who tries to avoid both; nevertheless they are different states. In the first case, the individual experiences a sensation of impending peril, the fear of punishment; in the second, he experiences irritation and melancholy, engendered by lack of success. Characteristics of unsatisfied needs account for the three basic varieties of reactive depression: apathy, anxiety and melancholy. In apathy, needs are attenuated, there are no desires, and the objective content of emotional experiences is absent. This lack of desires is perceived by the reflective consciousness as manifest inferiority, pointlessness of existence, and gives a negative emotional colouring to the individual's state, sometimes leading to suicide. Characteristic of anxious depression is the sensation of one's inability to overcome or ward off life's difficulties. The feeling of guilt which arises in an individual in the state of melancholic depression has its source in moral values, in the notion of unfulfilled duty (Dragunskaya, 1983). In other words, anxious depression is connected primarily with failure to satisfy needs for preservation, whether oriented towards the self or towards others. Melancholic depression is a pathology of the needs for development, needs which are connected with values of a higher order.

This analysis of man's basic needs brings us to a formulation of one of the most succinct, but nevertheless most cogent definitions of the concept of "personality".

The personality of a given human being is determined by the relative strength in him of vital, social and ideal needs, with their subdivision into needs for preservation and development, "for self" and "for others".

Society evaluates the assortment and hierarchy of needs which characterise a given personality by relating them to the norms for satisfaction of those needs which have evolved in the given social environment. However, the multiplicity and variability of historically transient norms does not mean that all norms are of equal historical value, since at each stage in history the greatest objective value has been attributed to those norms and means of satisfying needs which to the greatest extent contribute to the development of society as a whole, and consequently to the replacement

of norms and the development of the individuals which make up that society. This is the reason why in oral and literary works from almost all epochs mankind has given preference to those of its sons and daughters in whom the needs "for others" and the bent for development were at least equal to the needs "for self" and the proclivity for self-preservation. We call a person *pusill*animous if he rejects the achievement of a distant goal in favour of one which is closer and as a rule dictated by the need to maintain his own well-being, social status or a generally accepted norm. On the other hand, he is *magn*animous who renounces an easily achieved goal (for example revenge against an offender) in favour of the satisfaction of a higher need, for example the restoration of the offender's trust in people and the awakening in him of regret for the committed act.

The best person, said L.N.Tolstoi, is he who lives primarily by his own ideas and others' feelings, while the worst sort of person is one who lives by others' ideas and his own feelings. ...The whole diversity of mankind is based on different combinations of these four principles or motivational forces (Markusha, 1979). If this classification is translated into the language of needs, the best variation turns out to be the social need "for others" combined with the need for knowledge, free of distracting influences and not content with a mechanically achieved norm. The worst is a personality which is egoistically oriented towards itself, subordinating its judgements not to objective truth but to borrowed and conveniently utilitarian opinions. It should be noted that Tolstoi speaks of the presence of "four principles" which go to form "the whole diversity of mankind". In other words, he does not emphasise "types", but the *parameters* by which they can be judged, a system of coordinates which coincides with the four varieties of need: the "motivational forces".

We are deeply convinced that any system for testing personality will be effective in practice only to the extent to which it succeeds in objectively diagnosing individual variations in the relationship between the needs for preservation and development, "for self" and "for others". Unfortunately, the tests which exist at the present time have a purely empirical character. Lacking a scientifically based theory as a foundation, they operate with a huge quantity of secondary factors and as a rule fail to bear upon what is most important in the structure of personality traits. Even less developed are instrumental psychophysiological methods for the differential diagnosis of personality. Here only the first steps have been taken (Valueva, 1969; Gryzlova, 1976; Milgram, 1974).

As well as the three basic groups of need enumerated above, there are two additional ones: the *need for preparedness* and the *need to overcome*, usually called the will. If individual variations in the hierarchical correlation of the basic needs determine the *personality* of a human being, then individual variations in the level and degree of satisfaction of the additional (supplementary) needs form the basis of his *character*.

In order to satisfy his multifarious needs, man must be equipped with the corresponding means and methods. The mastering of skills is in many respects divorced from the process of satisfying basic (vital, social, ideal) needs, and is motivated by an independent need which is sometimes defined as the "competence motivation", the urge to perfect motor coordinations which is subsequently transformed into the desire for mastery, the development of capabilities, and the potential for controlling the external environment (Yarrow and Messer, 1983).

The acquisition of the very first, most elementary abilities by a young child is not connected with its hunger and thirst. What is more, hunger and the discomfort caused by wet nappies or a chilly temperature interrupt and slow down the process of acquisition of skills which the child will actually need much later.

Attempts to move the arms and fingers emerge as early as one hour after birth. By the end of its fourth month, a child will reach out and grasp visible objects and try to manipulate them. During growth, more and more significance attaches to imitation of the actions of adults. At two months, children react to the attention paid to them with a whole series of actions, including smiles and movements of the lips and tongue. Some authors believe that a two-month old child is capable of imitating the mouth movements of its mother. Subsequently this ability will become the basis for learning the articulation and reproduction of speech sounds. A child is capable of repeating the same actions tens and hundreds of times, the sole purpose of which (of course, unbeknownst to the child) is the training of its psychophysiological apparatus.

Awareness of the autonomy of the need for preparedness, which is capable of generating its own positive and negative emotions, accompanied by the specific ability to activate, arouse and strengthen this need, ought to form the basis of the theory of labour education. Even when an activity is lacking in novelty and creativity, the high level of professionalism, accuracy, and perfection required for the performance of the routine operations it involves endows this activity with a special attractiveness, even though it

does not satisfy the need for preparedness and the positive emotions which this engenders. Unfortunately, pedagogic practice often fails to appreciate in full measure the reality and significance of this need, and neglects to support and cultivate it. In an attempt to make the learning process interesting and fascinating for the child, the teacher usually appeals to its curiosity, relies on the need for knowledge and ... encourages dilettantism. Fascination turns into superficiality, curiosity turns into triviality. In fact, the joy of discovery should constantly be supplemented with the joy of competency: the need for preparedness is subject to the principle that there can be no substitute for it through the satisfaction of other motivations.

The level of satisfaction of the need for preparedness strongly influences the formation of character and the attributes it will possess. A high level of preparedness, consciously appreciated or unconsciously sensed by the individual, makes him calm, confident, independent and capable of self-control in complex and rapidly changing circumstances. Insufficient preparedness, depending on the domination of one or other primary (basic) needs, endows the character with the attributes of anxiety, unease about position in society, jealousy towards the successes of others and dependence on their patronage and support. Instead of lamenting the "bad" or "weak" character of a pupil, and instead of abstract appeals for "reformation", we should be thinking about how to equip him with the means to satisfy those of his needs which have social value.

The need for preparedness is satisfied to a significant extent through imitation and with the aid of play, especially in the early stages of individual development. The most important characteristic of imitative behaviour is its ability to address itself directly to the subconscious. This gives the examples which a child finds in its immediate microsocial surroundings a strength which easily overcomes appeals directed at its conscious mind to behave well and not to do what is naughty. It is precisely the mechanisms of imitative behaviour that underlie and expedite the internalisation of social norms, a process in which externally originating norms are converted into the internal regulators of behaviour we call conscience, sense of duty, call of the heart, etc. Conscience occupies its proper place in human behaviour only when its commands are enacted as imperatives which require no logical argument. The same is true of good manners, responsibility, and accuracy in fulfilling obligations, as they become character attributes and not pragmatically advantageous forms of behaviour. In

fact, good manners presuppose not simply a knowledge of behavioural norms, not the observance of these norms with the aim of reward or the avoidance of punishment, but the impossibility of breaching norms which have become internal regulators of actions and behaviour. As a certain jurist wittily remarked, a normal person will not threaten the life of another, even when enraged, not because he is afraid of the ultimate punishment, but because he is moved by the ancient commandment "thou shalt not kill". A person who observes norms in the name of advantage or fear of retribution is immoral. Calculations based on the principle "an eye for an eye, and a tooth for a tooth" leave conscience and morality in tatters.

One example of imitative behaviour, with its characteristic weakening of conscious control, is hypnosis. In the graphic phraseology of Sigmund Freud, hypnosis is "a crowd of two" in which the hypnotised "assistant" uncritically follows the leader, the hypnotist. Surrendering to the hypnotist all responsibility for the situation and the content of suggestion, liberating himself from the heavy burden of freedom of choice (F.M.Dostoevsky), the subject experiences his state as something clearly positive. The wish to submit to the commands of the hypnotist plays an essential, if not decisive role in the mechanism of suggestion (Chertok, 1982). We shall return to the mechanisms of hypnosis in connection with the problem of unconscious manifestations of higher nervous functions.

Another method of satisfying the need for preparedness is through play. There is one common distinctive feature in any play, whether it be the play of children, sport, the "business games" of production managers or the war games of general staffs, namely, the temporary divorce of actions from the goal these actions are intended to achieve. Play arms the individual with abilities, the real need for which will emerge only later.

Play trains and develops not only the individual's physical skills, his competence in carrying out externally focussed actions and his volitional qualities, but also his imagination, fantasy, logic and creative intuition. The maturational functions of play are greatly assisted by its "disinterestedness", its relative freedom from the satisfaction of needs of a pragmatic kind, including those connected with social prestige. As a consequence, the need for preparedness assumes a dominant position, and creative intuition begins to "work" almost exclusively on behalf of this need, aiding the development of natural skills and abilities. The creative principle which is in the very nature of play adds attraction to even the most mundane

activities. This most important quality of play was fully appreciated by a child psychology expert like A.Gaidar, the author of the chidren's book Timur and his Team. Indeed, if Timur and his team are deprived of the mystery with which they surround their aid to the families of front-line troops, their secret meetings in a hayloft, special signalling systems, and the anonymity which heightens their altruism etc., all that is left is a routine "operation" carried out at the initiative and under the control of adults. Dreamers and schemers will be replaced by more or less conscientious doers.

Alongside the need for preparedness, we must mention one more need which is supplementary to the basic needs. This is man's *need to overcome* the obstacles to the satisfaction of another need that is the primary initiator of behaviour, i.e., the will. In the introduction, we have already stated that the overwhelming majority of contemporary writers see the will as a quality derived from consciousness, as "the conscious self-regulation by an individual of his activity and behaviour", "the basis of self-control", "the ability of the consciousness to govern behaviour", etc. Such interpretations seem to ignore the energising factor, the force which motivates a person to carry out the action dictated by the will. Nor is it possible to consider the will as the strongest dominant need, since a motivation which overpowers all others has no need of will. This is where I stand, I *cannot* do otherwise; in the situation which Martin Luther had in mind, there was no place for the will.

L.S.Vygotsky (1982) saw the manifestation of the will in those actions which follow an instruction given by the individual to himself: for example, counting "one, two, three" before jumping into the water. Again the question arises: what motivates a person to give himself such an instruction and to carry it out?

We consider the phylogenetic precursor for the emergence of the will to be the freedom reflex discovered by I.P.Pavlov in higher animals, recalling that, in the words of Karl Marx, "the overcoming of obstacles is in itself the accomplishment of freedom..." (Marx and Engels, Works, vol.46, part 2:109). The independence of the will as a specific need is demonstrated by its ability to generate its own emotions, emotions connected with the overcoming of an obstacle before the achievement of the final goal. A competing need can itself become the obstacle preventing the achievement of a goal. In such a case, the dominance of one of the competing motivations will be determined not only by its strength, but also by the emergence of the activity to which the subordinate motivation is an obstacle, an internal

blockage.

The activity provoked by an obstacle can in certain situations and in a certain type of person push the original motivation into the background. In this case what we encounter is obstinacy, a behaviour in which overcoming has become a goal in its own right, and the original motivation loses its purpose and is even forgotten.

Pleasure in overcoming is the clearest indicator of will. This positive emotion also provides a method of educating and strengthening the will, so that a person is not depressed by the burdens of failure but repeatedly experiences the joy of overcoming obstacles, even when the obstacle to the achievement of a set goal is the person himself. Individual variation in the norm for satisfying the need for freedom is one of the basic features of character. It is no accident in our schema that "a person with character" means a "strong-willed" person, and "characterless" sounds the same as "weak-willed". To show character means to insist on one's own opinions, not to abandon a previously set goal, to finish what is begun.

Thus the will is in no sense a regulator of behaviour which stands above needs and emotions: it is itself a need armed with its own means of satisfaction and generating its own series of emotions. In conjunction with the individually varying need for economy of effort, the need for preparedness and the need to overcome, which are independent in origin but at the same time "service" the satisfaction of other motivations, determine individual character traits: they make the character strong, weak, decisive, tough etc.

There are certain activities which lead to the simultaneous satisfaction of a complex of needs. For example, work satisfies the material need for a wage, the social need to be an authority and an example to one's workmates, and, whenever a worker is able to bring to his work elements of inventiveness, technological discovery, etc., satisfies also the ideal need for knowledge and creativity. But much more frequently we encounter the competition of coexisting motivations, in which case the behaviour vector must be directed at the preferential or even exclusive satisfaction of one of them. Inasmuch as the objects which satisfy needs are to be found in the external environment, it is not possible for the behaviour vector to be determined solely by the need which dominates at a particular moment: all living creatures must take into account the *possibility* of satisfying their needs through interaction with their current surroundings. In other words, the *significance* of events which take place in the external environment, and the importance of whether this or that

object (or the signal which is its precursor) appears or disappears, are determined not only by the strength and urgency of the prevailing need and its place amongst other co-occurring motivations, but also by the probability (possibility) of satisfying needs in the given situation at the given moment.

The course of evolution objectively required the creation of a physiological mechanism which could perform an integral evaluation of any event and any alteration in the environment or in the organism itself, and on the basis of this evaluation intervene in the competition of motivations to determine the direction and goal of a behavioural act.

We find such a universal measure of values in the *emotions* of higher animals and man, with all the wealth of reflective-evaluative and regulatory functions they possess.

Chapter 3

THE REFLECTIVE-EVALUATIVE AND REGULATORY FUNCTIONS OF EMOTIONS. THE NEUROANATOMICAL AND NEUROCHEMICAL BASES OF EMOTIONS

> Despite the fact that each of us knows what emotions are, it is impossible to give the emotional state a precise scientific definition... At the present time there is no generally accepted scientific theory of emotions, nor any precise data concerning which centres emotions arise in, how they arise, or what their nervous substrate is.
>
> The Physiology of Man (1985:211-212).

Since our previous book (Simonov, 1981) is devoted to a detailed exposition of the physiology, neuroanatomy and psychology of emotions, this chapter is restricted to a very brief recapitulation of the basic principles of the need-information theory of emotions and a summary of the latest data concerning brain mechanisms of human emotions.

However, our prime concern is to formulate the questions which must be answered by any current theory of emotions which has some claim to completeness.

1. If the author of a theory shares the opinion that emotions are one of the forms of reflection of reality, he is obliged to define exactly what emotion reflects, and how it differs from other varieties of reflectory brain activity. The complexity and undecidability of this question was noted by V.K.Vilyunas. "When investigating cognitive processes, it it usually possible to base the investigation on two types of phenomena: the objective and the subjective, the source of the reflection and the reflection itself. In relation to a subjective reflection, objective phenomena can act as a kind of "stereotype" of what for example ought to or can be perceived, imprinted or comprehended... When investigating emotions however, this possibility does not

exist. Emotions have the function not of reflecting objective phenomena, but of expressing subjective attitudes to them... Therefore, data concerning a particular emotional experience can only be compared with data concerning other emotional experiences of the same person or of other people, and not with some objective 'stereotype'" (Reikovsky, 1979:7).

2. Any new theory of emotions must in our opinion contribute to the taxonomy and classification of observed emotions by providing the theoretical *principle* for such a classification. It is of course possible to proceed in a purely empirical manner, as in the classification of B.I.Dodonov (1978). After asking a reasonably large number of people which emotions they experience especially often, and which of these experiences seem to them most valuable and desirable, Dodonov groups the responses and comes to the conclusion that there are altruistic, communicative, glorious, practical, punic, romantic, gnostic, aesthetic and acquisitive emotions. The use of this kind of descriptive classification, which is not based on any theoretically justified classification principle, seems to be specific to the psychology of emotions and distinguishes it from other fields of science. Let us note for comparison that it is impossible to imagine the *classification* of chemical elements in Mendeleev's table without the discovery of the periodic *law* for the increase in atomic weight of each element. As far as these descriptive classifications are concerned, deeper analysis reveals, for example, that there are no "altruistic" emotions as such, since altruistic behaviour can be based on highly disparate motivations: co-experience and moral self-esteem. The emotions too are correspondingly different and their amalgamation into a single group is merely formal.

3. A conception which lays claim to be called a theory must answer the question as to what role is played by emotions in the activity of living organisms and the organisation of their goal-directed behaviour. What are the regulatory functions of emotions and how do they differ from the regulatory functions of consciousness, thought, memory and will?

4. A theory must contribute to the clarification of which brain mechanisms are involved in the formation and activation of emotional reactions in man and higher mammals. Thanks to progress in general brain physiology, neuropsychology and neurosurgery, we now have a reasonably

long list of the brain structures which participate in emotional reactions and states. Included in these brain formations are the frontal and temporal regions of the neocortex, the hippocampus, amygdala, hypothalamus, septum, central gray matter, non-specific nuclei of the thalamus, and a few other structures. At the same time, it is far from clear what precise role is played by each of these formations in the genesis and activation of emotions. Allusions to the "systemic" and even "holographic" distribution of functions, or to the activity of "the brain as a whole", seem to us unproductive. Attempts to return to a conception in which emotions are an ultimate, indivisible psychophysiological formation can be compared with calls to abandon modern conceptions of the diversity of elementary particles in favour of the "integral" atom of Demokrites.

5. Finally, the proposed theory must add something fundmentally new to educational practice, preventive care, and the struggle against the undesirable consequences of emotional stress and its effect on the health and performance of human beings. The universal validity of practice as a criterion of truth fully holds in the special case of research into the laws and mechanisms of emotion.

The reflective-evaluative function of emotions. To the question of what emotion reflects, the need-information theory gives a definite and unequivocal answer: emotion is a reflection in the brains of human beings and higher animals of some actual need (its quality and magnitude) and the probability (possibility) of its satisfaction, which the individual involuntarily evaluates on the basis of innate and previously acquired personal experience. In this definition the notion of source and the notion of reflection are both represented (through the need and the probability of its satisfaction respectively). Emotion reflects objects and events in the surrounding environment as they relate to the actual needs of the individual, whence these objects and events are endowed with significance and subjectively evaluated.

In its most general form, the law governing the origin of emotions can be presented as a structural formula $E = f(P, (I_n - I_s), \ldots)$, where E is the emotion, its degree, quality and sign; P is the strength and quality of the actual need; $(I_n - I_s)$ is the evaluation, on the basis of innate and ontogenetic experience, of the probability (possibility) of satisfying the need; I_n is information concerning the means which are predicted to be necessary for the satisfaction of the need; I_s is information concerning

available means, i.e., those means which the individual actually has at his disposal. The representation of established dependencies as formulae is widely used in theoretical and experimental psychology. As an example, we can cite the formula of McGrath (1976), which shows affinities with our own results: $S = Co(D - C)$, where S is the degree of stress, Co is the degree of importance of the demand; D is the perceived demand; C is the perceived possibility. It is not difficult to see that this formula strongly resembles the "emotion formula", the difference being that, having appeared twelve years later, it concerns only the special case of a conscious evaluation of a situation, while the vast majority of emotions are characterised by the prediction of the probability of achieving a goal (satisfying a need) at an unconscious level.

Can the validity of our formula be verified by direct experiment? Yes, it can. Of course, using present levels of experimental technique, the "structural" emotion formula becomes "measurable" only when comparatively elementary emotional reactions are investigated. For example, we can measure degree of emotional tension according to the magnitude of objectively recordable physiological changes (frequency of heartbeat, amplitude and duration of galvanic skin reactions (GSR), total potential of the theta rhythm of the electroencephalogram etc.). Within certain limits we can measure the need for food by the duration of the hunger state, and the need to avoid pain by the strength of a painful irritant. Finally, we can measure the objective probability of the satisfaction of a need by differences in the probability of reinforcement of a conditioned signal. In our books and articles we cite many examples of this type of experiment, showing the regularity of the dependence of the degree of emotional tension on the strength of the need and the probability of its satisfaction (see also Price and Barrell, 1984).

In our laboratory, A.Ya.Mekhedova (1969) developed classical conditioned reflexes in dogs, reinforcing the conditioned signal differently in a series of experiments with: (1) 5g of meat in 100% of cases; (2) 50g of meat in 100%; (3) 5g and 50g at random, but in an equal ratio of 1:1. It turned out that under a normal feeding regime the maximal frequency of heartbeats, by which the degree of emotional tension in the dog can be judged, is observed under constant reinforcement with a large portion of food (fig. 1, *A*), while twenty-four hours of hunger makes the situation in which the conditioned signal is randomly reinforced an emotionally tense one (fig. 1, *B*). In other

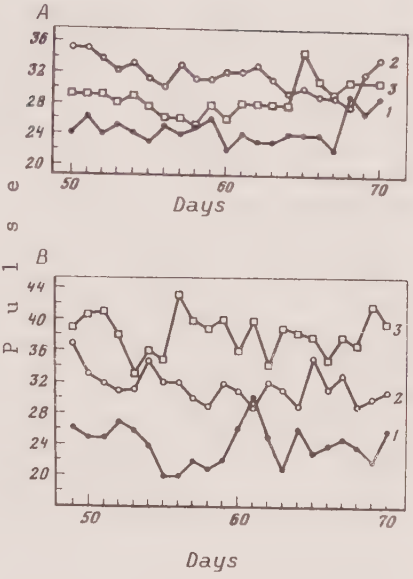


Fig. 1. Dynamics of the heartbeat component of a conditioned reflex in dogs under constant reinforcement with (*1*) a small portion of food, (*2*) a large portion of food, and (*3*) under random reinforcement with a probability of 50:50

A - under a normal feeding regimen;

B - after food deprivation

(data from A.Ya.Mekhedova).

words, the uncertainty of the experimental situation is not in itself emotiogenic, but pragmatic uncertainty is, i.e. both the magnitude of the actual need and the probability of its satisfaction play a role in the genesis of emotion. According to the data of D.N.Menitsky and M.M.Khananashvili (1969), the greatest emotional tension in dogs (yelping, barking, scratching, scraping the food-dispenser) was observed when the probability of reinforcement was 1:4, changing to 1:2 as the experiment continued. The importance of the information factor was especially apparent in experiments with paired animals, when both partners received an equal number of electric shocks, but only one of them could avert punishment by the appropriate instrumental reaction. It was in this animal that had control over the lever that signs of fear gradually disappeared and ulceration of the lining of the stomach and intestine was avoided.

It has been established that the heart rate of bank employees depends on the degree of their responsibility (counting notes of different denominations) and the amount of information contained in each operation. In the course of an experiment, K.Perkis (1984) altered both the size of the financial penalty imposed for the commission of errors, and the probability of their occurrence, which was independent of the efforts of the subject. The increase in heart rate

showed a regular correlation with alterations in both factors, and was more strongly evident in type A subjects.

There is evidence that the two components of emotional tension differently affect the magnitude of various vegetative shifts. In experiments with human beings, the size of an inducement (the amount paid for a correct decision) preferentially affected the pulse rate, the respiratory rate, and the galvanic skin response (GSR), while the difficulty of the task (the number of choices) affected both the GSR and the cardiac output. The preferential link between the GSR and the information factor is also demonstrated by experiments in which the GSR was weaker when a painful shock was expected with a high probability than when the shock was less frequent but hard to predict. The fact that the GSR and evoked potentials were recorded in response to an orienting stimulus shows that the motivational components of the orienting reflex are determined to a greater extent by the genotype of the subject than are the informational components (Kochubei, 1985).

However, the significance of the probability (possibility) of satisfying an actual need is by no means taken into account by all investigators of emotion. "From the physiological point of view," wrote P.K.Anokhin, "the task which faces us is to discover the mechanism of those concrete processes which in the end give rise either to a negative emotional state (need) or a positive emotional state (satisfaction)" (Anokhin, 1964:355). In his treatment of the genesis of emotions, P.K.Anokhin took into account only the prediction of the content (or semantics) of the goal, assuming that at a given moment there can only be a single goal, i.e., a person intends to pick up either a glass, or a fork, or a plate (we use an example which P.K.Anokhin himself was wont to use). P.K.Anokhin rejected the notion that prediction of the probability of achieving a goal is involved, although without such a prediction it is difficult to understand the fact that emotions can arise before actions. He wrote: "... the expression 'probability prediction' has simply no relation to the physiological meaning of events, and is misleading to those readers who are interested in our work. The probability of the prediction, i.e., of the parameters of the action acceptor, is always maximal and equal to one, since it reflects the need of the organism at the particular moment. On the other hand, the result is always less probable in relation to the action acceptor, and consequently the expression 'probability prediction' is of little use in the investigation of living systems" (Anokhin, 1978:272). So as

not to have to return to P.K.Anokhin's "biological theory of emotions", we emphasise our agreement with him with respect to the prediction of the content of the goal, the link between emotions and needs, and the genesis of some negative emotions. At the same time that we consider it absolutely necessary to introduce into a model of the origin of emotions a mechanism for predicting the probability that the goal will be achieved, we substantially disagree with P.K.Anokhin on how to explain the mechanism of positive emotions, and of course we cannot limit the application of our model solely to biological needs (a limitation inherent in the very name of P.K.Anokhin's theory).

In what way does a human being predict the probability of achieving a goal (satisfying a need)? Experimental and theoretical analysis show that the evaluation involves a comparison of the information about the means, methods and time which the individual predicts to be necessary, and that which he actually possesses. The probability of satisfaction turns out to be an integral index, the result of this comparison. For example, the probability of a safe ending to a hunter's encounter with three furious predators will be substantially different depending on whether he has an automatic rifle with a full clip or a single cartridge. In many experiments, the difference between the necessary and the actually available can be measured empirically by the total number of errors committed by the subject: this number is evidence of the extent of his "informedness", including not only the theoretical knowledge of what needs to be done and how, but also the degree to which the corresponding practical skills have been perfected.

The relationship between the necessary and the actually available can be treated both instantaneously, as an "instantaneous section" of the degree of informedness, and dynamically. In the first case, the result of the comparison will be a deficit or excess of information; in the second case, it will be a rise or fall in the probability of achieving the goal.

The universality of the comparison mechanism is such that it is found even in the genesis of those elementary emotions which are usually called emotional colourings of sensation. For example, the emotional colouring of the sensation of food in the mouth (tasty, indifferent, unpleasant) is formed only after the hunger stimulus (the need) is brought together with the afferentation (the information) from the oral cavity indicating an increase in the probability that the need will be satisfied by food.

The probability of satisfaction can be both subjective and objective. Of course, only the subjective evaluation of

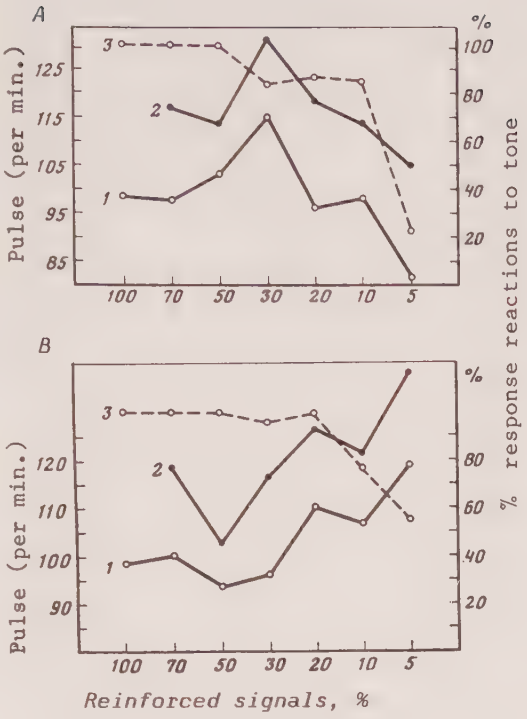
the probability of achieving a goal participates in the formation of emotions. Animals and man can only exist because their subjective evaluations of probability are as a rule adequate reflections of the objective probability of particular events. In individual cases the subjective prediction turns out to be false, and then the emotional evaluation of events fails to correspond to their real significance (this is captured by Russian proverbs such as "to a drunk the sea is only knee-deep" and "a scared crow is even afraid of a bush").

Uncertainty is incompatible with a high probability of achieving a goal, even though the maximum uncertainty of impending events (50%) leaves more room for optimism that the denouement will be satisfactory than does a patently low probability of 20% or 10%.

In applying our theory to emotions, we must now deal with an additional factor which is not represented in the formula, just as the formula makes no reference to the dynamics of the unfolding of emotional reactions in time and much else. What are meant are the individual (typological, characterological) properties of the emotionality of a given subject. The experiments of our colleague L.A.Preobrazhenskaya have shown that emotional tension, as deduced from the heart rate of dogs, reaches its maximal values in some dogs when reinforcement is maximally uncertain (fig. 2, *A*), and in other dogs when the probability of reinforcement is low (fig. 2, *B*). There are even "probability-indifferent" dogs (fig. 2, *C*). We have found similar observations in the research of V.M.Rusalov, (1979), who detected three groups in his sample, each of which reacted differently to a probabalistically organised environment.

The individual characteristics of a particular animal are also displayed in situations of conflict between the quality (value) of reinforcement and the probability of satisfaction of the corresponding need. D.I.Menitsky (1983) calls these two factors the activational and informational components of reinforcement. In collaboration with L.P.Rudenko, we carried out a series of experiments on three dogs in a chamber containing four food-dispensers (fig. 3). Each dispenser accommodated a disc with eight metal cups full of minced meat. With the aid of a remote control device, the disc could be revolved so that one of the cups appeared in the opening of the dispenser.

Each dog was let into the chamber in turn (ten times in the course of each experiment) and given access to the food when it approached the dispenser which had been "activated" for the particular test according to a previously



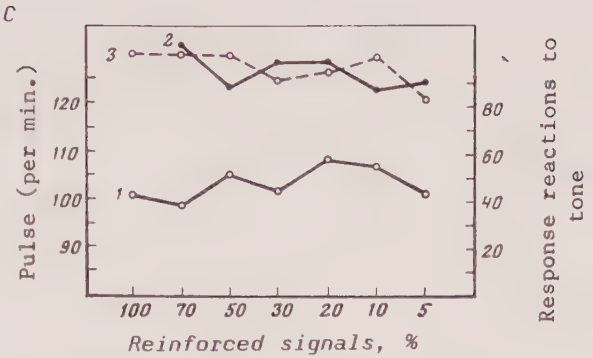
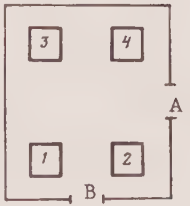


Fig.2. Background heart rate (*1*), heart rate on the appearance of an empty food-dispenser (*2*), and the percentage of motor reactions to the conditioned signal (*3*) in three dogs (*A*, *B*, *C*) with different probabilities of reinforcement (according to L.A.Preobrazhenskaya).

Fig.3. The position of food-dispensers *1-4* in the experimental chamber

A - dogs' entrance
B - experimenter's window



determined program. The basis of this program was that the probability of obtaining meat on approaching dispenser no. 1 was 50%; dispenser no. 3, 30%; and dispenser no. 2, 20%. Approaches to dispenser no. 4 were never reinforced. After the first seven days, the experimental conditions were changed so that on approaching dispenser no. 1 the dogs now received, instead of meat, a meat-cracker powder moistened with water. The probability of receiving powder from dispenser no. 1 and meat from dispensers no. 2 and no. 3 remained unaltered. In each of the ten tests the dogs could receive reinforcement from only one dispenser. The experimenter could observe approaches to the dispensers through a window. In addition, the approaches were recorded on a pen-recorder connected to pressure pads placed next to all four dispensers.

The experiments showed (fig. 4) that, starting on the 3rd - 5th day of the tests, all the dogs give preference to the dispenser with the highest probability of dispensing food. In the first 3 to 4 days Ikarus and Dinka (*A* and *B* in figure 4) displayed a preference for dispenser no. 2 with 20% reinforcement. This anomalous behaviour can probably be explained by the position of dispenser no. 2 on the path to the frequently reinforced dispenser no. 1 (see fig. 3), as a result of which the approach to dispenser no. 2 becomes one component of a reinforced complex: dispensers nos. 2 and 1. Figure 4 shows only the quantity of *first* approaches to dispensers no. 1, no. 2, and no. 3, when a dog entering the chamber immediately goes to the given dispenser. If the behaviour of the dogs is considered as a whole, it is possible to convince oneself that all three dogs treated the dispensers in a manner consistent with the probability of reinforcement. First they would approach dispenser no. 1 (50% reinforcement), then dispenser no. 3 (30%), and finally dispenser no. 2 (20%). They totally abandoned approaches to dispenser no. 4 (0%).

The behaviour of the dogs significantly changed when meat was replaced by meat-cracker powder in the frequently reinforced dispenser no. 1 (arrow a in fig. 4). The number of approaches to this dispenser started to fall, and the number of approaches to the "meat" dispenser no. 2, increased. We have already discussed the question why dispenser no. 2 was a more effective conditioned signal than dispenser no. 3. A preference for the infrequently reinforced "meat" dispenser no. 2 as opposed to the frequently reinforced "cracker" dispenser no. 1 was observed in Dinka and Buyan (*B* and *C* in fig. 4). After a two-week "struggle between the probability of reinforcement and its value" (the 11th and 12th experiments), Ikarus

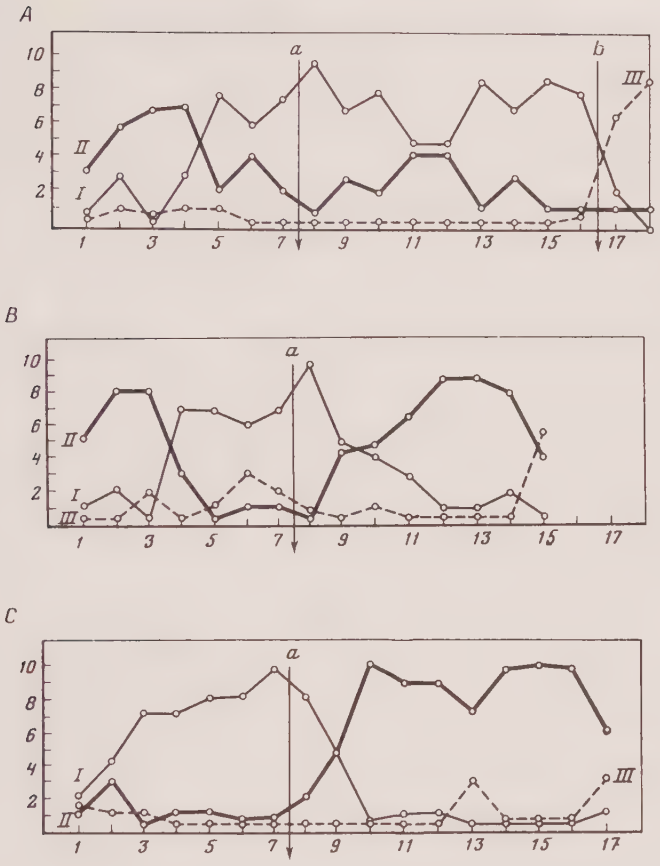


Fig. 4. The quantity of first approaches to food-dispensers no. 1 (*I*), no. 2 (*II*) and no. 3 (*III*) by dogs Ikarus (*A*), Dinka (*B*) and Buyan (*C*).

Abscissa - days of the experiments; arrow *a* - replacement of meat by crackers in dispenser no. 1; arrow *b* - satiation with crackers.

continued to give preference to dispenser no. 1. Only the satiation of this dog with crackers before the experiment (17th and 18th days) led to a clear dominance of the

frequently reinforced "meat" dispenser no. 3. In other words, in the event of a conflict between the probability and value of reinforcement, the motivation level and the individual characteristics of the animal assume a decisive importance.

Research into the dependence of the food-seeking behaviour of dogs on the probability and quality (value) of reinforcement has revealed the complex relationships between these two factors in the organisation of goal-directed behaviour. When the level of motivation is constant, the food-seeking strategy is determined by the probability of finding food at a particular point in space, and this probability is predicted on the basis of previously acquired experience. The situation becomes significantly more complex whenever a conflict arises between the probability and quality of reinforcement, inasmuch as the strength of the need affects not only the level of emotional tension, but also the activity of the brain mechanisms which evaluate the possibility of satisfying the need. Strengthening the motivation generally results in a transfer to the optimal strategy, i.e. to reactions which secure the maximal total profit (Sigel and Goldstein, 1959).

I.M.Feigenberg (1972) demonstrated experimentally that the degree of distortion in the dependence of reaction time on the probability of occurrence of a signal can act as a quantitative measure of the significance of this signal to the subject. As we have already noted, predictions of the probability of a given event are determined to a large extent by the individual (typological) characteristics of the subject (Krauklis, Yanson, Shiraev and Kazakovskaya, 1979; Rusalov, 1979).

Experiment and observation have shown that an emotion generated by a need has a retroactive effect on the need and on the prediction of its satisfaction. Indeed, the prediction too can significantly affect the strength of the need, as is demonstrated by numerous experiments with so-called "learned helplessness". Of course, when we speak of the effect of emotions on needs, and of needs on predictions of the probability of achieving a goal, we certainly do not think that emotion and need can grow without limit. The reason such limits are not stipulated and not reflected in the emotion formula, we repeat, is that the formula is to be considered as a structural and qualitative model and only in certain relatively simple cases its symbols be substituted by empirically measured quantities.

Nevertheless, the formula is a clear rendition of the complex internal structure exhibited by emotions and by the interdependence of emotion, need, and the probability of

satisfaction of need, both at the conscious and the unconscious levels of higher nervous (psychic) activity. M.A.Kotik (1978) proposed a method of evaluating the significance of an event to an individual as a function of the value (importance) of the event and its probability. The results achieved with this method are in good correspondence with the emotion formula.

According to G.T.Beregovoi and V.A.Ponomarenko (1983:27), "Experimental materials concerning the reception and processing of information in cases of partial technology failure show that the greatest extremes of danger are to be found in states of the "pilot-plane" system in which the need to intervene in the control of the plane is recognised, but there is not enough information (signals) for the pilot to take a decision; the main factors which disorganise behaviour are the lack and ambiguity of information." A similar evaluation of the theory is given by V.I.Lebedev (1980:51): "The emotional tension shown in the express determination to fulfil a task when a risk factor is in operation and definite information about impending events is lacking is fully consistent with the information theory of emotions developed by P.V.Simonov". The evidence from practical research cited above, and similar evidence from elsewhere, convince us that the theory is an adequate account of the objective laws governing the genesis of the emotional state.

The classification of emotions. Inasmuch as at the basis of any given emotion lies a corresponding need, and inasmuch as at the same time there could be several needs with differing probabilities of their being satisfied ("I feel sad and easy, light is my sorrow" - A.S.Pushkin), an attempt to give a full classification of emotions seems attractive but hopeless. For this reason, many authors try to isolate just a limited number of "basic" emotions.

The information theory of emotion suggests first of all a classification into the two traditional groups of positive and negative emotions. Positive emotions arise in situations where there is an excess of pragmatic information in comparison with an earlier prediction, or where the probability of achieving a goal increases (if the genesis of emotions is considered dynamically). Negative emotions represent a reaction to a deficit of information or to a decrease in the probability of achieving a goal.

The probability of achieving a goal depends to a great extent on the effectiveness of an individual's actions, and for this reason the second principle underlying the classification of emotions is based on the nature of the interactions of living organisms with the objects which are

capable of satisfying a given need. We distinguish contact interaction, which is already in progress, and distance interaction in the form of acquisition, defence and conquest (struggle). Using such a coordinate system we obtain four pairs of "basic" emotions: pleasure-disgust, joy-sorrow, confidence-fear, exultation-rage. We first published such a classification of emotions in 1966 (Simonov, 1966). It was later supported by V.D.Nebylitsyn. The qualitative characteristics of such emotions as delight, joy, fear and anger are totally determined by the need in connection with whose satisfaction they arise. We in no way consider the proposed classification of emotions as superior to or incompatible with other possible classifications. We wish only to emphasise that it follows directly from the theory we are developing.

The reinforcing function of emotions. As a universal measure of the value and significance of events taking place in the external environment, emotions are intimately involved in the processes of learning and memory, and in the formation mechanism of new skills and new conditioned reflexes. Inseparably linked with emotions is the phenomenon of reinforcement. Inasmuch as the formation, existence, extinction, and characteristics of all conditioned reflexes depend on the fact of reinforcement, reinforcement occupies a central position in the conceptual system of the science of higher nervous activity. Under reinforcement "Pavlov understood the action of a biologically significant stimulus (food, noxious irritant, etc.) which makes another combined (paired) but biologically unrelated stimulus act as a signal" (Asratyan, 1971:5). Numerous data show that a conditioned reflex can be developed by combining even so-called "indifferent" stimuli, although the speed of connection of the conditioned link and its stability and subsequent fate depend decisively on the species-specific characteristics of the animal and the intensity, sensory modality, and order of combination of the stimuli (Schoenfeld, 1978). It should be noted that a stimulus which appears irrelevant to the experimenter may be ecologically important to an animal of a particular species, not to mention the fact that the exploratory need (curiosity) is exceptionally strong in many animals and can make "indifferent" events "vitally important" (Berlyne, 1978).

In another sense, reinforcement can be considered as the action of a second stimulus, as a result of which the first stimulus starts to excite a reaction previously uncharacteristic of it. Discussing this issue, E.A.Asratyan particularly emphasised that the expression "'reinforcing

reflex' more fully and accurately reflects the essence of the matter than the term 'reinforcing stimulus'. It seems that an unconditioned stimulus must achieve its reinforcing effect through the unconditioned reflex it excites, by means of this reflex. In other words, it is the reflex which reinforces, not the stimulus which gives rise to it... It is not difficult to see the logical connection between this proposal and the definition we proposed almost two decades ago of a primary conditioned reflex as a product of the synthesis of two or more unconditioned reflexes..." (Asratyan, 1977:12). Confirmation of E.A.Asratyan's notion of the "reinforcing reflex" can be seen in the fact that a necessary condition for the irreversibility of imprinting in ducklings is the reaction of following a moving object. Passive observation of this object is insufficient (Kertzman and Demarest, 1982). Inasmuch as according to E.A.Asratyan any unconditioned reflex has a complex, "multistorey" morphofunctional organisation, further development of this idea entails clarification of the components of the reinforcing reflex which are of decisive importance for the activation of the reinforcement phenomenon.

The role of these components emerges sufficiently clearly even when a conditioned link is developed by the direct stimulation of brain structures with the aim of investigating cellular-synaptic connection mechanisms.

In our laboratory, V.A.Markevich and L.L.Voronin (1980) developed a conditioned pyramidal response by combining a single bipolar electrical stimulus with a packet of 3-5 stimuli at 100 Hz. The two pairs of electrodes were placed in direct proximity to each other in the sensori-motor cortex of a rat in the zone where its front paw was represented. This combination was accompanied by stimulation of a point in the lateral hypothalamus which in preliminary experiments elicited the reaction of self-stimulation. A recording of the responses of the pyramidal tract was made at the level of the medulla oblongata (see schema *A* in fig. 5). From the fragments *B* and *C* in fig. 5 it can be seen that the combination of all three stimuli leads to an increase in the synaptic components of the response while the direct response remains relatively stable. These changes are not observed in control experiments when the stimulation of the hypothalamus precedes the cortical stimulation (*D*) or when the cortical stimuli are combined without additional stimulation of the emotiogenic zones of the hypothalamus (*E*). Thus the involvement of emotiogenic structures turns out to be extremely important in the development of even a relatively simple analogue of a conditioned reflex.

The requirement of the involvement of brain mechanisms

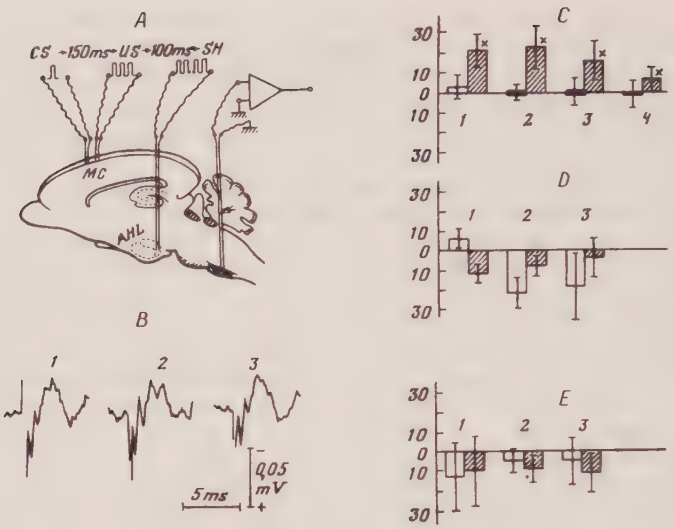


Fig. 5. Development of an analogue of a conditioned reflex

A - schema showing the localisation of stimulating and recording electrodes; intervals (ms) between the application of stimuli are shown above; *B* - illustrative recordings of averaged responses of the pyramidal tract: *1* - before combination, *2* - after combination, *3* - after extinction; *C* - summed changes in the direct and synaptic (shaded columns) components of the pyramidal response based on seven experiments; the ordinate shows percentage changes in relation to the control before combination, taken as 100%, *1* - during combination, *2*, *3*, *4* - successive series of extinctions; *D* - the effect of stimulation of the hypothalamus preceding the cortical stimuli (*1*), *2* and *3* - the aftereffect; *E* - combination of cortical stimuli without stimulation of the hypothalamus, *2* and *3* - the aftereffect. Other explanations in the text.

of emotions in the development of conditioned reflexes is demonstrated especially clearly in the case of instrumental conditioned reflexes, where reinforcement depends on the reactions of the subject to a conditioned signal. In a comprehensive analysis of the development of instrumental reflexes, W.Wyrwicka (1975) comes to the conclusion that direct reinforcement in this case involves not the satisfying of a need, but the receiving of desirable

(pleasant, emotionally positive) stimuli or the removing of undesirable (unpleasant) stimuli. Depending on their intensity, the functional state of the organism and the characteristics of the external environment, the most varied "indifferent" stimuli can seem pleasant: light stimuli, sound stimuli, tactile stimuli, proprioceptive stimuli, olfactory stimuli, etc. On the other hand, animals often refused life-sustaining ingredients of food if the food was not tasty. In rats, it was impossible to develop an instrumental conditioned reflex when food was introduced into the stomach through a tube (i.e., bypassing the taste receptors), although such a reflex can be developed when morphine is introduced into the stomach, immediately inducing a positive emotional state in the animal. On account of its bitter taste, this same morphine ceases to be a reinforcement if it is introduced through the mouth (Cytawa and Trojniar, 1976). In another series of experiments, these authors developed an instrumental alimentary conditioned reflex in rats, and once it was consolidated, replaced the natural food by introducing a nutrient solution into the stomach through a nasopharyngeal tube. The reflex of pressing a lever was in this circumstance extinguished, but was preserved if a 0.05% solution of morphine was introduced into the stomach (Trojniar and Cytawa, 1976).

We believe the results of these experiments to be in good agreement with those of T.N.Oniani (1975), who used direct electrical stimulation of the limbic structures of the brain as reinforcement for the development of conditioned reflexes. When an external stimulus was combined with stimulation of the brain structures which in a satiated cat excite the need for food, drink, aggression, rage, and fear, it was possible after 5-50 combinations to develop only the conditioned reaction of avoidance, accompanied by fear. The conditioned reflexes of eating and drinking could not be developed. Conditioned reflex hunger cannot be obtained even in natural circumstances: the environmental signals of a situation in which rats were forced to go hungry did not provoke feeding behaviour, but rather fear and a conditioned avoidance reaction (Mowrer, 1960). An analogous reaction was observed in T.N.Oniani's experiments when the conditioned stimulus was reinforced with stimulation of the "centres of aggression".

From our point of view, the results of T.N.Oniani's experiments are yet another demonstration of the decisive role of emotions in the development of conditioned reflexes. Fear presents a distinct aversion for the animal and is actively minimised by means of the avoidance reaction.

Stimulation of the food and drink systems of the brain in animals which are well-fed and without thirst elicits stereotyped acts of eating and drinking without involving the neural mechanisms of emotion, thereby excluding the development of conditioned reflexes. Stimulation of the aggression centres with a particular localisation of electrodes and particular current parameters generates an emotionally negative state which, just as in the case of the emotion of fear, leads to the minimising reaction of avoidance. If the aggressive behaviour of cats is accompanied by the involvement of emotionally positive structures, then through the stimulation of these structures it is possible to develop the conditioned reaction of self-stimulation, as was shown by A.V.Val'dman, E.E.Zvartau, and M.M.Kozlovskaya (1976). The emotionally positive colouring of aggressive behaviour can also be demonstrated under natural conditions. For example, in mice it is easy to develop the instrumental conditioned reflex of pressing a lever if this action is reinforced by the appearance in the cage of another mouse, which is immediately attacked by the "performer" (Connor and Watson, 1977).

After 110 combinations of sound and light with stimulation of the thirst zone of the hypothalamus in goats, the conditioned signal does not lead to drinking behaviour, although reinforcing stimulation immediately provokes the animal to drink (Milner, 1973). On the other hand, E.Fonberg (1967) succeeded in developing an instrumental conditioned reflex in dogs, reinforcing it with stimulation which caused a satiated animal to eat. The author supposes that in these experiments the electric current did not activate the hunger structures, but rather engrams of the properties of tasty food, which caused the dogs to continue eating despite their satiated state.

From the moment of its creation, the theory of conditioned reflexes presupposed the convergence of two stimuli: the conditioned stimulus, and the stimulus which gives rise to an unconditioned reflex, for example, the afferentation from the oral cavity when food enters the mouth. Then the importance of the "current functional state" became clear, for example, the alimentary arousal which we can nowadays consider as a consequence of the stimulation of brain structures activated by the emergence of the corresponding need: by the state of hunger. However, neither afferentation from the oral cavity nor hunger excitation can by themselves act as the reinforcement which guarantees the formation of an instrumental conditioned reflex.

Only the integration of hunger excitation with

excitation by a factor capable of satisfying the given need, i.e., a mechanism which generates a positive emotion, can guarantee the development of a conditioned reflex. With other correlations between the converging excitations, for example, when food enters the mouth of a satiated animal, activation of the mechanisms of negative emotion leads to the defensive reaction of avoidance.

Emotions at the moment when conditioned links are reproduced depend on the degree of actuality of the need on which the emergence of the emotional reaction is based. It has been shown experimentally that 8-year-old children reproduce verbal materials better ten days after the first attempt if these materials correlate with the dominant motivation in their personality hierarchy, whether this be hostility, leadership, curiosity, affection or whatever.

We are justified in speaking of emotional recall in its "pure form", it would seem, only in those special cases when neither the external stimulus which provokes the recollection nor the engram retrieved from the memory are reflected in the consciousness, and the emotional reaction which arises seems motiveless to the subject (Kostandov, 1983).

At the level of populations, the role of stimulating and reinforcing factors can be played by signals of the emotional state of another individual of the same species (see ch. 1). In the course of biological and subsequently socio-historical evolution, mechanisms of "emotional resonance" led to the formation of the striking capability of man for *co-experience*, entering the subjective world of another individual by relating it to one's own internal world. Likewise it became possible to comprehend those aspects of reality which are in principle inaccessible to discursive thought based on a system of verbalised concepts.

The switching function of emotions. If until now we have been considering the role of emotions in the formation of a single conditioned reflex, it is now necessary to turn to the participation of positive and negative emotions in determining the course of behaviour when there is competition between innate and acquired behavioural acts aimed at the satisfaction of various human and animal needs.

It might appear that behaviour is oriented towards the immediate satisfaction of one need or another through a direct comparison of the strength (magnitude) of each need. If this were correct, however, the competition of motivations would be isolated from properties of the subject's environment. For this reason, we are dealing with a competition not of needs, but of the emotions generated by

these needs, which, as we showed above, depend not just on a need, but also on the probability (possibility) of its satisfaction. "It must be admitted," writes A.S.Batuev, "that the system of emotions is the only system capable of evaluating the relevance of an organism's actions corresponding to a dominant motivation and the predicted probability of its satisfaction" (Batuev, 1980:639). In other words, emotions originated and took shape in the course of evolution as a unique "currency" of the brain, as a universal measure of values. Emotions themselves have no inherent value. Here we see the analogy with the function of money. Is money of value to people? Naturally, yes. They may desire it, and among other things they try to save it and multiply it. But we know that what counts is not notes and coins, but their purchasing power.

Further, the need to measure values only arises when it is necessary to *compare* different values. If there were just one thing of value, there would be no necessity to measure it. For this reason the function of emotions cannot be reduced to the mere signalling of influences which are useful or harmful to the organism, as is assumed by proponents of the "biological theory of emotions". Let us make use of the example cited by P.K.Anokhin (1964:342), and subsequently by J.Eccles (1980:120). When a joint is injured, the sensation of pain restricts the motor activity of the limb, thereby aiding the repair processes. In this integral signalling of "harm", P.K.Anokhin saw the adaptive significance of pain. However, an analogous role could be played by any mechanism which automatically inhibits the movements harmful to the injured organ, without the participation of emotions. The sensation of pain is a more plastic mechanism: when the need to move becomes very great (for example, when the very existence of the individual is threatened), movement takes place in spite of pain.

As a measure of values, emotions are not values in themselves. People cannot desire pleasure as such, since there are many kinds of pleasure. If we consider a normal, mentally healthy individual as opposed to a masochist or a religious fanatic, then this individual will of course have no desire to maximise his negative emotions. The real issue belongs on an altogether different plane: which needs and which motivations are involved in the competing struggle, the "jousting", of positive and negative emotions?

In an attempt to provide a definitive proof of the inherent value of emotions, B.I.Dodonov (1978; 1983) cites the human desire, seemingly paradoxical from the viewpoint of the information theory, to repeat the experience of negative emotions in conditions where there is an

information deficit. What he has in mind are various kinds of risk, acute sensation, and the deliberate creation of critical situations. However, a more careful analysis of these situations shows that when people create them, they nevertheless count on a favourable outcome (we repeat, unless they are suicidal or mentally abnormal). The individual deliberately creates a deficit of pragmatic information and a low probability of achieving a goal, so as in the end to gain a maximum increase in probability (i.e. in positive emotions), and is not simply trying to experience fear or despair for yet another time. In the poetic quotation that B.I.Dodonov cites to illustrate his point ("to place on a card, in joyous hope, all that is earned through work"), he clearly did not pay attention to the meaning of the phrase "joyous hope".

From the physiological point of view, emotion is an active state of a system of specialised brain structures which stimulate a change in behaviour in the direction of minimising or maximising that state. Since positive emotion indicates the approaching satisfaction of a need, whereas negative emotion indicates its withdrawing, the individual tries to maximise (strengthen, extend, repeat) the former state and minimise (weaken, suspend, prevent) the latter. This hedonistic maximisation-minimisation principle, which is equally applicable to human beings and animals, allows us to overcome the apparent inaccessibilty of animal emotions to direct experimental investigation.

We are deeply convinced that the decisive criterion for the presence of emotion in an animal, as opposed to some other phenomenon of higher nervous activity, is *the attitude of the animal itself to its state*. Direct stimulation of the brain by an electric current, like no other method, is capable of revealing a positive emotional state which an animal is trying to maximise , i.e., strengthen, extend or repeat, or a negative emotional state which an animal is trying to minimise, i.e., weaken, suspend or prevent. We emphasise that emotion in an animal must be identified not through the nature of any external factor (food can cause revulsion in a satiated subject, whereas a destructive narcotic can give pleasure), but rather through the attitude of the animal to its own state as actively revealed in its behaviour. Behavioural criteria, rather than forms of expression such as baring the teeth, wagging the tail or vocalising, decisively indicate to the experimenter whether an emotional state is present or absent, and whether it has a positive or negative colouring.

The switching function of emotions is revealed both in innate forms of behaviour as well as in conditioned reflex

activity, including its most complex manifestations. One need only recall that in human beings the evaluation of the probability of satisfying a need can take place not only at the conscious, but also at the unconscious level. A clear example of unconscious prediction is intuition, when evaluations of the closeness or remoteness of a goal take the form of an emotional "presentiment of a solution". This presentiment provokes a logical analysis of the situation which gave rise to the emotion (Tikhomirov, 1969). Precisely at the moment when the idea of a solution appears but is not yet formulated as a hypothesis subject to verification, the author has recorded a maximal fall in the electrical skin resistance. According to O.K.Tikhomirov, emotional activation is connected with the materialisation of a search zone in which the solution to a mental problem can be found (Tikhomirov, 1984).

The switching function of emotions is revealed particularly clearly in the process of competing motivations, when a dominant need appears and becomes the vector of goal-directed behaviour. In a military battle, for example, the conflict between the natural instinct of self-preservation and the social need to follow a particular ethical norm is experienced by an individual as the conflict between fear and the sense of duty, between fear and shame. The dependence of emotions not only on the magnitude of the need, but also on the probability of its satisfaction, adds a significant complication to the competition of co-occurring motivations. As a consequence, behaviour is often switched to less important but more easily achieved goals: a "tomtit in the hand" beats a "crane in the sky" (consider also the equivalent English proverb: "a bird in the hand is worth two in the bush"). The constant threat of such a switch forced evolution to form a special brain mechanism which was capable of blocking this emotional "Achilles heel", viz. the "reflex of freedom" (the need to overcome obstacles in one's path) discovered by I.P.Pavlov. At the level of human higher nervous activity, the "reflex of freedom" is represented by the physiological mechanisms of the will.

The compensatory (substitutional) function of emotions. Since emotions are an active state of a system of specialised brain structures, they affect other cerebral systems which govern behaviour, the perception of external signals and the retrieval from memory of the engrams of these signals, and the visceral functions of the organism. In the case of visceral functions, the compensatory role of emotions can be seen especially clearly.

The point is that the emergence of emotional tension is accompanied by a number of visceral changes (increased heart rate, rise in blood pressure, release of hormones into the blood stream, etc.) which generally exceed the actual needs of the organism. It seems that the process of natural selection has consolidated the appropriateness of this redundant mobilisation of resources. In a situation of pragmatic uncertainty (which is especially characteristic of the emergence of emotions), when it is not known what will be needed in the next few minutes, it is better to engage in an excessive expenditure of energy than to remain without a sufficient supply of oxygen and metabolic "raw materials" in the heat of the moment, during a "fight or flight" reaction.

But the compensatory function of emotions is in no way restricted to the hypermobilisation of the visceral system. The emergence of emotional tension is accompanied by a shift to forms of behaviour different from those which are characteristic of the calm state, and to different principles for evaluating and reacting to external signals. The physiological essence of this shift is definable as a reversion from narrowly specialised conditioned reflexes to reactions based on A.A.Ukhtomsky's principle of the dominant. It is no accident that V.P.Osipov (1924) called the first stage in the development of a conditioned reflex "emotional": the stage of generalisation, the behavioural, electrophysiological, and microstructural characteristics of which display a striking similarity to analogous manifestations of the dominant (Pavlygina, 1973).

An emotionally aroused brain starts to react to a wide range of signals which are conjectured to be significant, although their real significance, their correspondence or lack of correspondence with reality, will become clear only later when they are juxtaposed with this reality. Here the role of emotions in the individual creative and exploratory activity of the brain is reminiscent of the role of emotional stress in the evolution of living creatures: stress heightens the variety of genetic material subject to selection (Belyaev, 1979; 1981).

If the consolidation of a conditioned reflex is accompanied by a fall in emotional tension and a concurrent shift from a dominant (generalised) reaction to strictly selective reactions to the conditioned signal, then the emergence of emotions leads to secondary generalisation. The stronger the need becomes," writes G.Newton (1975:89), "the less specific is the object that elicits the corresponding reaction". At the same time, the strengthening of a need is more likely to increase reactivity to external stimuli than simply to heighten motor anxiety. In an informationally

impoverished environment, the motor activity of hungry rats grew by only 10%, whereas under normal conditions it showed a fourfold increase. On the one hand the growth of emotional tension widens the variety of engrams retrievable from memory, and on the other hand it lowers the criteria for "decision-making" when these engrams are juxtaposed with current stimuli. Thus, a hungry person will begin to perceive nonspecific stimuli as being associated with food. In addition, the number of food associations at first grows, and then after twenty-four hours of deprivation decreases. It is assumed that at this stage we see the effect of a psychological defence mechanism, which suppresses groundless fantasies and switches the subject's activity towards more long-term exploration (Levine, Chein, and Murphy, 1942). It has been shown experimentally that the type of response to a neutral slide in a series of emotional slides (viz., a change in heart rate or plethysmogram of the head) depends on the degree of anxiety of the subject. The greater the anxiety, the more often the subject responds to a neutral slide as if it were objectionable (Hare, 1973). We consider the physiological basis of this kind of reaction to be the activation and the intensification of the functional significance of reverse conditioned links. In experiments on dogs, the defensive arousal of the animal leads to an increase in inter-signal reactions, and there are objective manifestations of reverse links in the system of motor defensive conditioned reflexes (Ioffe and Samoilov, 1972).

It is obvious that the hypothetical dominant reaction is advantageous solely in conditions of pragmatic indeterminacy. When this indeterminacy is removed, the subject can change into "a scared crow, which is afraid even of a bush". For this reason, evolution has formed a mechanism through which emotional tension and the type of reaction which is characteristic of it depend on the magnitude of the deficiency in pragmatic information: this mechanism eliminates negative emotions in parallel with the elimination of the information deficit. Let us emphasise that emotions per se carry no information about the surrounding world; information deficits are remedied by exploratory behaviour, perfection of skills and the mobilisation of engrams held in the memory. The compensatory significance of emotions consists in their *substitutional role*.

The compensatory function of positive emotions is to be seen in their effects on the need which initiates the behaviour. In a difficult situation, when there is a low probability that a goal will be achieved, even a small success (increase in probability) will generate the positive

emotion of enthusiasm; this then strengthens the need to achieve the goal, according to a rule which follows from the formula of emotion.

Positive emotions cause living organisms to disturb an achieved "equilibrium with the surrounding environment". Striving to repeat the experience of positive emotions, living systems are compelled actively to seek out unsatisfied needs and indeterminate situations in which newly obtained information can exceed earlier predictions. It is positive emotions that permit the differentiation of needs into two basic categories: needs of preservation (necessity) and needs of development (growth). Corresponding notions in the literature are those of stimulation and desire, and the two varieties of motivation, negative and positive (appetite).

The compensatory function of emotions at the level of populations can be exemplified by imitative behaviour. The switch to imitative behaviour is highly characteristic of the emotionally aroused brain. In essence, this is a special case of the dominant reaction to signals with a low (problematic) probability of reinforcement (in this case, signals emanating from other individuals). When an individual lacks the information or the time to make an independent and well-grounded decision, he is forced to rely on the example of other members of the community. Since the advantageousness of adaptive reactions is relative, imitative behaviour is by no means always optimal, and in the case of mass panic often leads to catastrophic consequences.

This completes our brief survey of the regulatory (i.e., switching, reinforcing, and compensatory) functions of emotions at the individual and populational levels. We have attempted to show that the regulatory functions of emotions are a direct consequence of their reflective-evaluative function, and are conditioned by it. In distinction to concepts which are based on such categories as "attitude", "significance" and "meaning", the information theory of emotions accurately and unambiguously defines the objective reality, the "stereotype" which is subjectively reflected in the emotions of human beings and higher animals, namely, the need and the probability (possibility) of its satisfaction. It is precisely these two factors which make events "significant" for an individual, which endow events with "personal meaning", and motivate the individual not only to experience, but also to express in action his "attitude" to the surrounding world and to himself.

The neuroanatomy of emotions. Data concerning the brain

structures directly responsible for the origin and activation of emotional reactions have been obtained in the case of animals with the aid of destruction or stimulation of particular areas of the brain, and in the case of man through analysis of brain areas pathologically affected by tumours, haemorrhages, epileptic foci, and the like.

Amongst the various brain formations, the most "emotiogenic" are the frontal and temporal lobes of the neocortex, the hippocampus, the nuclei of the amygdaloid complex, and the hypothalamus. In addition, a large amount of data has been accumulated in recent years on the functional asymmetry of the cerebral hemispheres, including asymmetry with respect to the regulation of emotions.

The importance of the frontal lobes of the neocortex is already marked in higher animals. Thus, removal of areas 9 and 10 of the prefrontal cortex increases aggression in sacred baboons, and removal of area 47 increases their timidity and fear (Panina, 1983). The region in which lesions most radically affect the aggressiveness of rhesus monkeys is the posteromedial area of the orbital cortex (Butter, Snyder, and McDonald, 1970). According to the data of A.I.Shumilina (1950), removal of the frontal regions of the cortex prevents the development of experimental neurosis in dogs.

Temporary inactivation of the left hemisphere by means of a unilateral electroconvulsive shock leads to a deterioration in the mood of a patient, but inactivation of the right hemisphere leads to an improvement (Deglin, 1973). This effect is especially characteristic of the temporal regions, and to a lesser extent of the frontal regions. When the frontal regions are inactivated, either on the right or on the left, 16% of cases show emotional dullness, apathy and indifference to the surroundings (Traugott, 1979). Patients with a damaged left hemisphere are anxious and concerned about their condition and their future. Patients with right-sided damage are frivolous and light-hearted (Bragina and Dobrokhotova, 1977). Damage to the medial sections of the right frontal lobe is accompanied by an impairment of the patient's ability to evaluate his own condition and a preponderance of positive emotions (Filippycheva and Faller, 1978). Damage to the left frontal lobe reduces the ability of a patient to evaluate his own condition, and strengthens his fixation on his experiences (Ol'shansky, 1979). According to the data of E.A.Kostandov et al., the emotional state of euphoria, light-heartedness and irresponsibility which arises under the influence of alcohol is connected with the preferential effect of alcohol on the right hemisphere (Kostandov, Arzumanov, Genkina,

Reshchikova, and Shostakovich, 1981). V.L.Deglin (1973) conjectured that the depressive state is determined by heightened tonus in a patient's subordinate hemisphere (the right hemisphere in right-handers), and that the maniacal state is determined by activation of the left hemisphere. Indeed, the results of investigation into post-stimulus auditory adaptation show that depression in patients suffering from manic-depressive psychosis is accompanied by high tonus in the right hemisphere and mania is accompanied by high tonus in the left hemisphere. Normalisation of mood leads to equilibrium in the activity of both hemispheres (Asadova, 1985).

Of course it would be an oversimplification to think that the "centres" of positive and negative emotions are localised in the left and right hemispheres respectively. But then how can we explain the emotional asymmetry of the cerebral hemispheres? One of the most plausible hypotheses is that of L.P.Zenkov (1978). According to Zenkov, inactivation of the left hemisphere makes a situation incomprehensible, unverbalisable, and therefore emotionally negative. Inactivation of the right hemisphere, on the other hand, makes a situation simpler and clearer, which leads to a predominance of positive emotions: "... the emotional effects which arise when the hemispheres of the brain are differentially affected are a consequence of informational processes, rather than of strictly emotiogenic mechanisms" (Zenkov, 1978:745).

At the present time, a large number of experimental methods have been developed for investigating the functional (including emotional) asymmetry of the hemispheres. Showing films on a variety of subjects in the right and left visual fields with the aid of contact lenses shows that the right hemisphere is preferentially connected with evaluations of what is unpleasant and repugnant, and the left hemisphere with evaluations of what is pleasant and amusing (Dimond, Farrington, and Johnson, 1976). The reaction time (as recorded on an electrooculogram) when slides showing expressions of joy were presented in the right visual field was significantly less than when they were presented in the left visual field, and with slides showing expressions of sorrow the correlation was reversed (Reuter-Lorenz and Davidson, 1981). However, other investigations testify to a more complex involvement of the hemispheres in the identification process than an unambiguous specialisation for positive and negative emotions. Thus, the identification of emotionally expressive faces is carried out more quickly when they are presented in the left visual field, independently of whether the expression is one of happiness,

grief or anger (Suberi and McKeever, 1977). The recognition of an emotional tone of voice is improved (the latency period is shortened) when the left hemisphere is inactivated, regardless of the character of the emotion (Balonov and Deglin, 1976). These authors suppose that there exists a tonic inhibitory regulatory interrelationship between the hemispheres. Tachistoscopic presentation of neutral, happy, and sad faces at an angle of 5° to the left or right of the point of fixation failed to reveal any differences between the hemispheres. At the same time, the right hemisphere seems to react better when the emotion is clearly signalled, while the left hemisphere reacts better in situations of conflict, when analysis and deduction are required (Buchtel, Campari, De Risio, and Rota, 1976). When a text whose content is inconsistent with the emotional tone of voice is presented to the left ear, there is a preference for the tone, but presentation to the right ear leads to a preference for the content. If subjects are asked to evaluate both the content and the tone, more accurate responses are obtained when the right ear is listening. This experiment clearly shows that the involvement of the left (verbal) hemisphere hones the response of the right hemisphere even when non-verbal (intonational) signals of emotion are being analysed (Safer and Leventhal, 1977).

The functional asymmetry of the hemispheres is also displayed when the expressive components of emotion (whether eye-movements or the electrical activity of the facial musculature) are recorded. The emotional tension provoked by questions which disturb a subject leads to an increase in the frequency of movements of the left eye, indicating activation of the right hemisphere (Schwartz, Davidson, and Maer, 1975; Tucker, Roth, Arneson, and Buckingham, 1977). Positive emotions are accompanied by stronger electrical activity in the zygomatic muscle on the right side than on the left. When emotional facial expressions were reproduced at will, the electromyogram of the corrugator muscle did not depend on the sign of the emotion: it was always stronger on the left than on the right (Schwartz, Ahern, and Brown, 1979). The predominant dependence of emotional facial expression on the right hemisphere was also revealed when photographs were presented consisting of two right or two left halves glued together. The emotional state of the faces on the left-sided photographs was considered by the observers to be more intense (Sackeim and Gur, 1978).

Studies of the electrical activity of the brain also help to elucidate the role of the hemispheres in the perception of emotional stimuli. Judging by electroencephalograms of positive emotional states, the

frontal region of the left hemisphere is most activated. In negative emotions the frontal region of the right hemisphere is most implicated. As far as the parietal region is concerned, it is more strongly activated on the right-hand side whatever the emotion (Davidson, Schwartz, Saron, Bennett, and Goleman, 1979). A.M.Ivanitsky, I.V.Kurnitskaya, and S.Sobutka (1985) recorded cortical potentials during a game of television tennis. According to their data, winning leads to an increase in wave N600 in the left posterior association area, and losing leads to a decrease in the amplitude of wave P800 in the right frontal region. In a female patient with implanted electrodes, beta-spindles at a frequency of 16-26 Hz were recorded in the inferior frontal cortex. They appeared at a moment of psychic tension and were accompanied by a lowering of heart rate (Kamp, Schrijer, and Storm van Leeuwen, 1972). Investigation of the evoked potentials to a series of words not consciously recognised by the subject as neutral or emotional led E.A.Kostandov and Yu.L.Arzumanov (1980) to conclude that the right hemisphere is predominantly involved in the organisation of "unaccountable" emotions, whose cause is not apparent to the subject. Although it is the source of unconscious motivation, the right hemisphere has an influence on conscious psychic functions, sometimes making their true origin puzzling for the individual (Dimond, Farrington, and Johnson, 1976). An emotional word which is not consciously recognised generates as an aftereffect a unilateral activation of the right hemisphere. This is revealed during testing with an unrecognised neutral word. The latency period of wave P300 is shorter in the left than in the right hemisphere if the emotional word is recognised. When an unrecognised word is presented, there is no difference. Combining a conditioned visual signal with an unrecognised emotionally negative word leads to depression of the cortical response to this signal. This depression is most marked in the left posterior association zone, corresponding to the basic speech area (Wernicke's area). E.A.Kostandov (1983) sees in this depression a psychological defence mechanism against external influences which are distressing to the subject.

A considerable number of works are devoted to the recognition of emotional expression by patients with organic brain damage. When evaluating the results of these investigations, the significance of factors apart from the sign of the emotion must be taken into account. These factors properly appertain to the process of identification (the information content of signals, the signal to noise ratio, etc.). In this process, the right hemisphere plays a

predominant, but not exclusive role. Thus, the recognition of familiar individuals is more frequently impaired by bilateral brain lesions, while impaired recognition of unfamiliar individuals is connected with unilateral lesions of the right hemisphere (Benton, 1980). Patients with right hemisphere lesions could recognise familiar individuals not on the basis of their personal characteristics, but by secondary clues such as clothing and peculiarities of emotional expression (Dricker, Butters, Berman, Samuels, and Carey, 1978).

Many observations indicate that the recognition of emotional facial expressions is impaired by right hemisphere lesions (Cicone, Wapner, and Gardner, 1980; Bruger, 1981). According to the data from computer tomography, the recognition of emotional facial expressions is a function of the right-hemisphere temporal cortex (Benowitz, Bear, Rosenthal, Mesulam, Zaidel, and Sperry, 1983). But left hemisphere damage also impairs recognition in comparison with that of normal individuals. This might be explained by the uncoupling of the "emotional" regions of the right hemisphere from the speech structures of the left hemisphere (De Kosky, Heilman, Bowers, and Valenstein, 1980). Patients with lesions of the left frontal lobe made the most errors in identifying emotionally positive facial expressions; damage to the right frontal lobe was accompanied by a maximal increase in mistakes in identifying negative emotions (Ol'shansky, 1979).

Pathological damage to the temporal lobe (especially the right temporal lobe) impairs the identification of emotional intonation of speech (Tarkhan, Traugott, and Meerson, 1981). If emotionally coloured texts, intonations and facial expressions are presented for identification to patients with unilateral lesions of the right or left hemisphere, the greatest difficulties are caused by the identification of intonation. Right-hemisphere patients are worse in distinguishing negative emotions, but for positive emotions no hemispherical differences were established (De Bastiani, Di Palma, Monetti, and Palmonari, 1983). In left-hemisphere patients the identification of facial expressions is impaired more than the identification of intonation; especially difficult is the matching of facial expressions with intonation patterns. These data demonstrate that, in distinction to intonation, the visual perception of facial expressions is verbalised and requires the involvement of the speech areas (Sidorova, 1979).

Sense of humour may serve as a subtle test of functional asymmetry. Patients were asked to select the funniest of a set of pictures portraying various incidents. Lesions of the

right hemisphere make humour undiscriminating: patients are ready to laugh at any of the pictures. The humour of left-hemisphere patients is more similar to the humour of healthy individuals (Gardner, Ling, Flamm, and Silverman, 1975). H.Brownell et al. believe that the appreciation of verbal humour involves two components: (1) the isolation of the unexpected in the narrative, and (2) the juxtaposition of the unexpected with the content of the whole story. In patients with lesions of the right hemisphere, the first component is preserved but the second component is impaired (Brownell, Michel, Powelson, and Gardner, 1983).

This last result once again serves to exemplify the *secondary* nature of the emotional specialisation of the hemispheres. The point is not that the left hemisphere is more inclined towards positive emotions, and therefore more "given to laughter". Behind the emotionality of the hemispheres lurk complex informational processes which evaluate the significance of external stimuli and compare what is predicted with what is starting to happen. According to F.E.Vasilyuk (1984), the degree of difficulty a situation holds for an individual is evaluated through a juxtaposition of the individual's more or less complex inner world (sphere of motivations) with the simple or complex external world. As a broad generalisation, it can be said that the right hemisphere is more closely connected with the motivational components of emotion, while the left hemisphere is more closely connected with the informational components. Evidence in favour of this proposition is also provided by anatomical data pertaining to the predominant links between the right hemisphere and the diencephalon, and between the left hemisphere and the activational structures of the brain stem (Dobrokhotova and Bragina, 1977). Figuratively speaking, an individual with a lesion of the left hemisphere is one who has a rich assortment of needs and an insufficiency of means for satisfying them. A patient with a lesion of the right hemisphere has a surplus of means for satisfying an acutely impoverished, shrunken and simplified sphere of motivations. Thus the tendency for negative or positive emotions to predominate, the frivolity and light-heartedness which accompany alcoholic alteration of the right hemisphere and other such phenomena are *secondary* in origin. The fact that the structure of any emotion contains a need and an evaluation of the prospects for its satisfaction provides the most logical explanation of the emotional asymmetry of the hemispheres.

In any event, lesions of the frontal regions of the neocortex lead to the strongest debilitation of the human emotional sphere in comparison with other regions of the

neocortex. Characteristic of damage to the frontal regions are the syndrome of aspontaneity, emotional dullness and indifference, as well as the syndrome of disinhibition with signs of euphoria inconsistent with the real condition of the subject. In this case it is primarily the higher emotions which are impaired, those which are connected with activity, social relationships and creativity, in parallel with the disinhibition of primitive vital proclivities (Dobrokhotova, 1968). The changes in EEG which are characteristic of emotions are especially clearly marked in recordings of the frontal regions (Kovalev, Smirnov, and Rabinovich, 1976). In individuals with a dominance of positive emotions, alpha rhythms and slow EEG components are recorded, while in individuals with dominant anger there is a predominance of beta activity.

The anterior limbic cortex controls emotional tones of voice both in man and in apes. Bilateral impairment of the blood flow in this area results in the speech of the patient becoming emotionally inexpressive (Carmon and Jürgens, 1983). A variety of emotional impairments were recorded in cases of lesions of the temporal lobes (Bear, 1979). Of course, on each occasion the source of the observed deficiency needs to be made more precise: is it pathology of the neocortex, the hippocampus, or the nuclei of the amygdaloid complex?

Electrical stimulation of the hippocampus in man is accompanied neither by fear, nor anger, nor pleasure. What is recorded is only confused consciousness, temporary loss of contact with the physician, and episodically, fear, as a secondary emotional reaction of the subject to the derangement of his perception of the surrounding world (Smirnov, 1976). A bilateral stroke in the region of the hippocampus caused impairment of short-term memory without affecting the patient's emotional reactions (De Jong, Itabashi, and Olson, 1969). V.M.Okudzhava et al. came to the conclusion that affective disorders in cases of epilepsy focussed in the hippocampus are caused by the spread of the convulsive discharge to the amygdala (Saradzhishvili, Chkhenkeli, and Okudzhava, 1977). According to the data of S.V.Madorsky (1985), lesions of the right hippocampus cause a swing to introversion and lesions of the left hippocampus cause a swing to extroversion, when patients are tested with the Eysenck questionnaire. Destruction of the hippocampus leads primarily to responses to signals of high-probability events: verbal events when the left hippocampus is intact and non-verbal events when the right hippocampus is intact. This characteristic of the human brain must be taken into account when a comparison is made between results obtained

in the clinic and in experiments on animals. Thus, the desynchronisation of the electrical activity of the human hippocampus which is recorded during periods of mental tension or paradoxical sleep led to the conclusion that there is no analogue in man of the hippocampal theta rhythm in animals (Halgren, Babb, and Crandall, 1978). However, further investigations have shown that an increase in frequency, amplitude and regularity of the theta rhythm can also be demonstrated in the human hippocampus, but only in the course of oral or written operations at a sufficiently high level (Arnolds, Aitink, Bocyinga, and Lopes da Silva, 1979). In conclusion, it can be said that the hippocampus should be treated as an "informational" brain formation rather than as an "emotional" one. Its connection with emotions has a secondary and mediated character.

More emotiogenic are the nuclei of the amygdaloid complex. V.M.Smirnov (1976) noted that patients in whom the nuclei of the amygdala are stimulated report the occurrence of a state of fear, anger, rage, and occasionally pleasure. Prolonged stimulation of the amygdala in epileptic patients at a frequency of 50-100 Hz elicits emotionally coloured memories; most frequently these are memories of childhood, starting at 5-6 years, and what is more, repeated stimulation generally elicits memories of exactly the same events (Fernandez-Guardiola, 1977). Stimulation of the amygdala can cause hallucinations, fear, anxiety, and visceral sensations in the stomach. What is more, these effects depend not so much on the position of the electrodes as on the personal characteristics of the patients. Subjects who reported fear had a high index on the scale of psychasthenia (MMPI test), while patients with hallucinations had a high index on the scale of schizophrenia (Halgren, Walter, Cherlow, and Crandall, 1978). In patients with implanted electrodes, the high frequency activity of the amygdala increased when they were discussing emotionally coloured events (Eidelberg and Woodbury, 1972). Epileptic activity has been recorded in the dorsomedial part of the amygdala in patients with temporal lobe epilepsy who are inclined to aggressiveness. Destruction of this region makes a patient non-aggressive (Saradzhishvili, Chkhenkeli, and Okudzhava, 1977).

The phylogenetically young basolateral part of the amygdala, which is linked in the left hemisphere with the speech areas of the neocortex, is involved in the formation of complex motivations. When it is damaged, preservation needs, anxious emotions and fear begin to predominate. The corticomedial part, which is linked to the ancient structures of the hypothalamus, is responsible for the more

primitive vital needs. In other words, pathology of the amygdala affects the strength and the direction of motivations. Simultaneous lesions of the amygdala and the hippocampus on the right side lead to more marked impairments of emotion than does pathology of the left brain, while bilateral injury to the temporal lobe weakens the distinction between the objectively recordable symptoms of positive and negative emotions (Madorsky, 1981).

When the anterior and posterior sections of the hypothalamus are stimulated with an electric current, reactions of anxiety and rage are observed (Smirnov, 1976). Whereas stereotaxic intervention in the intergenicular region of the thalamus leads only to the elimination of aggressiveness caused by hallucinations, intervention in the hypothalamus makes the patient lose aggressiveness irrespective of the stimuli which provoked it. This enables us to speak of the localisation in the hypothalamus of executive emotional centres, responsible for the organisation of the somatic and visceral components of the aggressive reaction - "the executive command system" (Nadvornik and Ondrejcakova, 1984).

Stimulation of the mesencephalic structures of the brain stem and the nonspecific thalamic nuclei results in states of increased activation or inactivation (Smirnov, 1976). Activational states have a positive emotional colouring, or rarely, an active negative colouring (anger or spite, but not depression or sorrow). Inactivational states are characterised by calm and indifference. It has not been possible to make a direct link between the sensations of unusual "lightness" or "heaviness" of body which arise during these functional states and changes in muscular tone or vestibular functions.

Apart from the emotional states enumerated above, V.M.Smirnov's patients reported transitory reactions occurring at the moment of electrical stimulation. These included: a feeling of confusion and bewilderment (the mesencephalic sections of the brain stem, the subthalamus, the reticular thalamic nucleus); fear whose origin is unclear to the subject or connected with an emotional reaction to somatic changes (the limbicoreticular system); pleasure in the form of pleasant but not always precisely definable sensations; unmotivated joy, caused by stimulation of the centromedian nucleus of the thalamus, the globus pallidus or the mesencephalic section of the brain stem. In patients with lesions of the mesencephalic-diencephalic structures, speech impairments resulting from motivational deficiencies were observed: these patients suffered from a lack of the motivation to speak, although their ability to

speak was preserved (Vinarskaya, Michurina, Nikiforov, and Nosikov, 1980).

Stimulation of the septum, according to the data of V.M.Smirnov (1976), is accompanied by an experience of euphoria, delight, sexual arousal or general improvement of mood, while stimulation of the structures of the midbrain elicits a broad spectrum of emotions: from anger and tension to sexual arousal with a marked positive colouring.

To conclude this literature survey, we emphasise that the results obtained from the stimulation or destruction of various brain structures, as well as from the recording of their electrical activity, permit us only to state that a given structure is somehow involved in the realisation of the observed emotional reaction. Analysis of the data obtained by these methods is also complicated by the fact that the composition of the brain structures involved in a reaction can change according to the strength of the emotion, the condition of the patient, changes in external environment, etc. (Bekhtereva, 1980). More concrete conclusions about the specific contribution of each brain structure to the genesis and realisation of a given emotion can only be reached through an examination of the role of each structure in the integrated activity of the brain and in the organisation of each whole behavioural act, taking into account the other functions which the given structure possesses. At this point it is difficult not to recall the legitimate comment of K.Wilkis that lack of success in attributing psychic functions to localised brain structures is caused by inadequacies in the choice of the functions themselves (see Kelle, Naletov, and Sokolov, 1984). If we bear in mind that any given emotion includes in its internal organisation an actualised need, the evaluation of the possibilities of satisfying the need, the mobilisation of the traces (engrams) of those external objects which are capable of satisfying the need, the activation of structures which directly bring about the particular emotional state etc., then it becomes clear how complex and how heterogeneous must be the functions of the brain structures which participate in the generation and activation of emotional reactions to each event of significance to the subject. Abstracting from this real complexity, we remain mere recorders of facts, describing psychophysiological correlates of emotions without penetrating into the actual mechanisms which are involved.

Neurochemistry of emotions. Data concerning the neurochemical bases of emotional reactions are as numerous as they are contradictory. Attempts to attribute the

responsibility for activating particular emotions (for example, positive or negative emotions) to one or other of the transmitter systems generally founder amongst these contradictions. Whereas some authors come to the conclusion that the serotonergic system is the main factor in training when emotionally positive reinforcement (food) is used, and that the noradrenergic system is the main factor in training when emotionally negative, painful reinforcement is used (Semenova and Vekshina, 1977), others report facts which point directly in the opposite direction. For example, by pressing a lever, rats could switch off an aversive stimulation of the tegmentum of the midbrain. Inhibitors of catecholamine synthesis had no effect on this reaction, but a drop in the level of serotonin decreased the speed with which the lever was pressed. This led the authors to conclude that negative emotions depend on serotonin, and not on the catecholamines (Kiser and Lebovitz, 1975).

At the present time the opinion has formed that the activation of every emotion involves all the basic neurotransmitter systems: the noradrenergic, cholinergic, serotonergic and dopaminergic systems, plus a whole series of neuropeptides, including the endogeneous opiates. This point of view is all the more plausible if we consider the complex internal organisation of emotions, the existence of need-motivational, informational and reinforcing components, let alone the effector manifestations, motor and visceral, of emotional reactions.

A good experimental model for the study of the neurochemistry of emotions is the phenomenon of self-stimulation of the brain in animals. There was a time when it was assumed that the phenomenon of self-stimulation is rather like sham feeding, i.e., that it imitates the satisfaction of the animal's natural needs via the activation of "satiation centres", "thirst-quenching centres" etc. However, by no means all the facts can be explained in this way. Hunger and thirst may either influence or not influence self-stimulation of brain structures. In the lateral hypothalamus there are neurons whose impulse activity during self-stimulation reproduces the impulse activity which occurs when a hungry animal receives food reinforcement. However, self-stimulation of the adjacent nucleus does not have the same effect (Sasaki, Ono, and Nishono, 1983). Also in the lateral hypothalamus neurons can be found whose activity is inhibited both during feeding and during self-stimulation of the medial forebrain bundle. The activity of other neurons is inhibited solely during feeding and increases during self-stimulation. Apparently neurons of the first type are connected with

mechanisms of motivation, whereas neurons of the second type are connected with mechanisms of positive-emotional reinforcement (Sasaki, Ono, Muramoto, Nishino, and Fukida, 1984). The fact that cholecystokinin depresses self-stimulation independently of the degree of hunger is evidence of the aversive characteristics of the drug, and not of the imitation of satiation (Ettenberg and Koob, 1984).

The mechanism which causes the animal to press repeatedly on the pedal is connected not with hunger and thirst etc., but rather with the trace arousal of the structures of emotionally positive reinforcement which are activated at the moment the current is applied. The short duration of this trace arousal explains both the comparative ease with which the reactions are extinguished when they are not reinforced, and the necessity for "priming" stimulations in the animals being taught to press the pedal. J.Olds (1976) equated the phenomenon of self-stimulation not with hunger, but with the desire for tasty food. It is possible for rats to stimulate the hunger and thirst structures, but only if food and water are present in the experimental surroundings, when the high probability of satisfying natural needs guarantees the emergence of positive emotions during the process of eating and drinking. As far as the cessation of stimulation is concerned, depending on the position of the electrode and the parameters of the current it can be caused either by habituation to the effect of the current or by the involvement of the mechanisms of negative emotions (Zvartau and Patkina, 1972; Grigor'yan, 1978).

The points of self-stimulation coincide in position with the noradrenergic and dopaminergic structures directly involved in the self-stimulation phenomenon. The involvement of cholinergic mechanisms is indirect; however, the suppression of nicotine-cholinergic elements intensifies self-stimulation when the catecholamine system is unimpaired (German and Bowden, 1974). It must be emphasised that the involvement of the noradrenergic system in the mechanisms of self-stimulation is not connected with the satisfaction of the animal's natural needs for food and water etc. The introduction of disulfiram, which sharply reduces the level of noradrenaline in the brains of rats, elimates the consumatory effects of stimulation (eating, drinking, nibbling), increasing the frequency and lowering the threshold of self-stimulation (Mikhailova, Staikova, and Cheresharov, 1979). According to S.A.Borisenko (1977), phenamine and cocaine facilitate self-stimulation of the hypothalamus and septum while simultaneously depresing the feeding and drinking reactions of the animal.

Noradrenaline facilitates, whereas serotonin depresses self-stimulation of the lateral hypothalamus in rats. However, it is difficult to say what precisely determines the effect of serotonin: its inhibitory characteristics or its involvement in the mechanisms of negative emotions and the system of "punishment" (Stein and Wise, 1974). A number of data point to the involvement of dopaminergic structures in the self-stimulation reaction (Van Wolfswinkel and Van Ree, 1984). Administration of 6-oxydopamine into the region of the ascending mesocortical dopaminergic fibres completely stops self-stimulation of the prefrontal cortex in rats (Clavier and Gerfen, 1979). L-dopa restores self-stimulation after the administration of reserpine. Apomorphine restores motor activity, but not self-stimulation. These data indicate that the dopaminergic system is connected not with the motor reaction of a rat pressing on a pedal, but with the mechanism of reinforcement of movements through the activation of emotionally positive elements (Vander-Wolf, Gutman, and Baker, 1984).

Thus the phenomenon of self-stimulation involves the two basic transmitter systems: the noradrenergic and the dopaminergic. It is possible to conjecture that noradrenaline is connected with the excitatory, motivational components of the reaction, while dopamine is connected with the reinforcing, "rewarding" effect. Let me note that according to H.Matties (1982) the reinforcing function of emotions is carried out through the dopaminergic system, ensuring long-term memory.

The closeness of the relationship between noradrenaline and the mechanisms of motivation is also demonstrated by the fact that noradrenaline stimulates most of the neurons of the hypothalamus in satiated rats, but inhibits them in hungry rats (Dean and Dyer, 1984). The introduction of noradrenaline into the perifornical region of the anterior portion of the lateral hypothalamus can be made into a reinforcing factor in teaching satiated rats to prefer one of the arms of a maze. The point is that noradrenaline stimulated the rats to eat, secondarily activated the mechanism of positive emotions connected with the act of feeding, and made the food stimuli attractive to the animal (Cytawa and Jurkowlaniec, 1978; Cytawa, Jurkowlaniec, and Bialowas, 1980). It is interesting that, in distinction to what happens in the case of the hypothalamus, introduction of noradrenaline into the dorsomedial section of the amygdala can act as a reinforcement in the development of a conditioned reflex only in hungry rats, and loses these properties in satiated rats (Jurkowlaniec and Bialowas, 1981). We are inclined to explain this effect in the

following manner: when the noradrenaline is introduced into the amygdala, it maintains its stimulating functions, but, in distinction to what happens when it is introduced into the hypothalamus, it carries out these functions solely in relation to a dominant, previously activated need (in this particular case, hunger).

The role of the cholinergic system is clearly demonstrated in the aggressive behaviour of animals (Zakusov, 1972). However, the cholinergic triggering mechanism for aggression is subject to the modulating influence of the other transmitter systems, including noradrenaline (Johansson, 1974; Romaniuk and Golebiewski, 1979). According to L.H.Allikmets (1974), noradrenaline is responsible for the effectory manifestations of aggression. In other words, it maintains its excitatory properties even in relation to defensive behaviour. When a noise is combined with electric shocks, the administration of adrenaline permits the development of a conditioned reflex in rats anaesthetised with pentobarbitone (Weinberger, Gold, and Sternberg, 1984). The cholinergic system is primarily concerned with the informational components of behaviour. It has been demonstrated that cholinolytics affect the food-gathering behaviour of an animal, the overcoming of obstacles, and the choice of food, but the state of hunger itself is preserved (Val'dman and Kozlovskaya, 1972). Cholinolytics impair the precision and accuracy of the motor reflexes of avoidance without eliminating the reaction to pain.

K.Noll and J.Davis (1982) propose the following functional classification of neurotransmitter systems. The excitatory transmitters of positive emotions ("rewards") and negative emotions ("punishments") are the catecholamines and acetylcholine respectively. Serotonin plays the role of an inhibitory transmitter with respect to both systems. This view of the universal inhibitory effect of serotonin on emotiogenic structures is shared by other investigators (Panksepp, 1982). There is an inclination to explain heightened aggressiveness by a weakening of the inhibitory effect of serotonin. For example, aggressive mice have a lower level of serotonin in the hypothalamus, amygdala, and hippocampus than non-aggressive mice (Serri and Ely, 1984). The serotonin content of the midbrain and the hypothalamus of tame foxes is twice as great, and of the hippocampus one and a half times as great, as in wild foxes (Popova, 1983). The introduction of a dopamine precursor heightens the aggressiveness of rats, and the introduction of a serotonin precursor depresses it. It is possible that the former effect can be explained by blocking of the serotonergic

system (Allikmets and Zharkovsky, 1976). Suppression of the serotonergic system increases the sexual activity of rats, whereas injury to the noradrenergic and dopaminergic systems impairs the mechanisms of sexual motivation and lengthens the postejaculatory period (McIntosh and Barfield, 1984). R.Sh.Ibragimov (1980) explains the easier development of conditioned alimentary reflexes when serotonin is introduced into the brain by the inhibitory effect of serotonin on the mechanisms of the orienting reflex.

Notions of the universal inhibitory effect of serotonin are contradicted by data concerning the important role it plays in training processes when biologically negative reinforcement is employed. The introduction of r-chloramphetamine impairs the development and preservation of the active and passive avoidance reactions in rats (Ogren, Johansson, Johansson, and Archer, 1982). Research on molluscs has shown that plastic alterations in the central nervous system are connected with increased release of serotonin from the presynaptic neuron (Brunelli and Demontis, 1984). Serotonin is involved in responses of neurons of the rat raphe magnus to a painful stimulus (Dickenson and Goldsmith, 1984). P.M.Balaban et al., in experiments carried out in our laboratory, demonstrated that the degeneration of serotonergic neurons caused by the introduction of 5,7-dioxytriptamine blocks sensitisation of unconditioned defence reactions of the edible snail and the development of a conditioned defence reflex to a food stimulus. On the other hand, the application of serotonin can be used as a reinforcement when it is combined with a food stimulus. It is possible that the reinforcing action of serotonin is connected with its effects on conductivity of calcium canals in nerve cell membranes.

Two explanations can be offered for the contradictory data concerning the role of serotonin in training processes which use emotionally negative (painful) reinforcement. The crux of the first explanation is that serotonergic mechanisms are connected not so much with the development of conditioned reflexes as with their fixation, with the processes which consolidate memory traces independently of the emotional characteristics of the reinforcing factor (Kruglikov, 1978). The second explanation is as follows. Conditioned reflexes based on emotionally positive reinforcement require a specific transmitter, namely dopamine. Enkephalin-containing neurons also seem to be involved (Stein, 1978; Cutawa and Trojniar, 1978). Leu-enkephalin facilitates the self-stimulation reaction and suppresses the avoidance reaction when the central gray matter is stimulated, whereas introduction of naloxone

reduces the frequency of self-stimulation of emotionally positive structures. As far as the development of defensive conditioned reflexes is concerned, the reinforcement in this case is *the very fact that an emotionally negative state is removed*. A special neurochemical "reward" factor seems *unnecessary*. All that is necessary is to consolidate and fix the fact that "punishment" has ceased. This fixing, stabilising ("soothing") role is played by the inhibitory transmitter, serotonin. It is no accident that the neurons of the periaqueductal gray matter, which are sensitive to opiates, are important for the pain-relieving, but not the "rewarding", action of morphine (Bozarth, 1983).

It is thus possible to propose the following hypothetical schema for the neurochemical organisation of emotions, based on the need-information theory. The informational components of all emotions are mainly the product of cholinergic structures. For the excitatory, motivational components, the noradrenergic system is most important. As far as the transmitter for emotional reinforcement is concerned, in the case of positive reinforcement, it is dopamine plus the endogeneous opiates. In emotionally negative reinforcement an important role is played by serotonin.

Data obtained with animals are in good agreement with the results of clinical investigations. In the experiments of G.Ellison (1975), reducing the level of noradrenaline in rat brains made the rats listless in familiar surroundings and fearless in new surroundings, in which case the novelty turned out to be a powerful motivating factor. Lowering the level of serotonin had the opposite effect: the weakening of the inhibitory (stabilising) influence turned a new situation into an extreme, stressful factor, suppressing the animals' activity. The author sees these two alternatives as models for pathological states in man: a drop in the level of serotonin gives rise to unmotivated anxiety, while a noradrenaline deficiency leads to depression. Indeed, the brains of those who commit suicide in a state of depression have been shown to be depleted both in noradrenaline and in serotonin. Noradrenaline deficiency is manifested in melancholic depression, and serotonin deficiency in anxious depression (Nuller, 1981; Maas, Fawcett, and Dekirmenjian, 1972; Sachar and Baron, 1979).

The action of cholinolytics is characterised by psychosis with a predominant impairment of intellectual (informational) processes (Selivanova and Golikov, 1975).

Analysing the neuroanatomical and neurochemical bases of emotions, we have become convinced that the contradictions in the data presently available cannot be overcome if

emotions are treated as an autonomous, isolated (closed) phenomenon. The study of emotions must be placed in the wider context of the organisation of goal-directed behaviour and higher nervous (psychic) activity, and even more widely, in the context of evolution of organisms, and in the case of man, the process of his cultural-historical development. This imperative has determined the contents of the following chapter, where we are compelled to return to the examination of data primarily obtained in experiments on animals.

Such transitions from experiments on animals to studies involving humans and vice versa are one of the characteristic features of I.P.Pavlov's research method.

Chapter 4

PHYSIOLOGICAL MECHANISMS IN THE ORGANISATION OF GOAL-DIRECTED BEHAVIOUR

We define behaviour as those forms of vital activity in humans and animals which alter the probability and duration of contact with an external object capable of satisfying one of the organism's needs. The termination or prevention of a harmful influence, satisfying the need for the preservation of the individual organism, its offspring or the species as a whole, is a particular case of goal-directed behaviour.

If we treat individual behaviour as a juncture or link in the progress and self-development of the living world, and individual creative activity of humans as a fragment in the evolution of culture, we are obliged to indicate the physiological mechanisms which on the one hand determine the behavioural activity of living systems, and on the other hand the appropriateness of this behaviour to the reality of conditions in the external environment. We consider these two mechanisms to be: the dominant of A.A.Ukhtomsky, and the formation of conditioned reflexes according to I.P.Pavlov. In a single process of behavioural organisation and the acquisition of new skills, the mechanism of the dominant is revealed in the generalisation stage in conditioned reflexes (Pavlygina, 1973; Dostalek, 1980).

Generalisation as a stage in the active search for vitally important objects is a phenomenon which is constantly encountered in the natural behaviour of animals. Newly-hatched chicks peck at any objects which contrast with the background and which are commensurate with the size of their beaks. Later they learn to peck only at objects which can serve as food. The smiling reaction in children is at first provoked by any approaching person, but subsequently only by a person who is familiar. If a bear cub loses its mother, it begins to walk in circles, gradually increasing the radius until it comes across a track. Cases in which humans and animals have been saved by dolphins are not explicable by the dolphins' "intelligence" and "altruism", but by the generalisation of the parental instinct: female dolphins give birth in water and initially carry their young on their backs.

One of the characteristic features of the dominant is the capability of the reflex system which dominates at the particular moment to respond to a very wide range of external stimuli, including those which are being encountered for the first time in the life of the animal or person. However, the reactions which arise are by no means a chaotic selection of random trials and errors. When carrying out search activity, an animal makes use of actions drawn from its previous experience. At least two factors channel and limit the dominant search. The first factor is the nature of the dominant need. For example, rats which are feeling thirsty become sensitive to any signal which is connected with water (Schallert, 1982). The second limiting factor is the ecological adequacy (or inadequacy) of stimuli and previously accumulated experience. When a dominant focus is created in a rabbit by the method of polarisation of the cortex by a constant current, the appropriate reaction is more easily obtained, according to V.S.Rusinov, in response to the rustling of paper than the sounding of a tone. If a monkey convinces itself that a stick for fishing a bait out of a deep crevice is too short and thin, it will choose a longer and thicker stick the next time, but not vice versa. Previously accumulated experience restricts and channels the search, and the search in its turn enriches and transforms the neural links (associations) contained in memory.

In fig. 6, we have attempted to give a schematic representation of the process by which the dominant is transformed into a consolidated specialised conditioned reflex. Under the influence of an excitatory unconditioned stimulus (for example, hunger arousal), the specific food-gathering reaction assumes a dominant character: it can be elicited by a wide range of external stimuli. However only the stimulus whose action is one or more times coincidental with the arrival of afferentation from the reinforcing unconditioned stimulus (food) becomes a conditioned signal. We emphasise that the neural mechanisms of emotions are certainly involved here, comparing the afferentation with the level of alimentary arousal.

The presence of the dominant and its removal after the action of a conditioned signal (which can be the animal's own reaction) is a condition for the rapid formation (after one or at most two combinations) of a conditioned reflex (Pavlygina, 1982; Pavlygina and Sokolov, 1983). We wish to call attention to one of the experiments of R.A.Pavlygina (fig. 7).

After the switching on of a subliminal constant current affecting the area of the cortex in which the left paw of a rabbit is represented, previously indifferent stimuli (a

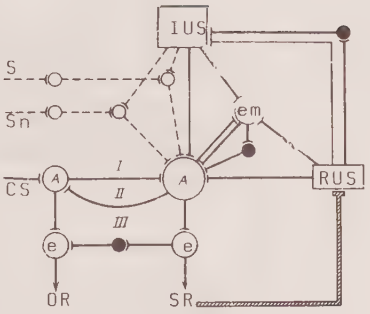


Fig.6. Schematic representation of the interaction of the dominant (broken lines) and a conditioned reflex (solid lines).

I - direct conditioned link; *II* - inverse activating conditioned link; *III* - inverse inhibitory link; black circles - inhibitory elements; thin line - excitatory effect of reinforcing stimulus; shaded line - instrumental conditioned reflex; S-Sn - indifferent stimuli; CS - conditioned stimulus; IUS - initiating unconditioned stimulus; RUS - reinforcing unconditioned stimulus; A - afferent reflex elements; e - efferent reflex elements; OR - orienting reaction; SR - specific reaction; em - emotion.

tone, a rustling sound) began to elicit movement of the paw. The dominant reached its optimum 20-25 minutes after the current was switched on. As an indicator that the optimal state of the dominant focus had been reached, it was required that a motor reaction of the extremity be obtained in response to three stimuli applied in succession, and only subsequently was the left eye of the animal stimulated with a stream of air. If this procedure elicited not only blinking, but also movement of the appropriate extremity, the dominant state was terminated by switching off the current. The renewed creation of a dominant state 20-30 minutes later in the same experiment led to voluntary blinking of the left eye, i.e. the rabbit was carrying out a reaction aimed at ending the dominant state. The constant current was then switched off. Voluntary termination of the dominant state was regularly observed in the first and all subsequent experiments. The rabbit would blink with the left eye at a variety of intervals after the switching off of the constant current. These intervals could be measured in minutes, and sometimes seconds. The period between tests lasted from two to ten minutes. In the early experiments, the voluntary blinking was sometimes accompanied by movement of the left extremity. In the subsequent experiments the movement of the extremity was absent, demonstrating the narrowing of the dominant's receptive field.

R.A.Pavlygina's discovery is of fundamental significance

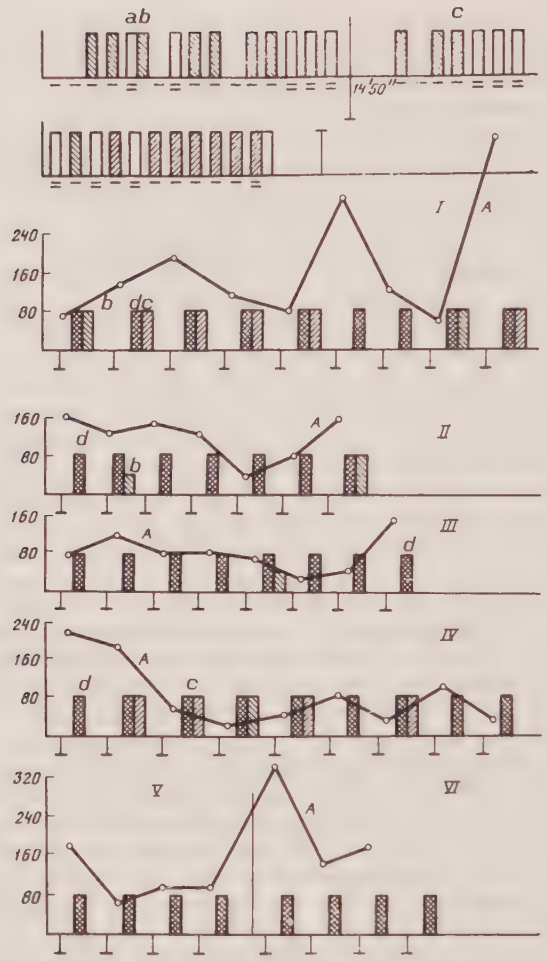


Fig.7. The formation of goal-directed reactions on the basis of the completion stage of the dominant.
a - the blinking reflex to a stream of air directed at the eye; *b* - the general movement of the animal; *c* - isolated movement of the left front extremity; *d* - voluntary blinking; single dash - application of a sound stimulus; double dash - a stream of air in the eye; vertical line downwards - switching on the constant current; vertical line upwards - switching off the constant current; ordinate - time in seconds; *A* - time of appearance of voluntary blinking after the constant current is switched on; *I-IV* - days of experiments (according to R.A.Pavlygina).

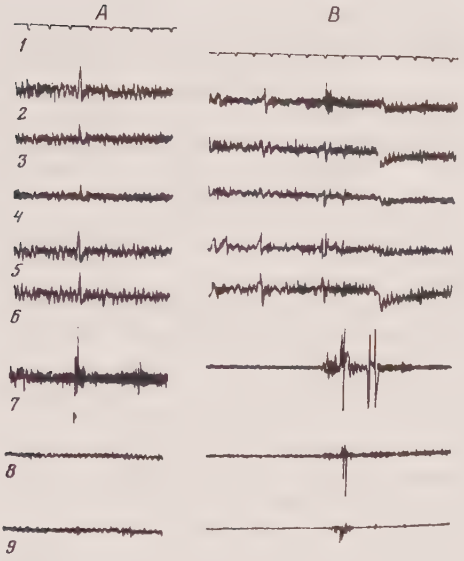


Fig.8. The electrical activity of different regions of the neocortex in the blinking reflex caused by a stream of air directed at the eye (*A*), and in voluntary blinking (*B*). *1* - time (secs.); *2* - EEG of the frontal region of the right hemisphere; *3* - EEG of the sensori-motor region of the right hemisphere; *4* - EEG of the parietal region of the right hemisphere; *5* - EEG of the frontal region of the left hemisphere; *6* - EEG of the sensori-motor region of the left hemisphere; *7* - activity of the eyelid muscles; *8-9* - activity of the muscles of the right and left extremities (according to R.A.Pavlygina).

for the physiology of higher nervous functions. The phenomenon she experimentally uncovered can act as the most adequate model of *truly voluntary* behaviour, initiated not by an external stimulus as in the case of instrumental conditioned reflexes, but by the dynamics of the internal state of brain structures. Studies of the electrical activity of the rabbit brain have revealed the restructuring of potentials which precedes a voluntary act (fig. 8). The recordings show that when a stream of air is directed at a rabbit's eye, it blinks. In the brain regions under investigation, an evoked potential (EP) is simultaneously recorded, and this is especially marked in the frontal regions of the cortex. When voluntarily terminating a dominant state, the rabbit blinks, but at this precise

moment evoked potentials (EP) are absent or occur with a reduced amplitude. At the same time there are EEG potentials which are similar in form to EP, but which precede the blinking. In a continuous recording the appearance of these potentials enables one to predict the appearance of voluntary blinking. The recorded potentials are essentially similar to the readiness potentials described by many authors for voluntary movement in humans. Although the parameters of the potentials studied by R.A.Pavlygina do differ from the parameters of human readiness potentials, she nevertheless considered it possible to call them readiness potentials of voluntary blinking.

It is worth recalling that the existence of readiness potentials is considered by a number of scientists (including J.Eccles) to be one of the justifications for a dualistic conception of the relationship between the brain and the psyche (Kostyuk, 1985). The investigations of R.A.Pavlygina are a further demonstration of the fact that voluntary action has a neurophysiological basis, and does not require the enlistment of any concepts lying outside the bounds of neurophysiology.

Simultaneous recording of the electrical activity of brain structures connected with blinking has permitted the establishment of a definite sequence for the restructuring of potentials prior to voluntary blinking. First of all a restructuring of the frequency spectrum towards a predominance of delta rhythms occurs in the subcortical centres (8-4 secs. before blinking). It is more marked than the restructuring in the cortex before the actual blink. Characteristically, the predominance of delta rhythms in the electrical activity of the subcortex is maintained after the constant current is switched off; at the same time, in the cortex the dominance of the theta rhythm is already established. It is possible to believe that the involvement of subcortical brain structures is essential to the rapid formation of conditioned reflex links after a single combination. According to the data of R.Yu.Il'yuchenok (1981), the development of a conditioned avoidance reaction after a single combination requires the intactness of the amygdaloid complex and the central gray matter.

Conditioned reflexes formed after a single combination are quite frequently encountered. For example, a bee will remember the colour of a food-dispenser after a single visit and maintain this memory for 5-6 days. Of decisive importance for such reflexes is the biological value (strength) of the reinforcement and the ecological adequacy of the stimulus. Conditioned aversion to food (the "lure effect"), in which poisoning acts as reinforcement a few

hours after the action of the conditioned signal, can be formed when this signal is a food stimulus, but not when it is a sound or lighting effect, etc. There is a tendency to treat reflexes which are connected after a single combination as a special variety of higher nervous activity called "psychonervous activity" or "behaviour directed by images of external objects". The experiments of R.A.Pavlygina suggest the need to investigate carefully the extent to which we are dealing with the dominant state in humans and in animals in all the cases where we observe the rapid formation of new conditioned links. A whole series of experimental results obtained by other authors make this proposition highly plausible. For example, weak painful reinforcement did not lead to the formation of the avoidance reaction in mice or rats. Preliminary application of a painful stimulus (a "fear session") facilitates the subsequent formation of a conditioned reflex over a long period of up to 2 weeks (Abuladze). Preliminary extensive stimulation of one of the positively emotiogenic brain structures speeds up the development of the instrumental reaction of self-stimulation of either this structure or a structure close to it (Ordzhonikidze, 1985).

Finally, the investigations of R.A.Pavlygina bring us closer to an explanation of the physiological mechanisms of Thorndike's "law of effect", according to which a single reinforcement with food or the cessation of a painful stimulus etc. bring about the fixation of the movement which led to the animal's achievement of its goal, despite the previous repetition of an ineffective movement for tens or hundreds of times.

Let us now return to our schema for the formation of a conditioned reflex (fig. 6). After the coincidence in time of the action of the conditioned stimulus and the arrival of afferentation from the reinforcing unconditioned stimulus, the system of inverse conditioned links begins to function. In this process, the activating inverse link selectively increases the sensitivity of structures which accept the conditioned signal, while the inhibitory inverse link removes effectory manifestations of the "proper" unconditioned reaction to the stimulus which has become conditioned. The reinforcing afferentation inhibits the effect of the excitatory afferentation (the phenomenon of "sensory satiation"), but in the early stages of the satisfaction of the corresponding need it can strengthen excitation according to the principle of "appetite while feeding". Finally, the dependence of reinforcement on the reactions of the subject converts the classical conditioned reflex into its instrumental variety.

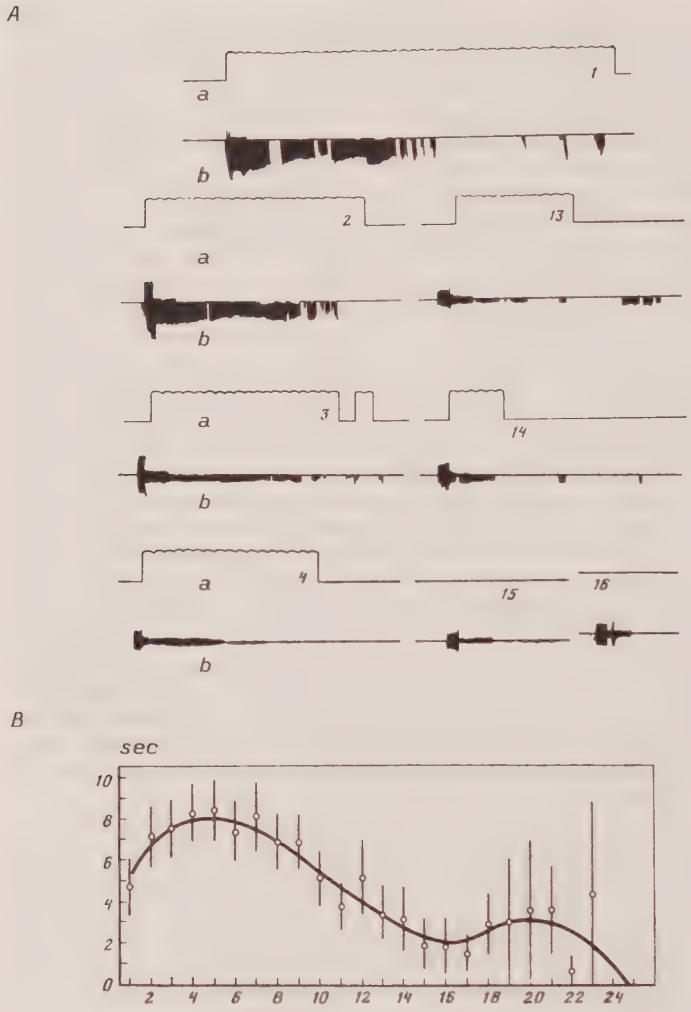


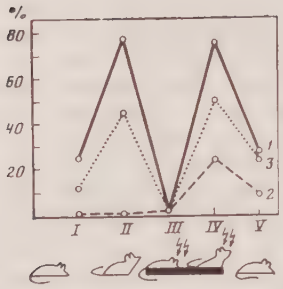
Fig.9. Inverse conditioned links in the drinking behaviour of rats.

A - motor reactions of pedal-pressing (a) and licking the drink-dispenser (*b*) when a succession of small portions of water are provided (*1-16*); *B* - the average period (secs.) of holding down the pedal when small portions of water are repeatedly provided: *1-24* - the filling of the drink-dispenser (according to V.N.Semagin).

The interaction of direct and inverse conditioned links was placed by E.A.Asratyan at the basis of his reflex theory of the motivation of behaviour (Asratyan, 1974). Asratyan treated this interaction as the fundamental general neurophysiological principle behind the integrative activity of the brain (Asratyan, 1981). Evidence for the universality of the mechanism of bilateral conditioned links is provided by its presence in invertebrates, as demonstrated both by the recording of behavioural reactions (Maksimova, 1979; Alexander, Audeskirk, and Audeskirk, 1982), and of the activity of the corresponding neurons (Maksimova and Balaban, 1983; Balaban, Maksimova, and Galanina, 1985). The development of alimentary conditioned reflexes has shown that old snails are capable of being trained only when they are hungry. Young snails can also be trained when they are satiated, but a conditioned reflex appears only after food deprivation (Audeskirk, Alexander, Audeskirk, and Moyer, 1982).

Experimental support for E.A.Asratyan's notion of the role of inverse conditioned links in the motivation of behaviour is provided by the fact that the number of inverse links decreases in accordance with the satiation of the animal, as was shown by V.N.Semagin (1983) on the basis of instrumental drinking reactions in rats (fig. 9, *A*, *B*). After the development of an instrumental motor reaction in which pressing a pedal was reinforced by the provision of a small portion of water, the rat was then time after time given 2ml of water in the drink-dispenser. When licking up the water, the animal would simultaneously press the pedal (fig. 9, *A*). As its thirst was quenched, the time the pedal was held down at first increased ("appetite while feeding"), but subsequently decreased to the point at which motor reactions had completely disappeared (fig. 9, *B*).

A good methodological technique for investigating the role of inverse conditioned links in the organisation of behaviour is to be found in M.N.Livanov's (1972) analysis of the spatial synchronisation of the electrical activity of brain structures. Included here is the case of self-stimulation of rats by a weak constant current (Pavlygina, Trush, Mikhailova, and Simonov, 1977). Fig. 10 shows the percentage of cases in which significant coherence ($p < 0.05$) was recorded in the alpha and theta frequency ranges when the potentials of the following brain structures were compared: the emotionally positive point of the hypothalamus - the motor region of the cortex (*1*), the emotionally negative point of the hypothalamus - the motor region of the cortex (*2*), the motor cortex and the visual cortex (*3*). The analysis was carried out at the following behavioural



I - calm state; *II* - before pressing the pedal; *III* - on the pedal; *IV* - before leaving the pedal; *V* - immediately after leaving the pedal; *1* - emotionally positive point of the hypothalamus - motor region of the neocortex; *2* - emotionally negative point of the hypothalamus - motor region of the neocortex; *3* - motor region - visual region of the neocortex (according to R.A. Pavlygina, V.D.Trush, N.G. Mikhailova, and P.V. Simonov).

Fig.10. The percentage of cases of statistically significant alteration in the coherence of the electrical activity of brain structures at various stages in self-stimulation in rats.

stages: *I* - calm state of the animal, *II* - immediately before pressing the pedal, *III* - while pressing the pedal, *IV* - the period of leaving the pedal, *V* - after leaving the pedal. If one examines the graph, one can convince oneself that immediately before the pedal is pressed there is a sharp rise (by a factor of more than 3) in the percentage of cases in which there is statistically coherent electrical activity of the emotionally positive point of the hypothalamus with the motor region of the cortex. This increase in coherence is evidence of the preparedness of nervous pathways for the transfer of excitation along three channels of inverse conditioned links: from the initially stimulated emotionally positive point to the motor cortex and to the visual cortex, and also between the visual analyser which accepts the conditioned signal of future reinforcement (the sight of the pedal, its location in the chamber etc.) and the motor cortex, since it is the sight of the pedal which will direct the movement of the animal initiated by the trace arousal of the emotionally positive region.

While the rat is on the pedal, the coherence decreases, the animal receives reinforcement and becomes totally

passive. Immediately before the rat leaves the pedal, there is for the first time an increase in the coherence of the negative point and the motor region of the cortex: the arousal of negative structures is ready for transformation into the motor reaction of avoidance. After the animal leaves the pedal, the percentage of cases in which there is a statistically reliable increase in coherence returns to its original value. Only traces of the emotionally negative state can still be seen in the comparison of the electrical activity of the negative point with the motor region of the cortex.

The mechanism of the inverse conditioned link explains not only the directedness of external actions towards the goal, but also the nature of phenomena such as, for example, the phenomenon of selective attention. In a conditioned reflex, at the same time as the first of a combined pair of stimuli has its effect, a tonic inverse conditioned link "can be restricted just to an increase in excitation of the central structures of the second", tuning the corresponding analyser to the selection of strictly defined stimuli (Asratyan, 1974:14).

The notion of inverse conditioned links permits an explanation of the classical and instrumental (operant) conditioned reflexes on a unitary theoretical basis (Ruis, 1984). "Thanks to the works of Pavlov's pupil, Asratyan," write I.Gormezano and R.Tait, "the hypothesis of the bilateral conditioned link has become a central point in the Pavlovian approach to the explanation of both classical and instrumental conditioned reflexes" (Gormezano and Tait, 1976). The inverse conditioned link is important in the treatment of a whole range of phenomena revealed by the study of human higher nervous activity (Kostandov, Vazhnova, Genkina, Zakharova, Ivashchenko, and Pogrebinsky, 1984).

Thus, we have a substantial basis for treating the interaction of the dominant and the conditioned reflex as a functional unit in individually acquired behaviour. It is now appropriate to ask the question: to what extent can this theoretical schema be "superimposed" on the morphofunctional organisation of real brains?

As was demonstrated above (c.f. chapter 3), the experimental and theoretical analysis of the genesis of emotional reactions in humans and higher animals has led us to the conclusion that there are two factors which are of fundamental importance in the determination of behaviour. In our opinion, these are the presence of actualised needs and the possibility of satisfying them through interaction with the external environment. The significance of stimuli arriving from the external environment depends on their

relationship with the needs which the organism has. All these stimuli can be divided into two basic categories: stimuli with a high probability of reinforcement by factors directly satisfying one or another need, and stimuli with a low probability of reinforcement. Amongst actual needs, in their turn, it is possible to distinguish the most urgent dominating needs which require immediate satisfaction, and subordinate needs which dynamically coexist with a dominant need or other competing needs.

Experimental data obtained in our laboratory, as well as the results to be found in the literature, demonstrate that this conception of the organisation of behaviour is in conformity with the interaction of the four brain structures which play a decisive role in the evaluation of signals arriving from the external environment and in the selection of reactions. These are the frontal regions of the neocortex, the hippocampus, the amygdala and the hypothalamus.

Since structures have been discovered in the hypothalamus which are connected with the actualisation of needs and the emergence of emotions, it can be said that the hypothalamus participates in the very earliest stages of the organisation of behaviour and in the later stages when an external response has finally been formulated.

The early (dominant) stage in the development of a new conditioned reflex is characterised by widespread involvement of the structures of the limbic system (Morrell, Barlow, and Brazier, 1960). What is more, alterations of neuronal activity and slow potentials take place earlier in these structures than in the neocortex (Rebert, 1972; Linseman and Olds, 1973). The most important role in the initiation of behaviour must be attributed to the hypothalamus (Sudakov, 1971), inasmuch as bilateral destruction of the lateral hypothalamus provokes a general breakdown in voluntary behaviour (akinesia and catalepsy), which includes, but is not restricted to, aphagia (Stricker and Andersen, 1980). Such animals characteristically present with symptoms of low mobility, flaccidity, and paralysis in what are sometimes unusual postures, i.e., signs of a kind of "weak will". Although the hypothalamus seems to be located at the "source" of a behavioural act, its activity is secondary in relation to the need-motivational mechanisms of lower regions of the brain and it represents a comparatively high level of integration. It is supposed that the hypothalamus has no "visceral centres" of its own, and that its influence on visceral functions is exercised through the emotiogenic structures which integrate the motor and visceral components of emotions (Polyakov, Talan, and

Chernigovsky, 1978).

In the monkey hypothalamus, neurons have been discovered which react exclusively to the sight of water or exclusively to the sight of food. What is more, the latent period of the neurons which react to the sight of food is equal to 150-200 ms, while the latent period of neurons which react to feeding is 300 ms (Rolls and Rolls, 1982). Stimulation of the lateral hypothalamus heightens the activity of neurons of the nucleus tractus solitarius which are connected with taste stimuli, and lowers the activity of neurons which are connected with the thermal or mechanical sensitivity of the tongue (Matsuo, Shimizu, and Kusano, 1984).

The degree of hunger arousal turns out to be of decisive importance for the involvement of hypothalamic structures in the learning process and in the reaction to external objects capable of satisfying the need for food. Only in hungry monkeys have neurons been found in the lateral hypothalamus which respond to the sight and smell of food, to the sight of a syringe of glucose, or to a nut-shell (Mora, Rolls, and Burton, 1976). What is more, the administration of glucose lowered the reactivity of neurons to these natural food stimuli (Burton, Rolls, and Burton, 1976). The neurons of the hypothalamus which are sensitive to the administration of glucose are involved in the process of food-gathering behaviour: neuronal activity rose sharply in monkeys 2 - 0.8 sec. before the pressing of a lever to receive food (Nishro, Ono, Sasaki, and Muramoto, 1979). The glucose-sensitive neurons are connected with the noradrenergic system. Their firing activity was suppressed during presses of the lever to obtain food. By contrast, neurons which were not sensitive to glucose increased their activity during the performance of motor reactions. This permits us to consider the first type of neuron as belonging to the excitatory, behaviour-motivating system, while neurons of the second type are more appropriately linked with the performance of a motor act or the anticipation of an imminent reinforcement (Aou, Oomura, and Nishino, 1983). It is supposed that the neurons of the lateral hypothalamus are primarily involved in the discrimination between food and non-food objects and in the initiation of food-gathering behaviour (Ono, 1981). Some of the glucose-sensitive neurons alter their impulse activity in response to a conditioned signal, and the majority alter their firing activity in response to food reinforcement (Aou and Oomura, 1984).

Neurons of the lateral hypothalamus in monkeys respond 150-200 ms after the opening of a door allowing access to food, whereas the activity of neurons of the globus pallidus

alters only after 300 ms simultaneously with the electromyographic indications of a motor reaction (Rolls, Roper-Hall, and Sanghera, 1977). An analogous sequence of events can also be observed in the process of development of a new conditioned reflex. Alteration of the hypothalamic neuronal discharge frequency occurs after 10-20 combinations of sound and food, whereas the behavioural indications of the new reflex appear only after 40-50 trials (Olds, 1973).

Investigation of mechanisms of thirst and morphinism in rats has shown that neurons of the lateral hypothalamus are activated by the emergence of a need (drive) and are inhibited by its satisfaction (reinforcement). In the medial hypothalamus the opposite effects are observed. Neurons of the basal regions of the rat forebrain react in a highly selective manner to objects which are important to the animal, whether a sexual partner (medial preoptic region), water (lateral septum), the experimenter's hand (lateral preoptic region), etc. (Mink, Sinramon, and Adams, 1983).

In comparison with the hypothalamus, the functions of the second brain formation included in the "motivational" group (the nuclei of the amygdaloid complex) depend to an even greater extent on factors of the external environment and on the immediate situation in which actual needs are satisfied. Regulation of body weight, consumption of food and water, and the response to blood glucose level and duration of food deprivation are essentially unaltered after a lesion of the amygdala. Its intactness is more important for appetite, and for discriminating between tasty and unpalatable food or between new and familiar food, i.e., for responses to exteroceptive food stimuli, including those after a short period of food deprivation when no metabolic changes have yet occurred in the organism (Schoenfeld and Hamilton, 1981). Rats with destruction of the basolateral nucleus of the amygdala lose the ability to evade the consumption of a solution which is unpleasant to intact rats (Rolls and Rolls, 1982). When a conditioned reflex of taste aversion is developed, the reaction of the nuclei of the amygdala has been recorded in response to the conditioned signal. It is possible that precisely in the amygdala there is a convergence of taste (conditioned) and visceral reinforcing signals (Buresh and Bureshova, 1979).

It seems that the amygdala is responsible for the continued response to conditioned signals of water and food in animals which have ceased to react to tissue thirst and the lowering of blood glucose level after destruction of the lateral hypothalamus. The basolateral part of the amygdala is connected with the effect of past experience of thirst quenching, and not with "tissue thirst" (Rolls and Rolls,

1973). Destruction of the ventral part of the medial nucleus impairs instrumental conditioned reflexes connected with food and especially drink, without affecting the consumption of water and food in any significant way (Korczynski and Fonberg, 1976). Analogous consequences of lesions of the amygdala are also observed in the case of defensive reactions. In this case amygdalectomy impairs behaviour provoked by fear, but fails to affect the threshold of painful stimulation (Ursin, 1965; Reeves, Martin, and Ghiselli, 1977). The fact that the functions of the amygdala are primarily linked with external rather than internal motivating stimuli is in good agreement with the characteristics of its morphological connections. The amygdala has strong pathways leading to the hypothalamus and weaker ones leading from it, as well as developed pathways from the frontal and temporal regions of the neocortex. This system (neocortex - amygdala - hypothalamus) is functionally formed during ontogenesis and plays an important role in individual behavioural characteristics (Chepurnov and Chepurnova, 1981).

The old corticomedial part of the amygdala receives afferent fibres from the hypothalamus, thalamus, and medulla oblongata, which process visceral and nociceptive signals. The basolateral part is connected with the structures of the telencephalon and the thalamus. Thus, there are two afferent paths to the amygdala: one from the temporal cortex and the other from the brain stem through the posterior nuclei of the thalamus. The direct path is the more ancient. The path through the cortex evolves in parallel with the development of the neocortex (Gonchar, 1984). Investigation of the spatial organisation of the biopotentials of the neocortex, the hippocampus and the amygdala in dogs has shown that in the case of a stable instrumental alimentary conditioned reflex there is an increase in the coherence of electrical activity in the delta and theta ranges in the paired structures: amygdala - frontal cortex, amygdala - sensori-motor cortex. The amygdala and hippocampus interact weakly: this must be a reflection of their different roles in the organisation of behaviour (Aleksanov, Vainshtein, and Preobrazhenskaya, 1984).

Summing up the existing data on the functions of the amygdala and its role in the organisation of behaviour, P.Gloor comes to the conclusion that "the main defect caused by a lesion of the amygdala can be described as a breakdown in the motivational mechanism which normally permits the selection of the behaviour acquired in the given situation" (Gloor, 1960:1416). The amygdala appears to be essential for the restructuring of behaviour in line with changing

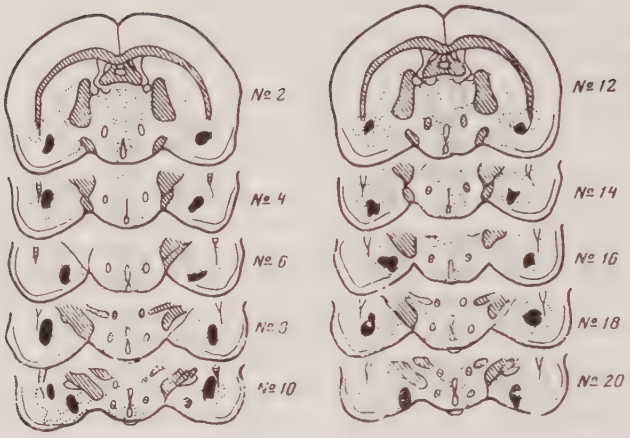


Fig.11. Reconstructive schema of lesions of the amygdaloid complex in 10 rats.

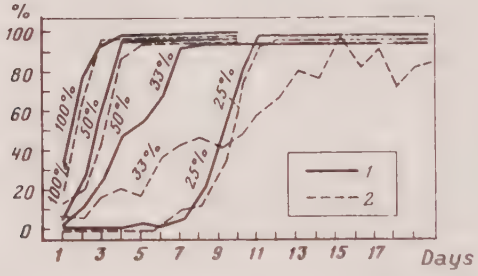


Fig.12. Percentage of alimentary conditioned reflexes in control (*1*) and amygdalectomised (*2*) rats with different probabilities of reinforcement of the conditioned signal.

Abscissa - days of the experiments (according to M.L.Pigareva).

circumstances of reinforcement (Richardson, 1973). In accepting this conclusion, it is necessary to make clear that the amygdala itself is relatively "indifferent" to the probability of reinforcement, to its informational

component. A shift to 50% reinforcement causes frustration in both control and septal rats without affecting amygdalectomised animals, including the process of extinction of conditioned reflexes reinforced in 50% of trials (Henke, 1977). M.L.Pigareva (1978) developed alimentary conditioned motor reflexes in rats after bilateral destruction of the amygdala (fig. 11). It turned out that the figures for the speed of development of reflexes in these animals do not differ from the corresponding figures for intact animals in the case of either a high (100% and 50%) or a low (25%) probability of reinforcement. Only a probability of 33%, which characteristically causes a maximal degree of emotional tension, is accompanied by a slight retardation in the formation of the conditioned reflex (fig. 12).

Bilateral destruction of the amygdala does not prevent the development of either an alimentary or a defensive conditioned reflex in rats (fig. 13). According to the results of R.Russell and R.Thompson (1984), the amygdala does not play a key role in the development in rabbits of a blinking conditioned reflex in response to a tone.

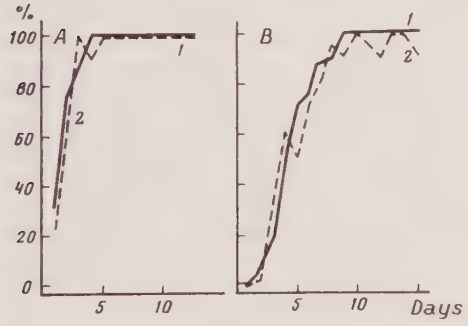


Fig.13. Percentage of defensive (*A*) and alimentary (*B*) conditioned reactions in control (*1*) and amygdalectomised (*2*) rats (according to M.L. Pigareva).

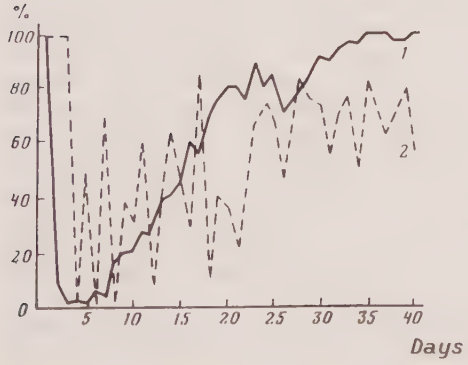


Fig.14. Percentage of correct defensive (*1*) and alimentary (*2*) conditioned reactions in the development of conditioned reflex switching in an amygdalectomised rat (according to M.L. Pigareva).

However, the picture changes radically in the case of competition between coexisting motivations, when it becomes essential to distinguish the need which is dominant and subject to immediate satisfaction. A good experimental model of a situation of this kind is the development of conditioned switching between different types of reflex using E.A.Asratyan's method of reinforcing one and the same signal (in M.L.Pigareva's experiments, a noise) in the morning with food and in the evening with a painful stimulus. Bilateral destruction of the amygdala in rats results in a failure to achieve switching for a period of forty days (fig. 14). The development of switching turned out to be possible only when a weak painful stimulus was combined with a high state of alimentary arousal, or vice versa, when a short period of food deprivation was combined with strong painful reinforcement of the defence reflex.

Many defects of conditioned reflex activity and natural behaviour which occur in animals following lesions of the amygdala can be explained by the competition of motivations. Rats with a lesion of the corticomedial region subsequently begin feeding under a new set of conditions, inasmuch as their alimentary activity is suppressed by investigative behaviour (Selafani, Belluzzi, and Grossman, 1970). Impairments of feeding and drinking conditioned reflexes in rats after destruction of the medial part of the amygdala become especially marked whenever the competition between motivations is created by corresponding periods of deprivation (Korczynski and Fonberg, 1976). Stimulation of the amygdala in cats weakens the galvanic skin reaction (GSR) to sound signals of low significance (clicks), but strengthens the GSR to clicks which are paired with painful stimuli (Gilinsky, 1985). Lesions of the ventromedial amygdala do not impair alimentary instrumental conditioned reflexes or the consumption of food, but suppress the hunting behaviour of cats. Lesions of the dorsolateral part have the opposite effect (Zagrodska and Fonberg, 1979). Destruction of the dorsal region does not affect mouse-catching or eating when a cat is acting alone. The presence of another cat suppresses the predatory reaction to the appearance of a mouse (Zagrodska, Brudnias-Stepowska, and Fonberg, 1983). Investigation of the food-gathering behaviour of rats in different situations led the authors to the conclusion that the corticobasomedial amygdala controls the relationship between food motivation and other motivations competing with it (Lukaszewska, Korczynski, Kostarczyk, and Fonberg, 1984).

Thus the conclusion that the amygdala belongs to the system of structures which determine choice of behaviour can

be accepted with the proviso that the amygdala participates in this choice by "weighing" the competing emotions generated by the competing needs. The amygdala is involved in the organisation of behaviour at comparatively late stages in the process, when the actualised needs are already being juxtaposed with the prospects for their satisfaction and being transformed into the corresponding emotional states.

The prediction of the probability of satisfying a need (the probability of reinforcement) is carried out with the participation of the primarily "informational" brain structures - the hippocampus and the frontal regions of the neocortex.

The hippocampus is considered to be the centre of the brain structures which model the world in a three-dimensional Euclidian space. With the aid of the hippocampus, events occurring in the surrounding environment are fixed in time and space: in the hippocampus of freely moving rats neurons have been discovered which encode the location of external objects (Keefe and Nadel, 1979). Japanese macaques were shown one of two buttons in red light. After a period of restraint, the monkeys had to press the previously shown button in order to receive a portion of fruit juice. Neurons were distinguished which altered their firing activity (1) while the button was illuminated, (2) during the period of restraint, (3) at the moment the button was selected, (4) when the button was pressed, and (5) when reinforcement was provided or withheld (Watanabe and Niki, 1985). It is supposed that the basic function of the hippocampus is "working" (short-term, medium-term etc.) memory, independently of whether spatial or temporal material is being fixed (Olton, Becker, and Handelmann, 1979). What is more, these functions are similar in humans and higher animals (Sahgal, 1980).

The hippocampus is involved in the learning process at its earliest stages (Segal and Olds, 1972). When alimentary conditioned reflexes were developed in combination with a noise, short-latency neuronal responses were recorded in the hippocampus, and long-latency conditioned responses were recorded in the temporal cortex. In the opinion of the authors, the hippocampus is the first point at which conditioned and unconditioned stimuli converge. It was precisely in the hippocampus and the lateral section of the septum that cells were found whose activity altered only when stimuli were paired. We note that destruction of the dorsal and ventral hippocampus in rats does not impair their learning abilities, and even facilitates the development of conditioned reflex switching (Pigareva, 1973). In fig. 15 it

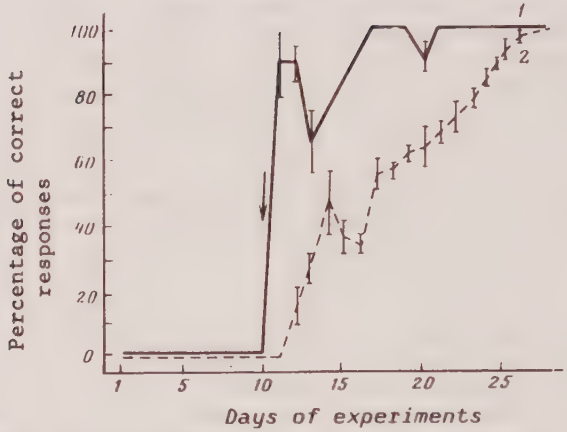


Fig.15. Dynamics of the development of conditioned reflex switching in three rats before and after bilateral lesioning of the hippocampus (indicated by an arrow).

1 - defensive reactions; *2* - alimentary reactions (according to M.L.Pigareva).

Fig.16. Reconstructive schema of bilateral destruction of the hippocampus.

The maximal extent of the lesion is shaded, and the minimal extent is blackened.

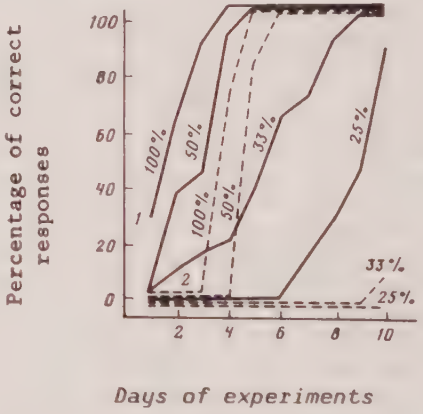


Fig.17. The percentage of correct conditioned alimentary reactions in control (*1*) and hippocampectomised (*2*) rats with different probabilities of reinforcement of a conditioned signal.

Abscissa - days of the experiments (according to M.L.Pigareva).

can be seen that, after ten days of unsuccessful attempts to develop the switching of defensive and alimentary conditioned reflexes in three rats, bilateral hippocampectomy (fig. 16) led over the course of two weeks to the formation of stable conditioned reflex switching.

The most striking defect in hippocampectomised rats turns out to be their sensitivity to situations in which there is a low probability that conditioned signals will be reinforced (Kimble and Kimble, 1970; Jarrard and Becker, 1977; Devenport and Hollowy, 1980). According to the data of M.L.Pigareva (1978), when the probability of reinforcement of alimentary conditioned reflexes is 100% or 50%, hippocampectomised rats are less advanced than intact rats, but nevertheless manage the task. The development of conditioned reflexes when the probability is 33% or 25% turns out to be beyond them (fig. 17). The collapse of reactions to low-probability signals has the consequence that hippocampectomised rats surpass control animals in the discrimination of signals with different probabilities of reinforcement (Means, Walker, and Isaacson, 1970; Stevens, 1973). A particular case is the facilitation in these animals of the development of conditioned reflex switching.

Impairments of the emotional sphere following lesions of the hippocampus are generally insignificant (Karamyan and Sollertinskaya, 1982). However, stimulation of the dorsal hippocampus inhibits emotional reactions in dogs which are elicited by direct stimulation of the hippocampus (Petrov, 1974), whereas stimulation of the ventral hippocampus in rabbits suppresses self-stimulation of the lateral hypothalamus (Koreli, 1977). Lesions of the ventral hippocampus in rabbits distort the effects of direct electrical stimulation of the medial hypothalamus: emotionally negative avoidance reactions are replaced by self-stimulation of the very same structures (Davituliani and Koreli, 1982).

Thus, the hippocampus has a regulating influence on the emotiogenic structures of the hypothalamus. The functional links between the hippocampus and the hypothalamus are also demonstrated by the fact that lesions of the posterior hypothalamus alter the electrical activity of the hippocampus in REM sleep (Gvetadze, 1980).

Since the hippocampus is a structure in which the motivational stimulation from the posterior and anterolateral hypothalamus is compared both with the information arriving from the external environment (via the septum) and with the traces of previously accumulated experience (from the cortex), it must be carrying out a double function. Firstly, it plays the role of a filter for

incoming information, which may or may not be recorded in long-term memory (Vinogradova, 1975). Secondly, the hippocampus is involved in the retrieval of traces from memory under the influence of motivational excitation for the use of these traces in the organisation of ongoing behaviour (Hirsh, 1974). By the method of correlational analysis of electrical activity it has been established that during the early stages in the development of a conditioned reflex, theta waves in the hippocampus precede theta waves in the temporal cortex, i.e., stimulatory impulses pass from the hippocampus into the cortex. When the conditioned link is stabilised, the theta waves of the entorhinal cortex precede the waves in the hippocampus, and stimulatory impulses spread from the cortex into the hippocampus (Adey, Walter, and Hendrix, 1961). It must be emphasised that traces can be retrieved from memory independently of external stimuli and can lead to readiness for these stimuli through the mechanism of inverse conditioned links (Asratyan, 1974).

The electrophysiological correlate of the mechanism which quantifies the flow of engrams retrieved from memory is the theta rhythm, which is a promiment feature of the electrical activity of the hippocampus. The situations in which we observe an increase in the theta rhythm, for example the orienting reflex, search behaviour, the organisation of complex non-automatic movements, and the emergence of signs of emotional tension, have one feature in common: they all require the active mobilisation of previously developed conditioned links, the retrieval of engrams held in memory so that they can be compared with signals arriving from outside, or so that traces can be reviewed and recombined with the goal of constructing new adaptive actions (Gray, 1982).

What we have said above permits us to attribute an important role to the hippocampus in creative activity of the brain and in the generation of hypotheses, especially as the hippocampus of the dominant hemisphere in humans is involved in the analysis of verbal signals, whereas the hippocampus of the right hemisphere analyses non-verbal stimuli. This functional asymmetry is in contradiction with the conception of the hippocampus as an ancient and therefore primitive structure, capable solely of carrying out rudimentary functions.

In the opinion of A.S.Batuev (1981), motivational excitation spreads from the limbic system into the frontal and particularly the parietal cortex. In essence, the frontal region can be considered as the neocortical extension of the limbic system (Nauta, 1964). Information

about the external environment enters the associative systems of the neocortex through the associative nuclei of the thalamus and transcortically from the sensory projection regions. On the basis of this information and the engrams retrieved from memory, the frontal cortex makes a probability prediction, while the thalamoparietal system provides selective attention to significant factors of the external environment and to the main links of the motor act to be performed. In other words, the parietal cortex ensures that motor reactions are appropriate to the spatial organisation of the external world.

The decisive importance of the frontal regions of the neocortex in predicting the probability of forthcoming events has been established in rats, cats, dogs, monkeys and man. Impairments of probability prediction following lesions of the frontal cortex last for three and a half years in monkeys. Bilateral lesions of the parietal cortex result in an impairment of probability prediction followed by its rapid restoration (over a period of one to one and a half months) (Malikova, 1981). Lesions of the prefrontal associative cortex in cats impair their preference for a food-dispenser with a high probability of reinforcement, whereas removal of the parietal cortex does not result in this defect (Batuev and Kulikov, 1983). It is possible that impairment of the mechanisms of probability prediction is precisely what is behind the distraction of patients with tumours of the frontal lobes by stimuli which are of little significance to them (Bely, 1979). At the same time, the probabalistic structure of the environment is reflected in the neuronal activity of a number of other regions of the neocortex. In the experiments of D.G.Shevchenko (1982), a rabbit would press a pedal in response to a flash either on its right or on its left, receiving food from a corresponding dispenser. The flashes were given from either side with either 100% or 50% probability. The reaction of neurons of the visual cortex differed depending on the probability of a flash appearing before the pedal was pressed, but this difference was not observed at other stages in the behaviour.

It must be emphasised that in distinction to the hippocampus, which must be intact if reactions to low-probability signals are to be supported, the frontal cortex is important for the orientation of behaviour towards signals of high-probability events. For example, after removal of the frontal regions of the neocortex in rats and dogs, the significance of frequently and infrequently reinforced conditioned signals seems to be evened out: all signals become equally effective (Andreev, 1969; Pigareva,

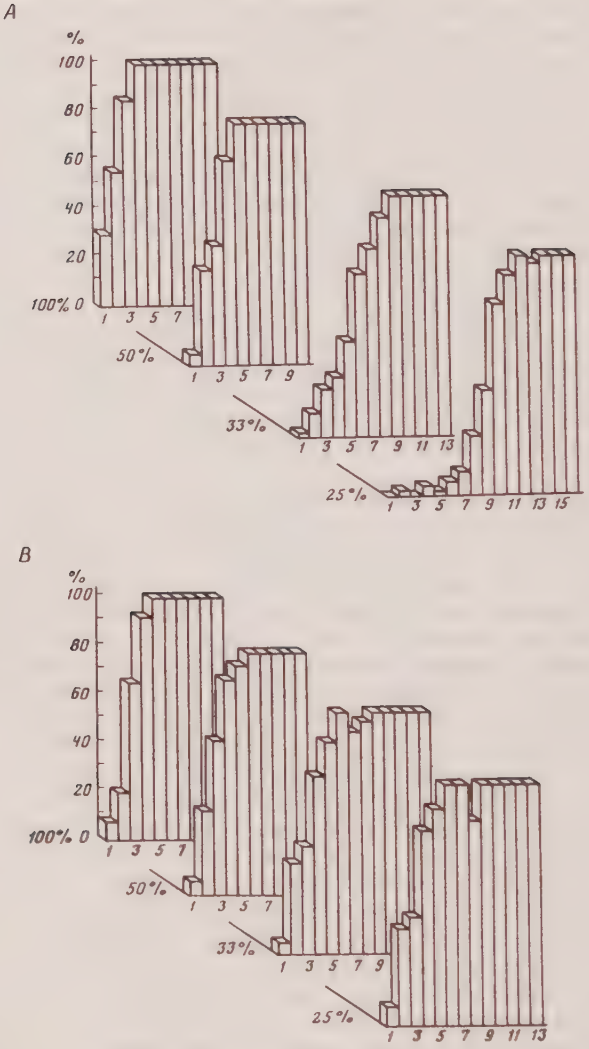


Fig.18. The percentage of motor alimentary conditioned reactions in control (*A*) and lobectomised (*B*) rats with differing probabilities of reinforcement.

Abscissa - days of the experiments (according to M.L.Pigareva).

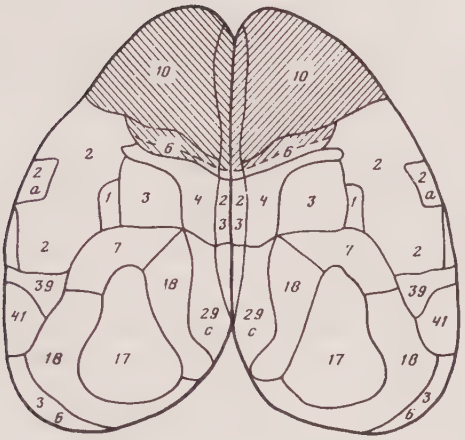


Fig.19. Reconstructive schema of the removal of the frontal regions of the neocortex in rats.

1983). Fig. 18 shows the dynamics of the development of alimentary conditioned reflexes in rats with different degrees of reinforcement before (fig. 18, *A*) and after destruction of the frontal regions of the neocortex (fig. 18, *B* ; fig. 19). It can be seen that the formation of the conditioned reflex is retarded when the probability of reinforcement is high and speeded up when it is low. In other words, signals with differing probabilities of being reinforced with food become equally effective. This result is especially interesting since, judging by the available data, the frontal region of the cortex in rat brains does not differ in its essential functions from the frontal cortex of higher vertebrates, including primates (Kolb, 1984).

In the course of his experiments on probability prediction, V.M.Rusalov discovered three groups of individuals. Representatives of the first group adequately coped with the characteristics of the probability environment (probability correspondence). Representatives of the second group underestimated the frequency of a common event (probability indifference), while representatives of the third group overestimated it (the strategy of maximalisation). Experiments on animals in which brain structures are successively removed lead to the hypothesis that in individuals of the first group the functions of the

frontal cortex and hippocampus are well-balanced; in individuals of the second group the functions of frontal cortex predominate; while in representatives of the third group it is the functions of the hippocampus which are most important. As a consequence, the subjective evaluation of the probability of events by representatives of the latter two groups does not correspond to the objective probability of infrequent and frequent events (Rusalov, 1979). The effectiveness of joint predictions by individuals belonging to opposite groups supports rather than contradicts this hypothesis (Rusalov, 1982). In the literature there is evidence that the probability structure of the environment is more adequately reflected in the right hemisphere of the human brain, whereas the left hemisphere reacts equally to high and low-probability signals (Krauklis, Yanson, Shiryaev, and Kozanovskaya, 1979).

The ability of the frontal cortex to carry out a selection of highly significant signals, filtering out stimuli which are secondary to the dominant motivation, may possibly involve the participation of the caudate nucleus. Neurons of the caudate nucleus are involved in the process of developing inhibitory conditioned reflexes more rapidly than in the reaction to positive signals (Suvorov, Danilova, Dryagin, and Shuvaev, 1981). It should be noted that impairments of probability prediction are observed in dogs after removal of the dorsolateral regions of the prefrontal cortex, but not in the mediobasal regions of the prefrontal cortex (Mekhedova, 1974). Thus, within the frontal neocortex one finds that the dorsolateral regions are primarily involved in the "informational" system of brain structures, while the mediobasal regions belong to the "motivational" system. This division of functions is in good correspondence with the anatomical links between these two areas of the frontal cortex: the dorsal area is linked to the hippocampus, and the ventral area to the amygdala (Nauta, 1972). The frontal cortex can influence the hippocampus through a bundle of fibres to the gyrus cinguli. The prefrontal cortex is the only neocortical region to receive innervation from the ventral part of the operculum and the amygdala (Divac and Kosmal, 1978). Investigation has shown that the neuronal activity of the dorsolateral prefrontal cortex in monkeys depends on the integration of sensory processes essential to the organisation of behaviour, whereas the neurons of the orbitofrontal cortex are connected with motivation and their activity depends on the quality of reinforcement (Aou Shuji, 1982). The reactions of some of these neurons are highly specialised: they respond to oranges, snakes, spiders etc., although the majority of

neurons react selectively only to the alimentary or aversive properties of the stimulus (Thorpe, Rolls, and Maddison, 1983).

Motivational influences enter the frontal cortex from the lateral hypothalamus (Oomura and Fakigama, 1976). According to E.Rolls and S.Cooper (1973), the prefrontal cortex in rats, in distinction to other areas of the neocortex, contains neurons which react to the stimulation of those brain structures which elicit the phenomenon of self-stimulation. In the prefrontal cortex there are neurons which respond in hungry monkeys to the appearance of food in a dispenser before the start of food-gathering behaviour (Orlov, Pirogov, and Shefer, 1979). The activity of these neurons weakens with the degree of satiation, but is resumed when more tasty food is provided (Batuev, 1985). Investigation of delayed instrumental alimentary conditioned reactions in monkeys revealed the following types of neuron: (1) motor programming neurons, which react to the opening of a screen which acts as a signal for the beginning of movement; (2) sensory programming neurons, which fire during the delay; (3) reinforcement neurons, whose activity alters when food appears (Batuev, 1894). In the frontal cortex, neurons have been recorded which react to the absence of reinforcement when an instrumental reaction is performed. Moreover, these neurons do not respond to the absence of reinforcement in the classical conditioning situation, when the appearance of food does not depend on the monkey's actions. The neurons of erroneous reactions are located in the medioventral regions of the prefrontal cortex (Niki and Hiroaki, 1982). Thus the frontal regions of the neocortex seem to participate both in the programming of a behavioural act and in the evaluation of its results. Neurons of the rostral dorsolateral prefrontal cortex are primarily involved in motivational processes, whereas neurons of the caudal part are primarily involved in the sensory analysis of the taste and quality of food reinforcement (Inoue, Oomura, Aou, Nishino, and Sikdar, 1985).

The first changes in cellular activity in the development of a new conditioned reflex have been observed in the frontal and sensori-motor cortex, and the hippocampus. Neurons of the sensori-motor cortex react 20ms after an auditory conditioned signal reinforced by blinking, i.e., simultaneously with the neurons of the primary auditory cortex (Batuev, 1984).

The existence of primary plastic restructuring in neurons of the neocortex leads some authors to distinguish two mechanisms of skill development, the first, but not the second, being connected with the limbic system. This second

mechanism is formed in monkeys by the third or fourth month, while the memory system which involves the limbic structures matures slowly and has not reached the adult level even a year after birth (Bachevalier and Mishkin, 1984). It is necessary to distinguish between "limbic" memory as the active retrieval of information which is needed for the satisfaction of a need, and the phenomenon of recall, which is limited to the selection of a familiar stimulus from those which are presented. This latter mechanism is not impaired as long as the temporal cortex remains intact (Malamut, Saunders, and Mishkin, 1984).

When analysing the functions of the neocortex, it is essential to take lateralisation into account. The beginnings of this lateralisation are observed already in animals, and it is affected by early individual experience. In chicks, songbirds, rats and primates, the left hemisphere seems to be more heavily involved in the processes of communication, whereas the right hemisphere is responsible for spatial orientation and emotions (Denenberg, 1981). Investigation of the perception of significant species-specific signals in Japanese macaques revealed the priority of reactions to signals presented to the right ear. The presentation of signals appropriate to another species revealed no lateralisation (Peterson, 1978; 1984). Removal by suction of the cortex of the right frontal lobe in rats causes hyperactivity and a drop in the level of noradrenaline in the cortex of both hemispheres. Destruction of the left frontal lobe does not result in these changes (Pearlson and Robinson, 1981). According to the results of V.L.Bianki (1985), the functions of right hemisphere in rats must include the perception of space and the concrete signs of external objects, the simultaneous processing of information, and deductive operations. The functions of the left hemisphere must include the perception of time and abstract signs, the sequential processing of information, and inductive operations. The generalisation stage of conditioned reflexes is more closely linked with the activity of the right hemisphere. The dynamic stereotype is better reproduced by the left hemisphere. It is interesting that in man the left hemisphere is more strongly activated during the first performances of a task, for example, one connected with the mental reproduction of significant situations. As this procedure is repeated, the asymmetry in the level of activity shifts in favour of the right hemisphere (Rusalova, 1983).

Having completed this survey of the functions of the frontal regions of the neocortex, the hippocampus, the amygdala, and the hypothalamus, we reach the conclusion that

the interaction of these four structures is both necessary and sufficient for the organisation of behaviour within a coordinate system: "needs and the probability of their satisfaction in the surrounding external environment". All the other brain structures play an executive or auxiliary role, whether as sensory systems, mechanisms for the construction of movements (pyramidal and extrapyramidal), or systems for regulating levels of wakefulness and visceral functions. As far as the other structures of the limbic system are concerned, the septum is so closely linked to the hippocampus that most investigators prefer to speak of a single septo-hippocampal system (Gray, 1982). The central gray matter is specifically connected with the evaluation of aversive stimuli and with the organisation of avoidance reactions, for example, when the medial hypothalamus is stimulated (Sandner, Schmitt, and Karli, 1982). The non-specific thalamus is a place where sensory and motivational impulses converge (Casey and Keene, 1973), and its significance is no more than that of a relay station. Although neurons have been discovered in the monkey thalamus whose firing rate either falls or rises and then keeps stable when conditioned reflexes are developed, the long latency period (200ms after the presentation of the conditioned signal) makes us think that these reactions are a secondary echo of events taking place in other brain structures. In other words, the four structures listed above are precisely the structures that determine which external stimuli the living organism will respond to at the particular moment, and which behavioural reaction will be used. According to Mogenson, Jones, and Yim Chi Yiu (1980), the link between the limbic and motor systems takes place in the mesencephalic tegmentum and the nucleus accumbens together with the globus pallidus. Destruction of the nucleus accumbens lengthens the latency period of the avoidance reaction in rats and lowers their drive to dominate, without affecting motor activity in the open field and food-gathering behaviour (Fantin and Bottecchia, 1984).

As far as the coordinated activity of the "decision-making" structures is concerned, the most fitting and profound comment belongs to A.A.Ukhtomsky: "The coordination of physiological devices in a neural network is a process which is obligatory and does not presuppose the intervention of a special additional "coordination centre" (Ukhtomsky, 1954:127).

Having completed our sequential review of the functional specialisation of individual brain structures, we shall now attempt to present the dynamics of their interaction as a whole (fig. 20).

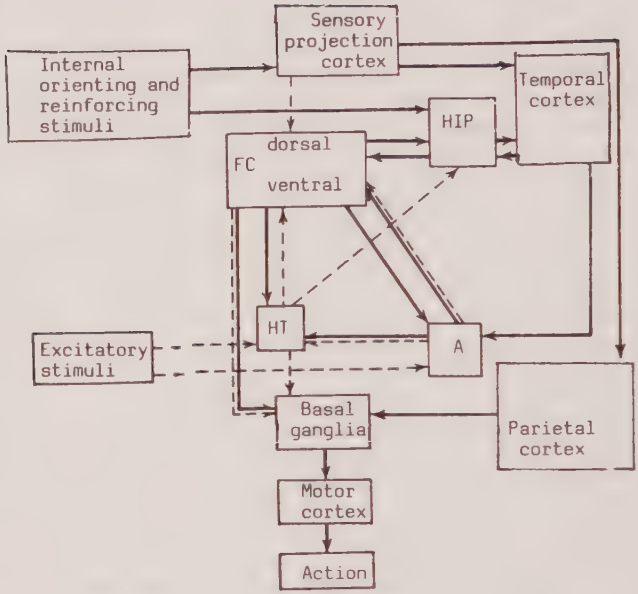


Fig.20. Schematic representation of the interaction of brain structures in the organisation of a behavioural act.

Internal (metabolism) and external (pain, smell etc.) excitatory unconditioned stimuli activate the motivational structures of the hypothalamus (HT), which in turn activates the hippocampus (HIP) and the frontal regions of the neocortex (the influence of the hypothalamus on the amygdala is less marked). The hippocampus makes possible the involvement of a wide range of external stimuli that strengthen the dominant state. In the event that these stimuli coincide with the action of reinforcing unconditioned stimuli, the hippocampus appears to be the first point at which the combined afferentations meet. When a behavioural act is formed as a result of the combined activity of the hippocampus and the frontal cortex (FC), a selection is made of those external stimuli (or their engrams) which were previously accompanied by the satisfaction of the particular need. Through the juxtaposition of a motivational stimulus with other accessible stimuli and engrams retrieved from memory, an emotional colouring of these stimuli and engrams is formed in the amygdala (A), leading to the distinguishing of a dominant motivation which requires immediate satisfaction. The program for action which is formed in the frontal cortex enters the basal ganglia, where through interaction with the parietal cortex it is "registered" in the spatial coordinates of the action to be performed. Then through the motor cortex the excitation arrives at the effector organs which carry out goal-directed behaviour. Solid lines - informational afferentation; broken lines - motivational influences; double lines - emotionally coloured afferentation.

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Through the juxtaposition of a motivational stimulus with other accessible stimuli and engrams retrieved from memory (via the temporal cortex?), an emotional colouring of these stimuli and engrams is formed in the amygdala, leading to the distinguishing of a dominant motivation which requires immediate satisfaction.

The program for action which is formed in the frontal cortex enters the striatum, where through interaction with the parietal cortex it is "registered" in the spatial coordinates of the action to be performed. The recording of evoked potentials has shown that during the formation stage of a conditioned reflex the parietal cortex is primarily connected with the cortical representation of the sensory systems, but as the conditioned reflex is stabilised the primary connection is with the motor cortex (Popova, Gneushev, and Derevyagin, 1982). Alterations in the neuronal activity of the corpus striatum, the globus pallidus, and the substantia nigra precede movements and arise in response to external sensory stimuli only when these stimuli and movements have behavioural significance (Evarts, Kimura, Wurtz, and Hikosaka, 1984). These authors conclude that the initiation of motor acts is mediated by the activity of the basal ganglia and the frontal cortex connected with them. Impulses from the basal ganglia and the cerebellum enter the cortex through the thalamus. In response to a signal for movement, the dentate neurons of the cerebellum fire after 30ms, while the neurons of the cortex fire 40ms after the signal. The nigrostriatal pathways are involved in the preparation and regulation of movements, but not in their motivation (Rolls and Rolls, 1982). From the frontostriatal system, excitation through the motor cortex arrives at the effector organs which carry out goal-directed behaviour.

Naturally, this proposed schema for the organisation of

behaviour is very general in character, and needs further refinement and experimental verification with reference to a variety of higher mammalian species. Nevertheless, this schema makes it possible to consider the integrative activity of the brain as a whole, and does not contradict any existing factual data or demonstrated anatomical connections between the structures of the brain. We are able to judge the activity of the brain on physiological grounds, without resorting to notions borrowed from other fields of knowledge such as "modelling of the external world", "decision-making", "rational activity" etc. etc.

On the other hand, by clarifying the role of different brain structures in the organisation of behaviour, we are in a position to state that any individual characteristics of human and higher animal behaviour follow from the individual (inborn and acquired) characteristics of the interaction of these structures. A similar approach to the problem of individual (typological) differences was once outlined by I.P.Pavlov, and deserves further detailed experimental and theoretical investigation.

Chapter 5

THE PROBLEM OF INDIVIDUAL (TYPOLOGICAL) DIFFERENCES

When speaking of the individual characteristics of a person as revealed in his social behaviour, we usually use three terms: "temperament", "character", and "personality". According to the definition given in the third edition of the Bol'shaya Sovetskaya Entsiklopediya (Large Soviet Encyclopaedia), temperament is "the characterisation of an individual with respect to the dynamic attributes of his psychic activity, i.e., the tempo, rhythm, and intensity of individual psychic processes and states. It is possible to distinguish three important components in the structure of temperament: the general behaviour of the individual, his motor activity, and his emotionality" (Vol 25:415). Character is "the integral and stable individual complexion of a person's emotional life, his spiritual type, his "disposition" as revealed in the individual acts and states of his psychic life, as well as in his manners, habits, cast of mind, and the orbit of his emotional life. The character of a person is one of the bases of his behaviour..." (ibid., Vol 28:193).

The initial reaction to these definitions of temperament and character is that they virtually coincide. However, in everyday life we would hardly confuse a person's temperament with his character. It is with character, and not temperament, that we use attributes such as "strong", "weak", "firm", "gentle", "difficult", "bad", "obdurate", and "insufferable". This intuitively felt lack of identity between temperament and character leads us to believe that they must have a basis in essentially different manifestations of individuality.

What is primarily being expressed in temperament is the *attitude* of a person to the events taking place around him, while character is manifested in activity: strenuous, goal-directed, indecisive, obedient, imitative, etc. What temperament and character have in common is that neither says anything to us about the social values of a person. They are connected with what V.M.Rusalov (1985) calls the formal-dynamic aspect of the psyche rather than its content aspect. This content aspect is revealed in personality,

personality being defined by the Large Soviet Encyclopaedia as "a stable system of socially significant features characterising an individual as a member of a particular society or group" (ibid., Vol 14:578). Personality includes both the temperament, the character and the abilities of a person (his intellect). But it is not restricted to these traits, inasmuch as personality is "the nucleus, the integrating beginning which binds together the different psychic processes of an individual and provides his behaviour with the necessary consistency and stability" (ibid., 579).

"A person's personality," wrote I.P.Pavlov, "is determined both by biological inheritance and by the environment. The strength of the nervous system (temperament) is an inborn property, but character (the form of behaviour) consists mostly of acquired habits" (Pavlov, 1954:618). It must be emphasised that the physiological organisation of the brain, individual variations in brain function, and the content aspect of the psyche as formed through social education, are not absolutely independent categories. Reducing the content aspect of the psyche to inherited instincts is as ridiculous as denying the role of these instincts in the individual manner in which a person assimilates social experience. Straight-line determinism is doomed from the start. It is a different matter, however, if we move to a position of systems determinism, recognising that one and the same social experience as provided by the surrounding environment can be assimilated differently depending on the individual (including "formal-dynamic") characteristics of the subject's psyche.

Considering that a person's needs are the source and the driving force which impel his behaviour, we conclude that every human personality is determined by the unreproducibly individual composition and internal hierarchy of his *basic* (vital, social, and ideal) needs, including individual needs of preservation and development, and needs "for self" and "for others" (see ch. 2). The most important characteristic of personality is: which of these needs occupy a dominant position in the hierarchy of coexisting drives and for how long, and which of these needs is "worked on" by the mechanism of creative intuition, the superconscious in K.S.Stanislavsky's terminology (a topic for the next chapter). We have already referred to L.N.Tolstoi and his brilliant intuition that "the whole diversity of mankind" arises out of "motivational forces". The personality tests of the future will be a system of methodological devices which permit an answer to the question: To what extent are the value orientations of a given personality determined by

its vital, social, and ideal needs, by the orientation of these needs (for self or for others), and by propensities for preservation and development? The supreme need, i.e., the dominant need which arises most frequently and lasts the longest, in Stanislavsky's terms, the "super-super-life task" of a particular individual, is the real nucleus of the personality, its most essential feature. Total satisfaction of this supreme need is usually called happiness. This makes conceptions of happiness a touchstone in personality testing. "The alpha and omega of my pedagogical beliefs," said V.A.Sukhomlinsky, "is the profound belief that a person is what his conception of happiness is" (Ovchinnikova, 1976:3). The difficulty in verbalising this conception, which belongs to the sphere of the superconscious, is reflected in the saying: "Happiness is a state in which a person does not ask what happiness is".

If the primary, basic needs determine an individual's personality, then the individual strength and composition of the *additional* needs (need to overcome, need for preparedness, need to imitate, need for economy of effort) determine his character. The need to overcome underlies a person's qualities of will, and the extent to which the need for preparedness is satisfied determines the characteristics of confidence, decisiveness, and steadfastness in crisis situations. The proclivity to imitate determines the degree to which a person acts independently, and the need for economy of effort results in an energetic, goal-directed character, or conversely, a passive, lazy character with a tendency to idle time away.

Just as the needs of mankind as a whole are a product of world history, so the composition and correlation of each individual's needs are a product of his life history, the particular circumstances of his upbringing, and his ontogenetic development. Despite the importance of natural instincts and abilities, personality and character are formed under the decisive influence of a concrete social environment. Most directly connected with individual characteristics in the structure and functioning of the brain is *temperament*, or in I.P.Pavlov's terminology, the type of higher nervous activity.

In Pavlov's approach to the problem of individual differences it is possible to distinguish two levels of analysis. Pavlov himself worked on these two levels in unequal measure.

Thr first level, if it is possible to use the expression, is the *microlevel*, i.e., properties of the processes of excitation and inhibition of nerve cells: their strength, balance, and mobility. The results of experiments

with conditioned reflexes and the observation of dog behaviour over many years led Pavlov to the idea that types of nervous system, analogous to the "temperaments" of writers of antiquity, are common to man and higher mammals. In Pavlov's classification, the strong excitable unbalanced type corresponds to the choleric type, and the weak type corresponds to the melancholic type. Pavlov's strong balanced mobile type corresponds to the sanguine type, and the strong balanced inert type corresponds to the phlegmatic type. With typical sharpness of observation, Pavlov noticed the features of emotionality which were characteristic of each of the basic types. In Pavlov's view, the strong unbalanced type is inclined to anger, and the weak type is inclined to fear. Characteristic of the sanguine type is the predominance of positive emotions, while the phlegmatic type displays a total lack of violent reactions to his surroundings. Pavlov wrote: "The strongest manifestation of the excitable type is mostly found in animals with an aggressive character... The extremely inhibited type of animal is called cowardly" (Pavlov, 1973:321).

Although he based his classification on the properties of excitation and inhibition, Pavlov did not limit himself to this level. He well understood that the path from elementary neural processes to external behaviour is based on the interaction of *macrostructures*: different functionally specialised areas of the brain. Pavlov considered the extreme types (the strong unbalanced type and the weak type) to be the basic "carriers" of mental diseases, especially neuroses. He emphasised that hysteria is strongly characterised by emotionality, and that "emotionality is the predominance... of the functions of the subcortical centres associated with a weakening in cortical control... The hysterical subject lives a life which is to a greater or lesser extent emotional rather than rational, governed by his subcortical rather than cortical activity" (Pavlov, 1973:323,406). Considering "specifically human types of artists and intellectuals", with a predominance of either the first (concrete image) or second (verbal, abstract generalisation) signal system for the representation of reality, Pavlov saw that the classification was again based on functional characteristics of brain macrostructures. "In artists," wrote Pavlov, "the activity of the cerebral hemispheres, flowing throughout, begins to touch the frontal lobes less and concentrate mainly in the remaining regions; conversely, in intellectuals, activity concentrates in the frontal lobes" (Pavlov, 1973:411).

Today it is clear that we would prefer to consider the

Pavlovian "specifically human" types as a result of the functional asymmetry of the cerebral hemispheres, the "artistic type" corresponding to a relative predominance of the right (non-verbal) hemisphere. The discovery of the functional specialisation of the right and left hemispheres was a real triumph for Pavlov's idea that the "artistic" and "intellectual" types represent the poles between which a whole variety of intermediate forms of human higher nervous activity can be found.

Pavlov's typology as it applies to man has been subjected to the most systematic experimental and theoretical scrutiny in the works of B.M.Teplov and V.D.Nebylitsyn. We give here a very brief summary of the results of these investigations, concentrating on the following fundamental points.

Teplov and Nebylitsyn came to the well-founded conclusion that it is preferable to speak not of types, but rather of properties of the nervous system, the combination of which characterise a given individuality. It turned out that the number of these properties must be substantially increased, that it is necessary to consider the strength and mobility of nervous processes separately in relation to excitation and inhibition, and that the list of properties must be supplemented with a parameter of dynamism, on which the speed of development of new conditioned reflexes depends.

Teplov's school convincingly explained why the so-called weak type did not become extinct in the course of evolution, why it was not eliminated by natural selection. If the strong type displays a high degree of steadiness in critical situations, the heightened sensitivity of the weak type is no less a valuable quality under other circumstances, when the ability to distinguish quickly and accurately between external signals is required. Special experiments have shown that representatives of different types of nervous system can solve the same problem with equal success, each using their own tactics.

As research has advanced, it has become more and more clear that the experimental methods traditionally used for the identification of types reveal only *particular properties* of the nervous system. For example, methods based on visual processing might lead to the diagnosis of a strong type, whereas a test of auditory processing would characterise the same individual as a representative of the weak type. Similar contradictions were revealed in experiments on animals. For example, according to the data of V.N.Dumenko and V.I.Nosar' (1980), the ability to develop instrumental motor reflexes in dogs does not correlate with

the type of their nervous system as determined by secretory methods. Consequently, by the beginning of the sixties a genuine situation of crisis had been reached in the field of human typology (differential psychophysiology). In an attempt to find a way out of this crisis, V.D.Nebylitsyn introduced the idea of *general properties* of the nervous system. Included in these were two basic parameters: activity and emotionality (Nebylitsyn, 1968). V.D.Nebylitsyn believed that activity is based on individual characteristics of the interaction between the activating reticular formation of the brain stem and the frontal regions of the neocortex, whereas emotionality is determined by individual characteristics of the interaction between the frontal regions of the neocortex and the structures of the limbic system. Unfortunately, the tragic death of V.D.Nebylitsyn interrupted the course of his creative research on the threshold of a radically new era in the development of differential psychophysiology.

Similar conclusions about the morphophysiological bases of human typology were reached by a group of English investigators which we link primarily with the names of H.Eysenck (1981) and J.Gray (1972).

With the aid of specially developed tests, H.Eysenck (Eysenck and Eysenck, 1976; Eysenck, 1981) distinguished three basic parameters: (1) extraversion-introversion; (2) emotional stability and its opposite, neuroticism; (3) psychoticism, the opposite pole of which is the stable observance of social norms. Eysenck characterises the extravert as an open, sociable, talkative and active individual, and the introvert as someone who is unsociable and reserved. These characteristics remind one of the activity parameter in V.D.Nebylitsyn's (1968) classification. A highly neurotic individual is characterised as one who is anxious, preoccupied, easily disposed to anger, and emotionally unstable. His opposite is the emotionally stable personality. It is not difficult to see that neuroticism is very close to Nebylitsyn's "emotionality". Finally, Eysenck's maximally psychotic type is egocentric, cold, indifferent to others, and aggressive, while the minimally psychotic type is friendly, sympathetic, respectful of others' rights, and altruistic.

Eysenck's typology can be considered as yet another example of the existence of links between the neurodynamic and content characteristics of personality, although these links are far from being clear and obvious. Extraversion-introversion is a formal-dynamic parameter. At the same time, each type shows a definite preference for the satisfaction of particular needs, and this is especially

marked in individuals prone to neuroticism. For example, extraverts place a high value on a busy, active life. Introverts value freedom and self-respect, while neurotics value internal harmony and are less concerned with external success (Furnham, 1984).

In Eysenck's opinion, what underlies extraversion-introversion is the existence of individual differences in the interaction between the activating reticular formation and the frontal regions of the neocortex. To these two structures, J.Gray (1972) added the hippocampus and the medial part of the septum. In the introvert, the septo-hippocampal system is more developed, inhibiting behaviour; in the extravert, the excitatory system formed by the lateral hypothalamus and the medial fascicle of the forebrain is more developed. The degree of neuroticism is determined, according to Eysenck, by individual characteristics of the interaction between limbic and neocortical structures. In Eysenck's view, there is a correspondence between the emotionally unstable extravert and the choleric temperament of the ancient writers. Likewise, a correspondence exists between the stable extravert and the sanguine temperament, the unstable introvert and the melancholic temperament, and the stable introvert and the phlegmatic temperament.

Although the degree of extraversion-introversion is mainly determined with the aid of questionnaires, this typological parameter is associated with some experimental results. If individuals are placed in a room in which they can freely control the strength of the lighting and switch on an auditory stimulus, the introverts prefer to spend most of their time in quiet and dark surroundings, while extraverts prefer the opposite (Eysenck, 1975). In distinction to extraverts, introverts are better at reproducing material which they have been asked to remember some time after it has been shown to them. According to J.Gray, extraverts are more sensitive to rewards, and introverts to punishments (Wilson, 1978). In introverts, a stronger GSR to an emotionally significant question has been observed (Gudjonsson, 1982). The frequency and amplitude of the alpha rhythm in an EEG are higher in extraverts than in introverts, while the level of neuroticism shows no such correlation (Deakin and Exley, 1979; Gilliland, Andress, and Bracy, 1981). Recordings of auditory evoked potentials led Andress and Church (1981) to the conclusion that the difference between extraverts and introverts is manifested both at cortical and at subcortical levels. In an investigation of the individual characteristics of a number of EEG parameters, D.Robinson (1982) proposed that what

underlies the Pavlovian "strength of the nervous system" parameter and Eysenckian extraversion-introversion is the interaction of the neuron populations of the diffuse thalamocortical system. In the course of investigating patients with lesions of the mediobasal structures of the temporal lobe, S.V.Madorsky (1982) discovered that right-side lesions are accompanied by a shift towards introversion, and left-side lesions are accompanied by a shift towards extraversion, inasmuch as patients with right-sided pathology are more sensitive to pain stimuli, especially if the pathology involves the amygdala. A comparison between the characteristics of evoked potentials to light stimuli, the characteristics of cardiovascular reactions, and levels of neuroticism, led to the conclusion that these characteristics can be explained by the interaction of the frontal regions of the neocortex, the hippocampus, the amygdala and the hypothalamus (Polyantsev, Rumyantseva, and Kulikov, 1985).

In recent years there have been attempts to find analogues of extraversion-introversion, neuroticism and psychoticism in animals, mainly rats. The experimental method most often used in this case has been the open-field method, in which exploratory activity is an index of extraversion, and so-called "emotionality" (the number of urinations and defecations) is an index of neuroticism. The degree of aggression is seen as an analogue of psychoticism (Garcia-Sevilla, 1984). M.Zuckerman (1984) suggests that what underlies individual characteristics of behaviour is the level of catecholamines. It has been shown that activity in the open field correlates positively with the speed of development of a defensive conditioned reflex in a shuttle box, while passive rats are better at preserving the memory of a painful stimulus which has been applied only once (Chaichenko, 1982).

Behaviour in the open field is connected with the functioning of the neocortex and the hippocampus. This is demonstrated by experiments in breeding lines of mice which have different volumes for different brain structures. A small volume for the hippocampus and a large volume for the neocortex correlates positively with motor activity in the open field. Less mobile mice with a large hippocampus are quicker at learning passive avoidance (Shiryaeva and Vaido, 1980; Wimer, Wimer, and Roderick, 1971). On the other hand, the consequences of destruction of limbic brain structures depend on the genetic characteristics of the animal (Isaacson and McClearn, 1978; Isaacson, 1980).

The functional specialisation of the frontal regions of the neocortex, hippocampus, amygdala and hypothalamus, which

we discussed in detail in the preceding chapter, has given us grounds to suppose that the individual characteristics of the activity of each one of these structures, and especially the characteristics of their interaction, largely determine the individual (typological) characteristics of animal behaviour which are comparable with the Eysenckian classification.

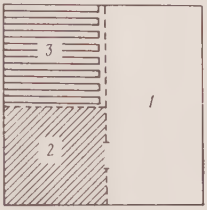

Fig.21. Diagram of a chamber for studying avoidance reactions to a partner's cries of pain.

Explanations in the text.

A set of experiments was carried out on 40 mongrel adult male white rats kept in a vivarium, with 10 animals to each quite sizable cage. The experimental chamber (fig. 21) was a wooden box, 33x41x34 cm. The box contained: (1) a relatively spacious compartment, 33x23 cm; (2) a plexiglass "little house", 16x14 cm, with a constantly open door and a floor which acted as a pedal: pressure on this floor would automatically start a timer; (3) next to the "little house", behind a transparent, sound-conducting screen, a compartment for a partner rat with a metal grid floor. The whole chamber was illuminated with diffuse light from a 100 watt bulb hanging from the ceiling of the room.

Every day, the animal under investigation was placed in the large compartment of the chamber for 5 minutes and a record was kept of the time it spent in the "litle house" on the pedal, and the number of occasions it entered the "little house". For the first five days of the experiment, each entry into the "little house" resulted in the switching on of a supplementary 100 watt light situated 45 cm above the floor of the chamber, and the emission of a sound stimulus (a 220 Hz, 80 db tone). For the next five days, each entry into the "little house" was linked to electical stimulation of the paws of a "victim" rat at 1-2 mA. The stimulation of the "victim" lasted for 3-5 seconds at 5 second intervals for as long as the rat under investigation remained on the pedal. During the final five days of the experiment, entry into the "little house" would again result in increased illumination and the emission of the tone.

The amount of time spent on the pedal, completing the electrical circuit, was considered to be an indication of the sensitivity of each rat to the cries of pain of another

member of the same species (psychoticism in Eysenck's terminology). Extraversion and introversion was judged on the basis of the comparative effectiveness of the two aversive stimuli: increased illumination and the sounding of the tone, or the defensive arousal signals of the partner rat (cries, movements, secretion of specific odorous substances). An indication of the level of emotional stability (neuroticism) was provided by the average amount of time spent in the "little house" during the operation of either the artificial or the zoosocial aversive stimuli, as well as by the number of times the rat ran from the open compartment into the "little house" and back.

The following criteria were used. A rat was considered to be sensitive to a cry of pain if it remained on the pedal for less than 1 minute. Extraversion was diagnosed if the amount of time spent on the pedal during the operation of sound and light stimuli exceeded by at least 1 minute the amount of time spent on the pedal during the painful stimulation of another rat. The opposite relation between the two types of stimuli was evaluated as introversion. The remaining rats were considered to be ambiverts. We considered a rat to be emotionally stable (minimally neurotic) if the average amount of time spent on the pedal during the operation of aversive stimuli exceeded 1 minute 30 seconds.

Examples of rats with the characteristics listed above are given in table 1. It is clear that the allocation of rats to particular types must be highly provisional: the individual behavioural characteristics of each rat have been determined in relation to absolute values of the chosen parameters, rather than in relation to conditional boundaries between extraverts, introverts and ambiverts. Such boundaries are only necessary for statistical calculations aimed at characterising a population, or determining comparative resistance to neuroticising influences. This will be discussed below. The correlation of different behavioural types in the population of 40 rats investigated in our experiment is presented in table 2.

It is difficult to say how much these individual behavioural characteristics depend on genetic or environmental factors, although there is evidence that the frequency of lever-pressing reinforced by the switching on of a light and the turning down of a noise is 71% genetically determined in laboratory rats (Oakeshott and Glow, 1980).

In an investigation carried out jointly with M.L.Pigareva, V.N.Mats, and T.I.Mikheeva (Simonov, 1981), we discovered that the parameters listed above depend on

Table 1
Typical examples of individual behavioural characteristics of rats

Number of rat	Average amount of time on the pedal (mins)			Difference in average time with light and sound or cry (mins)	Average number of entries on to the pedal	Characterisation of the rat
	during operation of light and sound	during cry of another rat	general average time			
293	4.18	1.44	2.81	2.74	1.4	Low-sensitivity, emotionally stable extravert
291	4.49	0.68	2.59	3.81	1.6	High-sensitivity, emotionally stable extravert
288	1.69	0.52	1.10	1.17	1.9	Low-sensitivity, emotionally labile extravert
349	1.36	2.64	2.00	-1.28	6.8	Low-sensitivity, emotionally stable introvert
294	0.56	1.92	1.24	-1.36	6.2	Low-sensitivity, emotionally labile introvert
345	0.62	1.88	1.25	-1.26	3.4	Low-sensitivity, emotionally labile introvert
287	0.84	0.81	0.82	0.03	3.6	High-sensitivity, emotionally labile ambivert
290	0.31	0.68	0.49	-0.37	1.8	High-sensitivity, emotionally labile ambivert
337	0.98	1.33	1.15	-0.35	3.8	Low-sensitivity, emotionally labile ambivert
310	2.60	1.95	2.27	0.65	3.2	Low-sensitivity, emotionally stable ambivert
338	4.39	4.57	4.48	-0.8	1.3	Low-sensitivity, emotionally stable ambivert

Table 2
Correlation of different behavioural types in a population of 40 adult male rats

Group of rat	Number of rats in group	Emotionality (neuroticism)			Sensitivity to a cry of pain (psychoticism)	
		stable	unstable	average number of runs (anxiety)	high	low
Extraverts	12	9	3	1.6	10	2
Introverts	9	2	7	5.4	-	9
Ambiverts	19	11	8	2.7	9	10

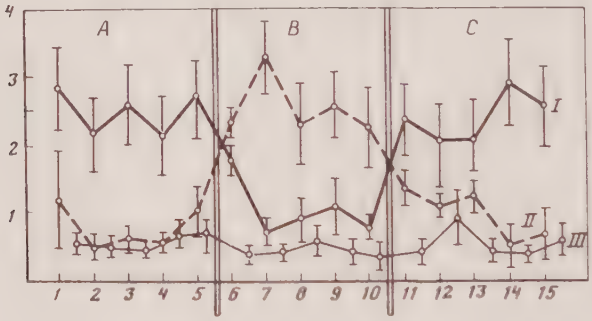

Fig.22. Average time spent on the pedal during the operation of light and sound (*A*,*B*) or a partner's cry (*C*) in intact rats (*I*), after a lesion of the frontal cortex and hippocampus (*II*), and after a lesion of the frontal cortex and the hypothalamus (*III*).

Abscissa - days of the experiments; ordinate - time in minutes.

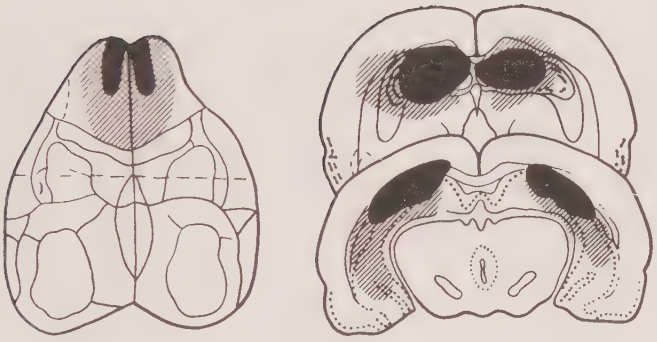

Fig.23. Reconstructive schema of a lesion of the frontal regions of the neocortex and the hippocampus in rats. Designations are the same as in fig. 19 (according to M.L.Pigareva and V.N.Mats).

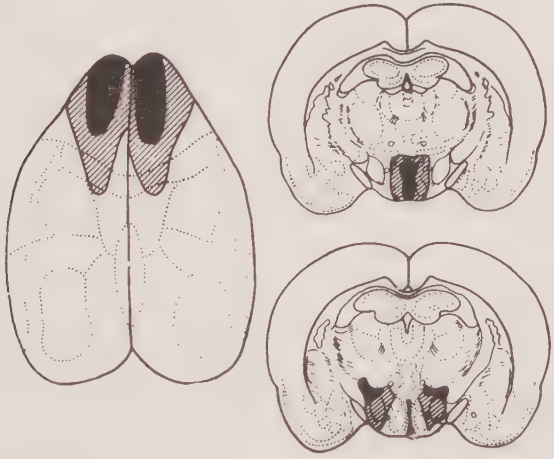

Fig.24. Reconstructive schema of a lesion of the frontal regions of the neocortex and the lateral and ventromedial hypothalamus in rats. Designations are the same as in figs. 19 and 23 (according to M.L.Pigareva and V.N.Mats).

whether a range of limbic structures are intact or damaged. In fig. 22, graph *I* shows the average time spent on the pedal by seven intact rats for whom the defensive arousal signals of their partners (cries, movements, secretion of specific odorous substances) were a more effective stimulus than the increase in illumination and the sounding of a noise. After bilateral coagulation of the frontal regions of the neocortex and the hippocampus (fig. 23), these rats displayed precisely the opposite reactions: the time spent on the pedal when sound and light stimuli were in operation decreased, and increased with the cries of the "victim" (see graph *II* in fig. 22). Five rats with bilateral lesions of the frontal cortex, and lateral and ventromedial hypothalamus (fig. 24) turned out to be equally sensitive to the combination of a sound with increased illumination, and to their partner's signals of defensive arousal (see graph *III* in fig. 22). These animals were distinguished by timidity, heightened aggressiveness, and a violent reaction to being touched, and showed signs of decreased aversion to the open space. They would enter the "little house" slowly and infrequently, and when the light and sound were switched on, or their partners cried, they would leave the "little house" in 10-20 secs. If a rat was distracted (for example, by starting to clean its coat), the light, the sound, and the partner's cry would lose their effectiveness.

Thus, simultaneous lesions of the structures of the "informational" system (frontal neocortex and hippocampus) make rats highly sensitive to previously ineffective artificial stimuli (light and sound), and at the same time lower their reactivity to zoosocial signals concerning the state of another individual of the same species. On the other hand, lesions of the frontal cortex, and lateral and and ventromedial hypothalamus are accompanied by a heightened "neurotic" reaction to any external stimulus, together with an inability to react selectively to signals of different biological significance.

Taking into account the totality of facts available at the present time, we are inclined towards the hypothesis that the extraversion-introversion parameter is based on individual characteristics of the relationship between the "informational" system (frontal cortex and hippocampus) and the "motivational" system (amygdala and hypothalamus) (fig. 25). A second parameter describing individual behavioural characteristics, one which is featurally close to the neuroticism-emotional stability parameter, is determined by the relationship between the two systems: "frontal cortex-hypothalamus" and "amygdala-hippocampus". From this point of view, the Pavlovian scale of strong and weak nervous systems

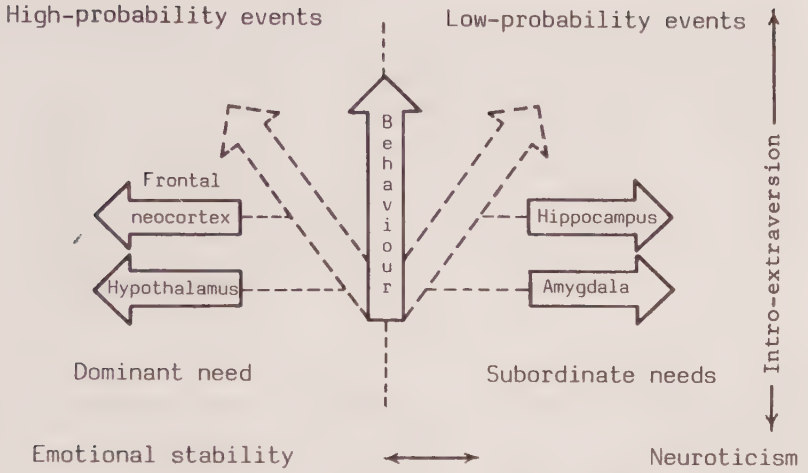

Fig.25. Hypothetical schema of the dependence of the extraversion-introversion and emotional stability (neuroticism) parameters on individual characteristics of the interaction between brain structures.

corresponds more closely to the neuroticism scale than to the extraversion-introversion scale, as was supposed by Eysenck (Eysenck and Levey, 1972).

At the present time there are no complete data on the extent to which the parameters under investigation correlate with the resistance of rats to neuroticising influences. In M.G.Airapetyants's laboratory, only one parameter was used: sensitivity to the pain cries of another individual of the same species (Khonicheva and Vil'yar, 1981). Fig. 26 illustrates three groups of rat which differ in respect of this feature. The stressful influence was the development of a defensive conditioned reflex with a low probability of avoidance of painful stimuli. This influence had radically different effects on the instrumental alimentary conditioned reflexes: the extent to which these were impaired provided a basis for judging the degree of neuroticism. The most stress-resistant rats turned out to be those with a high sensitivity to the pain cries of their partners and a low level of anxiety (a low number of runs from one compartment into another). The least resistant rats were those in which average sensitivity to zoosocial signals was combined with high anxiety and an inability to distinguish which motivation was dominant: aversion to open space or the

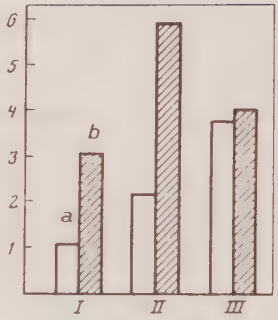

Fig.26. Average time spent on the pedal (*a*) and the number of moves off the pedal and onto the pedal (*b*) in three groups of rat (*I - III*).

Ordinate - minutes.

motivation to prevent the painful stimulation of another individual.

It was shown above that a high sensitivity to the defensive arousal signals of a partner shows a positive correlation with a low number of runs from one compartment of the chamber into another, with a high level of motor activity in the open-field test, with low "emotionality" (as judged by the number of urinations and defecations in the open field), and with a low degree of aggressiveness when two rats are subjected to painful stimuli (Simonov, 1976). These results provide the basis for supposing that the parameters in Eysenck's typology, suitably modified for the evaluation of the individual behavioural characteristics of rats, are useful in predicting the resistance or lack of resistance of these animals to neuroticising influences. The role of individual behavioural differences in the pathogenesis of experimental neuroses is thereby clarified.

Further investigations are also needed to shed light on the question of the genetic basis of the behaviour types described above. Genetic components of stress-resistance cannot now be doubted (Belyaev, 1979; Sudakov, Dushkin, and Yumatov, 1981).

Finally, it is quite clear that between a motivational conflict, unbearable for a certain type of nervous system, and impairment of the interaction of the limbic structures, leading to neurotic disorders of higher nervous activity, there are a number of intervening neurophysiological and neurochemical links which can transform a psychogenic influence into a constant pathological state of the brain. The search for these links is now the most important and least developed field in experimental neurology. One of these intervening links seems to be hypoxia of the brain, as discovered in experimental neurosis in M.G.Airapetyants's laboratory (Airapetyants and Vein, 1982). According to the

data of M.G.Airapetyants et al., neuroticising influences lead to a decrease in local blood flow in the brain and to the micromorphological shifts characteristic of the hypoxic state. Under these conditions, compensatory activation of the system of lipid peroxidation is observed, impairing the structure and functions of biological membranes. Administration of antioxidants removes transitory hypertension and cardiac hypertrophy, and prevents an increase in the activity of cytochromoxidases in the neocortex and hippocampus of neuroticised rats (data from N.V.Gulyaeva).

Thus, we can outline the following sequence of events. Chronic emotional tension, generated by a motivational conflict, leads to a decrease in local blood flow in the brain. This causes a state of hypoxia which in turn impairs the functioning of limbic structures. The nature of the impairment depends decisively on the individual characteristics of the interaction of these structures. These individual characteristics are conditioned by innate factors and by the period of early ontogenesis. Individual characteristics also determine the direction in which the symptoms of neurotic derangement will develop.

It must be emphasised that an interest in the individual characteristics of brain structure interaction at the macrolevel does not remove the necessity for analysing the neurophysiological bases of individual differences at the microlevel of excitatory and inhibitory processes within nerve cells. An example of this approach is L.A. Preobrazhenskaya's (1981) investigation of the electrical activity of the hippocampus during the development of conditioned reflex switching in dogs. In four dogs, an instrumental food reflex was first developed. This involved pressing a pedal with the right front paw in response to an auditory conditioned signal (a tone). Next, the same conditioned signal, presented against the background operation of a switching signal (the sound and flash of fan blades), began to be reinforced with the painful stimulation of a hind paw by an electric current. The dog could interrupt or totally prevent this stimulation by raising its left front paw to a particular level.

Under Nembutal anaesthesia, metal electrodes were implanted in the dorsal part of the hippocampus according to the coordinates of the Lim atlas. The electrical activity of the hippocampus was considered to be rhythmic if regular oscillations continued for no less than 1 sec. Using the electrohippocampogram trace, a count was made of the number of regular oscillations in a consecutive sequence of one-second intervals, and this number was checked against the

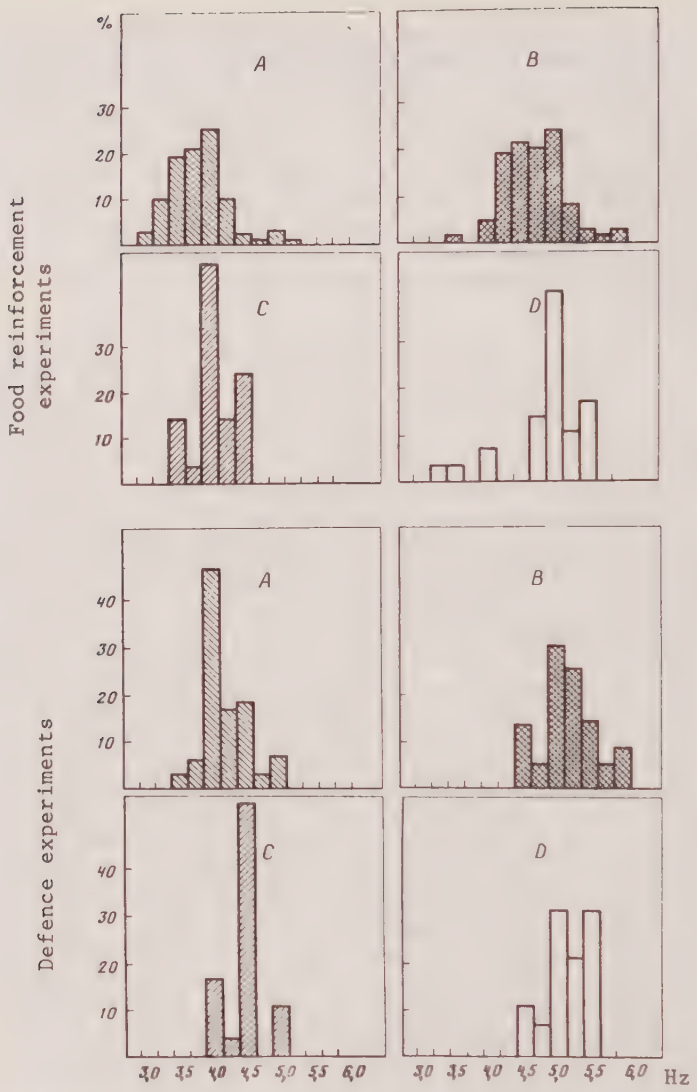

Fig.27. Histograms showing the distribution of frequencies of hippocampal electrical activity in four dogs placed in alimentary and defensive situations during experiments on conditioned reflex switching.

Abscissa - oscillation frequency (secs.); ordinate - percentage of the total number of measurements (according to L.A.Preobrazhenskaya).

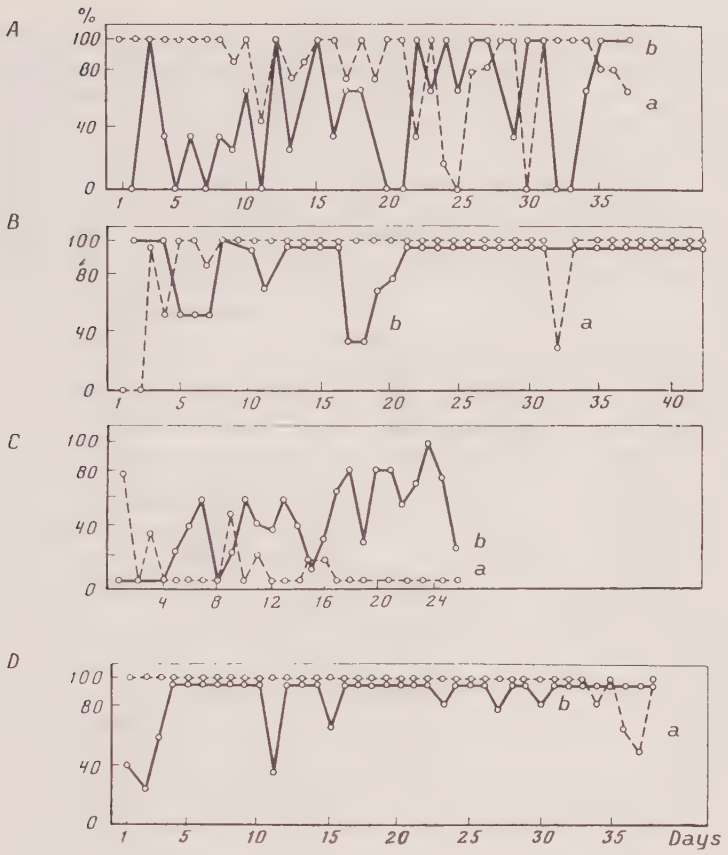

Fig.28. Dynamics of the development of switching between alimentary (*a*) and defensive (*b*) conditioned reflexes in four dogs (*A*, *B*, *C*, *D*).

Abscissa - days of the experiments; ordinate - percentage of conditioned reactions in relation to the number of presentations of the conditioned signal (according to L.A. Preobrazhenskaya).

oscillation frequency selected by an analyser. In each situation (defensive or alimentary), at least 30 measurements were taken, and a calculation was made of the average value of the oscillation frequencies and its error.

Fig. 27 contains histograms of the distribution of each frequency of rhythmic activity in the hippocampus of four

dogs placed in alimentary and defensive situations during experiments on the switching of conditioned reflexes. It can be seen that the transfer from an alimentary to a defensive situation is accompanied by an increase in the frequency of the hippocampal theta rhythm in all four dogs: the histograms are skewed to the right. At the same time, each animal is characterised by its own band of alterations to the frequency spectrum of regular activity, and this band correlates with the dynamics of the development of conditioned reflex switching (fig. 28). In dogs with a higher-frequency theta rhythm, the development of switching occurred relatively quickly and easily: after 5-6 tests, the dogs began to react to the conditioned signal in a way which corresponded to the actual situation (*B* and *D* in fig. 28). A different picture is presented by dogs whose conditioned reflex activity has an unstable, undulating character with a tendency towards neuroticisation (*A* and *C* in fig. 28). Analagous results were also achieved in experiments on a different group of four dogs. The animals with a relatively slow hippocampal theta rhythm were characterised by low sociability and an indifferent attitude towards the experimenter. They also experienced difficulties in performing other tasks connected with a change in the type of activity.

These results are in agreement with observations in the literature concerning the correlation between the dominant frequency of the theta rhythm and the level of investigative activity characteristic of individual rats (Irmis, Radil-Weiss, Lat, and Krekule, 1970). In the same animal, these two features are relatively stable. Thus, it is possible to say that the band of alterations in the frequency of the hippocampal theta rhythm which are typical of a given animal reflect the parameter which Pavlov called the inertness (or conversely, mobility) of the nervous system. If we take into account contemporary ideas of the role played by the mechanisms of inhibitory feedback in generating the rhythmic oscillations of biopotentials (Andersen and Eccles, 1962), Pavlov's hypothesis concerning the mobility of the nervous processes of stimulation and inhibition is given concrete neurophysiological content. On the other hand, the influence of the hypothalamus on the electrical activity of the hippocampus gives grounds for thinking that the mobility factor in the Pavlovian sense depends significantly on the activity of the macrostructural "hypothalamus-hippocampus" system and its relationship to the "amygdala-frontal neocortex" system. It has been established that the theta rhythm which accompanies human professional activity shows individual variation in

frequency stability, amplitude stability, and prominence amongst the other EEG rhythms (Cheliout, Sgouropoulus, and Hazemann, 1979). Constancy of intensity of the basic EEG rhythms is observed in individuals with high indices for the mobility of nervous processes (Shevko, 1980).

In summary, our hypothesis amounts to the claim that the types distinguished by I.P.Pavlov are based on individual characteristics of the interaction between the frontal regions of the neocortex, the hippocampus, amygdala and hypothalamus.

What are the features which characterise the behaviour of an individual with a relative functional predominance of the "frontal cortex-hypothalamus" system? This is an individual with a distinctly marked predominance of one particular need, and his attention will be purposefully focussed on the signals of those objects which are capable of satisfying it. At the same time, he has a tendency to ignore any competing needs or signals which distract from his progress towards the intended goal. Let us now compare this hypothetical characterisation with the description of a real boy, Sasha P., adduced by V.S.Merlin and B.A.Vyatkin (1976) as an example of the choleric temperament (Pavlov's strong excitable type). Sasha's interests are constant and stable, he is not flummoxed when faced with difficulties, and he is resolute in overcoming them. At school, he concentrates on his work and is not distracted.

According to the results presented above, the functional predominance of the "amygdala-hippocampus" system will be attended by a difficulty in distinguishing a dominant motivation and a readiness to react to a very wide range of objectively insignificant stimuli. This gives rise to a mixture of indecisiveness, continual vacillation accompanied by heightened sensitivity, and a tendency to overestimate the importance of external events. Is this not a description of Kolya M., a typical melancholic in V.S.Merlin and B.A.Vyatkin's opinion, or a weak type in I.P.Pavlov's terminology? Kolya is painfully sensitive to details; he is easily flummoxed, confused, and has no confidence in himself.

The predominance of the "hypothalamus-hippocampus" system ought to result in the clear discrimination of dominant motivations, somewhat paradoxically combined with generalised reactions to signals of low-probability events, to signals whose significance is unclarified. This is reminiscent of the description of the typical sanguine (strong, balanced, mobile) type, Seryozha T., who is persistent, energetic and industrious, but only in the lessons which interest him (the dominant motivation! -

P.S.). In the lessons which do not interest him, Seryozha is easily distracted and his attention turns to extraneous things. He is quick to adapt to new circumstances, but is difficult to discipline.

If within the four-structure system there is a predominance of the "amygdala-frontal cortex" subsystem, we obtain an individual with well-balanced needs, and with no single need especially accentuated. Such an individual ignores the majority of events which occur around him. He can only be stimulated into activity by highly significant signals. Does this not remind us of Aida N., described by Merlin and Vyatkin as an example of the phlegmatic (strong, balanced, inert) type? Aida is patient, restrained, and in good control of herself. In class, she is quiet and cannot be distracted. However, there is a reverse side to this inertness: the girl has difficulty in switching to the solution of new problems and takes a long time to adapt to new circumstances.

We have now considered four of the possible structural "pairs", and have discovered that the functional predominance of each corresponds to the psychological characteristics of one of Pavlov's types. There remain two further possibilities: "frontal cortex-hippocampus" and "hypothalamus-amygdala".

The predominance of the first of these, the "informational" pair, will result in a hypothetical individual who is primarily oriented towards the external environment and behaviourally dependent on the events which take place there. It seems that he can be called an extravert, since he possesses the characteristic qualities of extraverts such as sociability, an urge to meet new people, a liking for change and movement, and a desire to conquer the environment (Smirnov and Panasyuk, 1977). Very different features are found in individuals with a predominance of the "motivational" system. In this case, the sphere of internal motivations and goals will turn out to be rather rigid in relation to external influences. And indeed, according to V.M.Smirnov and A.Yu.Panasyuk's description, introverts tend to hold to previously acquired ethical norms, they like order, and they are self-restrained, shy, and unsociable.

It is not difficult to see that the "four structure" concept permits the integration of Pavlov's classification with the extraversion-introversion parameter. If this is accepted, there is no necessity either to identify extraversion with the parameter "strength of the nervous system", or to view extraversion and introversion as something completely isolated from Pavlov's typology. The

"four structure" idea necessitates the postulation of extraverts and introverts just as it necessitates the postulation of the temperaments of the writers of antiquity or of Pavlov's types of nervous system.

Of course, all the types described above are an abstraction. Real life provides us with an infinite variety of intermediate forms for the interaction of the four brain structures. Here we are in full agreement with B.M.Teplov and V.D.Nebylitsyn, who suggested that we speak not of types, but rather of the properties which characterise each individual. The tendency already noted by I.P.Pavlov for different types to react primarily with a single basic emotion needs to be explained, and we shall try to do this from the point of view of the theory of emotions developed above, and the classification which is based on it (see ch. 3).

Since the choleric (strong impetuous) type is moved by a constantly dominant need, his actions generally contain components of overcoming and struggling, and these are characterised by the emotions of anger, fury, and aggressiveness. By contrast, the melancholic (weak) type always gravitates towards defence and protection, which are frequently coloured by the emotions of fear, uncertainty, and confusion. The sanguine (strong mobile) type, who combines a strong motivational dominant with curiosity, questfulness, and openness to the environment, experiences positive emotions more frequently than the rest. As far as the phlegmatic is concerned, despite his emotional indifference he nevertheless gravitates towards positive emotions. Yet again we must emphasise, however, that these are just tendencies or preferred dispositions. The representatives of each type are equipped with the entire arsenal of human emotions.

We believe that the parameters developed by I.P.Pavlov for the characterisation of nervous processes, i.e., strength, balance and mobility, can be applied to each individual set of needs and the dynamic hierarchy which they form. Life shows that strength (urgency, exigency) of particular needs varies from individual to individual within very wide bounds. The balance parameter is determined by the manifest dominance of one of these needs, or by their relative equilibrium. On the other hand, the degree of balance is evidence of the presence of conflict and competition between needs, or their harmonious coexistence. Finally, mobility is characterised not only by the speed and rapidity with which motivational dominants are altered, but also by the range of transformations which take place from primary to secondary motivations, and the plasticity of the

hierarchy of needs present in each individual.

If, as is no doubt true, the individual characteristics of the functioning of the four brain structures have an inborn component, the question of a genetic element in the formation of a hierarchy of needs remains open. It must be said that the different socialisability of extraverts and introverts gives ground for the belief that the interaction of the four structures definitely correlates with each individual set of needs. An individual with a choleric temperament is more likely to assume the functions of leadership than a melancholic, the weak type of nervous system in Pavlov's classification. Nevertheless, the decisive role in the formation of a structure of needs belongs to upbringing in the microsocial and macrosocial environment. Even in animals, leadership characteristics are determined not by innate dispositions, but by relationships formed in a zoosocial group (see ch. 1). Research by ethologists has shown that a dominant individual is mainly created by manifestations of submission on the part of the subordinate members of the group. In truth, "the king is played by his retinue".

What has been said about the role of upbringing applies especially to the content side of needs, to the objects which satisfy them. The dominance of social needs in the structure of a given personality does not tell us whether we are dealing with a revolutionary who yearns for the equitable reconstruction of the world, or a political maniac who is obsessed with the idea of world domination. Equally, the dominance of ideal needs does not exclude the well-meant propagation of false ideas. Here man emerges as a child of his times and of his class, as an "aggregate of social relationships", and we enter the sphere of competence of sciences other than the science of higher nervous activity and psychology. Nevertheless, each epoch has presented the world with giants and dwarfs, heroes and cowards, cavaliers and scoundrels. Merely belonging to a particular epoch will not explain this higher court of history.

Finally, the results of experiments on animals with sequential or simultaneous lesions of various brain structures suggest the idea that individual differences in the interaction of the four structures might, in the event of their pathological impairment, determine the basic varieties of human neurosis as described by clinicians.

According to the data of the World Health Organisation, the number of neurotic disorders has increased several times over the last half-century. The cause of this sharp rise has sometimes been attributed to the life-styles typical of the populations of industrially developed countries, to the

negative consequences of the scientific and technical revolution. Factors such as the need to process large amounts of information in a strictly limited amount of time in order to make responsible decisions, the quicker pace of life, the biological disturbance of circadian rhythms by the shift system in industry and long-distance flights, added to inadequate physical activity on the part of brain-workers, bureaucrats, and managers, have an aetiological significance which has led to the idea of "informational neuroses" and even "informational pathology" in human higher nervous activity (Khananashvili, 1978; 1983).

While recognising the important role of such factors in the genesis of chronic emotional tension (in full conformity with the information theory of emotions), we nevertheless find it difficult to accept the hypothesis that the number of neuroses has increased as a direct consequence of scientific and technical progress. "The intensification of the industrial process," writes B.D.Karvasarsky, "like the intensification of life itself, is not inherently pathogenic. For this precise reason, millions of people who find themselves at the centre of the scientific and technical revolution do not suffer from neuroses. The people who suffer are rather those who are on the sidelines of social and industrial life... the prevalence of neuroses is lower in those who actually are engaged in work than in dependents and pensioners" (Karvasarsky, 1982). According to the data of G.K.Ushakov (1978), neurasthenia as a result of overwork is an exceptionally rare illness.

What is the cause of neurotic illness in man? A perspicacious answer to this question was once formulated by I.P.Pavlov. L.A.Orbeli reports that Pavlov "sought a cause for the occurrence of neuroses... in the extreme tension of physiological reactions brought about not by the operation of any physical factors, but rather by the effect of the social conflicts experienced by the particular individual. These social conflicts, e.g., work, family, and class conflicts, were considered by Ivan Petrovich to be far more important in human psychic activity than mere physical phenomena" (Orbeli, 1964:349). In an analysis of the causes of neuroses, F.Bassin, V.Rozhnov and M.Rozhnova justifiably give priority to the effect of interpersonal conflicts: family conflicts, age conflicts, household conflicts, work conflicts, etc. Unfulfilled destinies, dramatic clashes in human relationships, chronic emotional tension of a disorganised everyday life, sometimes going on for years, these are the typical situations encountered by physicians in conversations with neurotic patients. According to the statistics of the Bekhterev Psychoneurological Institute in

Leningrad, the factors which are most psychotraumatic are conflicts of a family or household character, and interpersonal conflicts at work (Karvasarsky, 1982). Contrary to the opinion of Sigmund Freud, who attributed the cause of neuroses almost exclusively to disharmony in sexual relationships, it must be emphasised that the dominance of sexual conflicts was observed in only 15% of patients aged 19 to 50. The clinical picture of neuroses almost never includes negative emotions brought about by a failure to satisfy purely biological needs. The emotional conflict of a neurotic is generally social in nature. What is more, each variety of neurosis is characterised by its own psychotraumatic situation (Voskresensky, 1980).

At the present time, the most well-founded and generally accepted definition of neurosis appears to be the following: neuroses are psychogenic illnesses, an essential role in the development of which is played by a clash between the most important, emotionally loaded attitudes of a person and a life situation which is intolerable to that person. Disturbances of personal attitudes are formed on the basis of individual properties of the nervous system, under the influence of an unfavourable social environment, especially an inadequate upbringing in the family (Zachepitsky, 1983). This definition, which originates in the ideas of V.N.Myasishchev, is accepted by B.D.Karvasarsky, M.M.Kabanov, V.V.Kovalev, A.E.Lichko, N.I.Felinskaya, and many others.

In this definition, we would like to give some real content to the meaning of the nebulous term "attitude". According to V.N.Myasishchev, "a psychic attitude is an expression of the active choice which determines the individual characteristics of a person's activity and his separate acts" (Myasishchev, 1960). As we have shown above, the system of attitudes which characterise a particular personality is based on the structure of the individual's vital, social, and ideal needs, and the dynamic hierarchy which they form. In this hierarchy, a special position is given to situational dominants as well as to motivations which are continually dominant over long periods of the individual's life.

Let us remember that the competition of simultaneously occurring (and frequently incompatible) needs takes place after they have been transformed into the corresponding emotions, i.e., the probability (possibility) of their satisfaction in the particular concrete situation is taken into account. The evaluation of the probability of satisfaction, in its turn, can take place either at the conscious or the unconscious level of higher nervous

activity. "The developmental history of a neurosis," writes A.M.Vein, "is a history of the formation of needs and the possibilities of satisfying them..." Neurosis is "an illness of unsatisfied or unsatisfiable needs" (Vein, 1974:105).

Two factors seem to us to be decisive in the origin of a neurosis: a situation of difficult choice which is subjectively dependent on the individual, and typological characteristics of the nervous system which favour a neurotic reaction. A neurosis will not occur if the individual's choice is predetermined by the manifest dominance of a particular need. In the case of a neurosis, the behaviour vector falls between competing motivations, or competing methods of satisfying one and the same need. The situation requires the individual to choose, and this choice turns out to be too much for him. In experiments on animals, we have shown that the degree of emotional tension is directly proportional to the sum of the magnitudes of the competing motivations and inversely proportional to the difference between them. This tension is relatively low when one of the strong motivations clearly predominates, but can reach a high value when competing motivations of moderate strength turn out to be roughly equal (Simonov, 1976).

How a psychotraumatic situation finally affects a person is determined by his individual (typological) characteristics. "It must be supposed," writes G.K.Ushakov, "that neither neuroses nor psychoses can arise without a pre-occurring constitutional or acquired deficiency in the corresponding functional systems of the brain" (Ushakov, 1978:323). The importance of functional disorders of the limbic system in neuroses is also mentioned in the works of A.M.Vein (1974).

In neurasthenia, a weakening of volitional impulses is combined with acute sensitivity and irritability. Any unexpected event: a knock at the door, a telephone ringing, a telegram, can provoke a state of anxiety, tachycardia, perspiration, and muscle tremor.

Do these symptoms not indicate a familiar weakening of the motivational structures (especially the hypothalamus) together with a functional strengthening of the hippocampus, which supports reactions to signals of objectively low-probability events?

By contrast, hysteria is characterised by an overvalued idea which occupies a commanding position in the individual's life. The hysteric imposes his own interpretation of external events on the environment. Here again one suspects a pathological strengthening of the functions of the hypothalamus, but this time it is combined with a powerful motivational dominant produced by the system

"hypothalamus-right hemisphere neocortex" (in right-handers).

The characteristic feature of psychasthenia is indecisiveness, an inability to take a decision quickly and then to be governed by it (pathological impairment of the functions of the amygdala?). This indecisiveness is accompanied by mistrustfulness, obsessive philosophising, obsessive fears, and hypochondria. This latter group of symptoms makes one think of a functional deficiency in the frontal regions of the left hemisphere.

If we accept I.P.Pavlov's general hypothesis that the basic "carriers" of neuroses are the extreme types (the strong unbalanced type and the weak type), and combine this hypothesis with the schema showing the interaction of the four structures, we obtain the following results. Pathology of the "frontal cortex-hypothalamus" system results in hysteria in its hypothalamic version, or obsessive state neurosis in the case of a primary impairment of the frontal areas of the neocortex. Impairment of the functions of the "hippocampus-amygdala" system resulting from illness leads to neurasthenia. As a rule, this does not affect the higher intellectual functions, demonstrating the unimpaired activity of neocortical structures. Involvement of the frontal areas of the neocortex in the pathological process, combined with impaired functioning of the amygdala, results in psychasthenic symptoms.

Up till now, when speaking of a dominant need and subordinate motivations, we have abstracted from their quality. However, this abstraction becomes impossible as soon as we enter the realm of human neurotic illnesses. The distinctive "social egoism" of the hysteric is qualitatively different from the "biological egoism" of the psychasthenic, who concentrates on the most trifling details of his internal morbid sensations. An especially complex origin must be attributed to the feelings of vague guilt and acute responsibility which are so characteristic of a number of cases of neurasthenia.

In other words, the individual characteristics of the interaction of the four brain structures, despite their importance, fail to fully determine the symptoms of neurotic illnesses. In the pretentiously theatrical behaviour of a hysteric, who is desperate for the attention of the people around him, we can clearly discern an unhealthy transformation of the social need "for self".

Preoccupation with one's health, in which the whole world seems to be eclipsed by the slightest sign of (frequently nonexistent) illness, is nothing more than an exaggerated biological need "for self". This is the basis of

hypochondriasis. Feelings of acute responsibility and haunting guilt are a different matter, as are the anxiety and despair which accompany the idea that "nothing works out well for me and I make a mess of everything". What dominates here is a chronically unsatisfied social need "for others".

The importance of the quality of needs is no less clearly revealed in the origin of neurotic depression. The two most wide-spread varieties of neurotic depression are anxiety depression and melancholic depression. What underlies anxiety depression is a chronic failure to satisfy preservation needs. The emotions typical of preservation needs are anxiety, a feeling of being under constant threat, a sense that unknown dangers face the individual, his position in the family and at work, or those close to him. Melancholic depression is generated by the failure to satisfy development needs, a failure to advance and improve one's position in life.

It must be emphasised that people are only partially conscious of needs, and far from appreciating their real content. When a patient complains of a feeling of anxiety or groundless melancholy, he has no inkling that what he means is the need of preservation or the need for development. "In the case of man," wrote I.P.Pavlov, "we must try to discover, with or without the patient's help, or even in the face of his resistance, those quick-acting or slow-acting conditions and circumstances which might with justice be connected with the origin of unhealthy deviation, with the origin of neurosis" (Pavlov, 1973:389). We will not be able to advance our understanding of the aetiology and pathogenesis of neuroses any further without taking into account the unconscious manifestations of human higher nervous functions.

Chapter 6

CONSCIOUSNESS AND NON-CONSCIOUS MANIFESTATIONS OF HUMAN HIGHER NERVOUS FUNCTIONS

Of all the definitions of consciousness which exist, the most adequate definition for the purposes of scientific analysis seems to us to be the one in which consciousness is defined as knowledge which, with the aid of words, mathematical symbols, and the abstract images of artistic works, can be conveyed to become the property of other members of society. Consciousness (< Latin *con* 'with' + *scire* 'know') is shared knowledge (compare compassion (< *com* 'with' + *pati* 'suffer'), commiseration (< *com* 'with' + *miserari* 'bewail'), etc.). To be conscious of something is to acquire the potentiality of communicating, of conveying one's knowledge to others, including conveying knowledge to other generations in the form of cultural memorials. The unconscious is everything that cannot be communicated to other people (Paritsis and Destouris, 1982).

When one individual conveys his knowledge to another, he thereby separates himself both from this other individual and also from the world, knowledge of which he is conveying. The communicative origin of consciousness makes it possible for an individual to have a mental dialogue with himself, i.e., leads to the emergence of self-consciousness. The internal "ego" which judges an individual's own acts is simply an internalised "alterego", inasmuch as each individual looks on himself as another person reflected in a mirror (K.Marx). We wish particularly to emphasise the *communicative* function of consciousness, for which speech is the most fundamental and important, but by no means the only medium. One only has to think of the grandiose system of images in artistic works, which are not fully verbalised but without doubt belong to the sphere of consciousness.

I.P.Pavlov's concepts about two signal systems of reality are in need of clarification, both in relation to animals and in relation to the investigation of human higher nervous functions. L.A.Firsov includes in the first signal system, which occurs in all anthropoids, both the "primary language" of sensually immediate concrete images and the "secondary language" of preverbal concepts. The second

signal system is formed by verbal concepts, which are present exclusively in humans (Suvorov and Firsov, 1975). Thus, higher apes have the ability to form concepts and can signal concrete events in their surroundings, but they cannot signal concepts (Kliks, 1980).

On the other hand, human higher nervous activity is not exhausted by the system of concrete images (shared, according to Pavlov, with animals) and the specifically human system of language. In their experiments, V.P.Kuranov and V.M.Rusalov (1984) used the Stroop colour interference test, in which the colour of the letters in a colour-word either coincides or does not coincide with the colour denoted by that word. The results of the experiments caused these two authors to distinguish a third factor, distinct from the verbal-lexical factor and the visual perception factor. This factor, connected with the processes of imagination and mental representation, they called the imagery factor. We have already indicated above that it is impossible to include the abstract images of art in the first signal system, which is common to man and the animals. We shall speak later of the special features of the "language of art", but for the time being we emphasise that speech and the brain mechanisms of speech are without doubt the first and most important basis of human consciousness. "The brain events which we perceive as conscious," maintain S.Springer and H.Deutsch (1983:203), "are events being processed by the language system in the brain". "Linguistic form," writes the French linguist E.Benveniste, "is not only a prerequisite for the transfer of thought, but above all a prerequisite for the occurrence of thought. We comprehend a thought when it is formulated in linguistic signs. Apart from language there are only unclear motivations and wilful impulses which overflow into gestures and mimicry. One only has to analyse the existing facts without prejudice, and the question whether thought can occur without language or whether it can bypass language like an obstacle is devoid of any meaning" (cited by Panov, 1984:35-36). A.R.Luria distinguished several consecutive stages in the formation of a verbal utterance: motivation first generates the design of an utterance, its subjective sense. This is then transformed with the aid of internal (curtailed, telegraphic) speech into a system of objective meanings, and subsequently into an expanded and grammatically expressed utterance (Luria, 1979).

Evidence for the decisive role played by the language structures of the brain in the phenomenon of consciousness is also provided by neurophysiological investigations. Careful analysis of the restoration of consciousness after a

long coma in patients with severe craniocerebral trauma has permitted the identification of several characteristic stages. The first, though distant sign of returning consciousness is the opening of the eyes. At this stage the intrahemispheric links with the left (speech) temporal region (according to data from EEGs) are still insignificant. Thereafter follow: staring, the recognition of familiar persons (found to a lesser degree in patients with impairment of the right hemisphere), the understanding of speech, and finally the ability to speak (Dobrokhotova, Grindel', Bragina, Potapov, Sharova, and Knyazeva, 1985). The return of the ability to understand speech coincides with the restoration of links between the motor-speech areas of the left hemisphere and other regions of the cortex. These links are diagnosed by the EEG alpha rhythm in the anterior frontal-temporal-central regions of the left hemisphere and a peak at the alpha frequency in the left temporal region. During the transition to active speech, intensified cycles of excitation are formed in the motor-speech area (Grindel', 1985). On the basis of systematic investigations, E.A.Kostandov reached the conclusion that "the activation of links between the gnostic regions of the cortex and the motor speech area is the decisive link in the structural and functional organisation of the mechanisms which bring a stimulus to consciousness" (Kostandov, 1984:408).

The discovery of the brain's functional asymmetry had a truly revolutionary effect on the study of the scientific bases of consciousness. However, it would be an unjustified simplification to attribute consciousness and speech exclusively to the left hemisphere (in right-handers). In reality the situation is more complex. For instance, the investigation of patients after unilateral application of ECT has shown that colours are better distinguished by the right hemisphere, but that the verbal description of the colours perceived by the right hemisphere is very impoverished and restricted to the basic colours: red, blue, yellow, and green. The colour lexicon of the left hemisphere is much richer and includes rare and object-derived terms (straw, pea-green, coffee-coloured) (Nikolaenko, 1982). Depression of the left hemisphere leads to the domination of the subject's native language and the forgetting of languages learned later. When the right hemisphere is depressed, the opposite is observed. The initial stages in the generation of a native-language utterance are connected with the right hemisphere, and the final formulation is connected with the left hemisphere (Chernigovskaya, Balonov and Deglin, 1982). V.L.Deglin (1984) came to the conclusion

that the functional specialisation of the hemispheres is a semiotic specialisation: the right hemisphere constructs iconic models and the left hemisphere constructs symbolic models. The right hemisphere is involved with the perceptual representation of space, and the left hemisphere with the conceptual representation of space. The same applies to the representation of time.

The question whether consciousness participates in processes of learning and the development of new conditioned reflexes in man is still a matter of debate. Using five auditory stimuli, M.Dawson and M.Biferno (1973) masked the link between some of these stimuli and electrocutaneous reinforcement. They succeeded in developing a classical conditioned GSR only in those individuals who were conscious of the link between a particular tone and the painful stimulus. If blinking is reinforced by a flash of light, lack of awareness (the individual fails to understand why the light comes on from time to time) excludes the development of a conditioned blinking reflex: the frequency of blinking was the same during periods with and without reinforcement (Jones and Hochhaus, 1976). The simultaneous presentation of colour stimuli with subliminal presentation of the corresponding colour terms led to the conclusion that there is no subconscious effect on the perception process (Severance and Dyer, 1973), and the careful testing of so-called "subliminal advertising" ended in a negative result (George and Jennings, 1975).

Nevertheless, there are facts which point in the totally opposite direction. At the end of the 40's, G.B.Gershuni discovered a new class of conditioned reflexes in response to unsensed (unperceived) auditory stimuli (Gershuni, Kozhevnikov, Maruseva, and Chistovich, 1948). In the experiments of M.Reiser and J.Block (1965), a circle and a ten-sided figure were presented to each subject while the lighting was gradually increased and the presentation of the circle was reinforced with an electric current. It was shown that the GSR starts to correspond with the appearance of the significant signal before the time it is verbally identified. The subjects were better at verbally identifying the stimulus not immediately, but only 10-11 sec. after its presentation, rather than immediately. If a person lists the details in a drawing which is presented to him, and then after a definite time names the fragments which were missing in the first list, we have every ground to speak of the existence of unconscious perception and involuntary memory, i.e., traces which only later penetrate the sphere of consciousness (Bukhtadze, Kadagishvili, Keuba, and Kalanarishvili, 1971).

A debate has also arisen around the fundamentally important results obtained from EEG studies. On the basis of systematic investigations, Donchin, McCarthy, Kutas, and Ritter (1983) came to the conclusion that evoked potentials (EP) in man are connected with the threshold of perception, the content of the stimulus, and the level of awareness. The N100 component depends on the direction of attention, N200 reacts to rare and unexpected stimuli, and P300 reacts to stimuli which are relevant to the task at hand. A conditioned negative wave reflects the expectation of a starting signal. Using EEG recordings from 48 points on the surface of the skull, M.N.Livanov and N.E.Sviderskaya (1984) showed that generalised synchronisation can act as a measure of the difficulty of an intellectual task, whereas restructuring of interhemispheric asymmetry corresponds to a change in the subject's emotional state, and marked local synchronisation correlates with mental activity and the presence or absence of errors.

In experiments to measure slow alterations (over a period of minutes) in the spatial synchronisation of an EEG and the heart-rate, a dependence was discovered between the ability of a subject to recognise noisy visual images and the variations in his state (Simonov and Frolov, 1985). Prior to the successful recognition of a meaningful light stimulus, the pre-stimulus electrical activity of the motor and visual regions in both hemispheres of the brain is characterised by a decrease of the proportion of slow waves in the total spectrum, and an increase in the proportion of faster waves. There is also a decrease in the correlation coefficient between the potentials of the motor cortex and the visual cortex of the left hemisphere, with a corresponding increase in the right hemisphere. A situation of correct recognition is reflected in an increase of evoked potential N140 and a shortening of its latency period (Potulova and Vasil'ev, 1985).

Although M.Schwartz (1976) decided that the EPs to conscious and subliminal stimuli are not distinct from one another, experiments by E.A.Kostandov et al. (1984) point to the opposite conclusion. The latency period of the P300 wave when a word is presented subliminally is 25-45 ms greater than when it is presented consciously. When the subliminal presentation of an emotionally significant word was followed by the presentation of an emotionally neutral word, the increase in amplitude of the late component of evoked potential P300 was greater in the left hemisphere than in the right. When an emotionally significant word is presented consciously, the latency period of the P300 component is shorter in the left hemisphere than in the right.

A.M.Ivanitsky distinguishes three basic stages in the perception of an external stimulus: (1) analysis of the physical characteristics of the stimulus, (2) synthesis of sensory and extrasensory factors which are retrieved from memory, resulting in the emergence of subjective perception, and (3) the stage at which the stimulus is categorised and assigned to a particular class of external phenomena, with the involvement of conceptual and verbal brain mechanisms. The perception process therefore seems to recapitulate the historical development of the psyche from elementary excitability to conceptual thought (Ivanitsky, Strelets, and Korsakov, 1984). Since nervous impulses arrive at the cortex 20-30 ms after the presentation of a signal, and subjective feeling appears only after 120-180 ms, the authors contend that the emergence of subjective perception coincides with the stage at which two types of information are being synthesised: information from the external world, and information from the structures which store the previously established significance of the signal (Ivanitsky and Strelets, 1981). At the present time, most authors agree that the early components of an EP are determined by the physical characteristics of the stimulus, while the late components which develop after 100-120 ms reflect its significance to the subject (John, 1967; Ivanitsky, 1976).

This conclusion is confirmed by the results of Yu.D. Kropotov's experiments, in which measurements were made of the discharge frequency of the neuron populations of the visual tuber and the extrapyramidal system (globus pallidus, caudate nucleus, etc.) (Kropotov, 1984). Two types of neuronal reaction to a visual stimulus were discovered: (1) reactions with a short latency period which depended on the physical properties of the stimulus, but not on its significance or whether the subject was conscious of it, and (2) late reactions, reflecting the significance of the external stimulus and its subjective meaning. According to the data of L.M.Puchinskaya (1974), when a subject mentally perceives an increase in brightness in a light stimulus which remains physically constant, the late components of the EP are affected. If a subject is asked to react to dull rather than bright flashes, and then a medium-intensity flash is presented, the EP depends on whether the observer assigns this flash to the bright class or the dull class (Begleiter and Porjesz, 1975). The variability of EPs in the two hemispheres is almost identical in the case of active attention, and asymmetric in the case of passive observation. These facts demonstrate that attention is connected with the involvement of subcortical mechanisms which synchronise the activity of cortical elements

(Robinson and Strandburg, 1973).

The use of current electrophysiological methods, combined with the utilisation of computational technology, has made the problem of consciousness, previously a topic monopolised by philosophy and descriptive psychology, into an object of everyday experimentation.

Directly related to the issue under discussion is the question of the possibility of sleep-learning. Careful monitoring of the depth of sleep with the aid of electroencephalography has shown that the assimilation of new information is impossible during sleep (Bloch, 1975). However, there are data which allow hypnopedia to be considered a special case of "dissociated learning": the information received in the course of sleep can be retrieved from memory in the course of sleep, but it cannot surface in the waking state (Arons, Vasil'eva, and Tiunova, 1985). The electroencephalographically established predominance of the right hemisphere has been connected with the lowering of the level of consciousness which is characteristic of natural sleep (Murri, Stefanini, Navona, Domenici, Muratorio, and Goldstein, 1982).

The changes which take place in hypnosis are strongly distinguishable from the EEGs of sleep and drowsiness by a decrease in slow waves and an increase in alpha- and beta-waves (Ulett, Akpinar, and Itil, 1972). However, subjects with a high degree of suggestibility show a more marked asymmetry of the alpha rhythm when carrying out logical and spatial tests. This is evidence of a shift in favour of the right hemisphere (McLeod-Morgan and Lack, 1982). In the waking state, people are better at distinguishing musical stimuli with the left ear and verbal stimuli with the right ear. In hypnosis, the ability to define musical stimuli with the left ear showed an even greater improvement, but the accuracy of verbal stimulus recognition was unaltered. In other words, hypnosis primarily affected the state of the right hemisphere (Levine, Kurts, and Lauter, 1984).

A comparative study of the GSR and motor reactions to a noise in individuals with a heightened degree of suggestibility showed that the GSR on the left hand were stronger than on the right hand, while the reaction time of the right hand was shorter than the left hand. Under hypnosis, the GSR was weakened, and the asymmetry of the visceral and motor reactions was distorted. The authors concluded that inhibition of the left hemisphere, which is dominant in the waking state, leads to the predominance of the right hemisphere (Gruzelier, Brow, Perry, Rhonder, and Thomas, 1984a). Processes in the left hemisphere are important for inducing a state of hypnosis in a patient,

while in hypnosis the left hemisphere is inhibited and the right hemisphere is removed from its control (Gruzelier, Brow, Perry, Rhonder, and Thomas, 1984b). Measurement of the evoked potentials to sound stimuli has shown that in susceptible subjects hypnotisation leads to greater activation of the right hemisphere in the central region, and greater activation of the left hemisphere in the temporal region. Subjects with a low degree of suggestibility did not display this asymmetry. It was concluded that the weakening of the inhibitory influence of the left hemisphere on the right hemisphere is especially distinct in the central region (Golds, Jutai, and Gruzelier, 1984).

The results derived from electrophysiological analysis, which point to the removal of the right hemisphere from the regulatory influence of the "verbal" left hemisphere, are in strikingly accurate agreement with the picture painted by I.P.Pavlov more than half a century ago: "... in the very first stages of the hypnotic state... the usually dominant work of the second signal system in the waking state is replaced by the activity of the first signal system... freed from the regulatory influence of the second. It follows that this activity will be chaotic in character, taking little or no account of reality and largely subordinated to the emotional influences of the subcortex" (Pavlov, 1973:412). Pavlov's formulation of the physiological nature of hypnosis coincides almost word for word with present-day conceptions. For example, according to V.S.Rotenberg's hypothesis, first proposed in 1978, "the essence of the change to the hypnotic state is the relative predominance of figurative thought when verbal thought is inhibited" (Rotenberg, 1985:131).

The predominance of the right hemisphere and its removal from the control of the left hemisphere are not the cause but the consequence of the emergence of the hypnotic state. We have already stated that hypnosis is a special case of imitative behaviour. The hypnotised individual takes on the subservient role willingly and with a sense of relief, uncritically carrying out the commands of the hypnotiser. A person under hypnosis refuses to be independent, transferring responsibility for the situation to the leader and remaining responsible to the leader solely for the carrying out of what is suggested (Hunt, 1979). One of the important links in the ancient mechanism of imitative behaviour is indeed the liberation of the "motivational-emotional", "iconic" (i.e., operating with graphic images) right hemisphere from the regulatory influences of the "informational", "conceptual" left hemisphere. However, this liberation has its limits, since a normal individual will

generally reject any instructions which conflict with his basic ethical tenets and system of values.

If we consider the relationship between hypnotiser and hypnotised to be a relationship between leader and follower, we cannot avoid a comparative evaluation of their volitional attributes. In the opinion of the author of the relevant article in the second edition of the Large Soviet Encyclopaedia, "suggestibility is susceptibility to suggestion; in a wider sense, it is one of the manifestations of a weakly developed will... Suggestion is a means by which one person can affect the psyche of another, and can be carried out both in the waking and the hypnotic state... Suggestion is accompanied by a weakening of the will of the individual who is subjected to suggestion, and the subordination of his will to the will of the suggester" (1951, Vol 8:306). An analogous definition of suggestibility as an attribute which is the opposite of strong will can be found in the most recent, third edition of the Large Soviet Encyclopaedia (1971, Vol 5:169). This feature links mechanisms of hypnosis in humans with the mechanism of so-called hypnotisation in animals, which is based on an acute extinction of the freedom reflex (see chapter 1).

However, this point of view is sharply contested by other authors. V.S.Rotenberg believes that human hypnosis has nothing in common with so-called animal hypnosis. "Passive-defensive behaviour," writes Rotenberg, "is antithetical in principle to the active expansion of an individual's psychic capabilities which is achieved through the activation of figurative thought during hypnosis" (Rotenberg, 1985:132). It should be noted that a *common initial mechanism*, the inhibition of the "freedom reflex", which in human beings has acquired the qualitatively new characteristics of the human will, in no way excludes species-specific (ecological) *differences in external expression* of this state of inhibition. In the complex circumstances in which so-called animal hypnosis occurs, general immobility and catalepsy have the biological purpose of making the animal inconspicuous or blocking an opponent's aggressiveness. In the case of human beings, greater advantage is derived from the transfer to imitative behaviour, rejection of personal choice, and obedience to a better orientated, decisive and competent leader.

Let us now turn to the activation of creative capabilities. The role of the right hemisphere and graphic thinking in the solution of creative problems is very important (Martindall, Hines, Mitchell, and Covello, 1984). The activation of the right hemisphere in the hypnotic state and the weakening of inhibitory influences by the left

hemisphere can without doubt contribute to the manifestation of an individual's creative potential. All of us have at some time observed how a person who possesses certain skills, such as the ability to speak a foreign language or the ability to draw, etc., may not be able to demonstrate these abilities because of diffidence, "nerves", indecision, and self-doubt. Experienced teachers have a variety of methods for overcoming "nerves". One of these methods is hypnosis, by no means the only and exclusive method, but often very effective.

The old dispute as to whether a hypnotised person is simply acting out a given role, or fully believes in the reality of what is suggested to him, has largely been settled by the elegant experiments of I.M.Feigenberg (1980;1985). After suggesting blindness in one eye to the subject, the experimenter convinced himself that the subject really could not see objects placed in the corresponding field of vision. Then spectacles with polarising filters were placed on the subject and a word was presented, for example "seaman", in such a way that the syllable "sea" fell to the "unseeing" eye. Of course, the subject was unaware of this device. It might be thought that the subject would read out the word "man", but instead he read "seaman". Thus the experiment showed that blindness in one eye under hypnosis is not connected with inhibition of the neural structures of the visual analysis system. One question which might be asked is: can the subject see with the supposedly blind eye?

I.M.Feigenberg correctly points out that this is not the right question to ask. The hypnotised person is subjectively blind from the point of view of his own consciousness, and objectively sighted from the point of view of an independent observer. In other words, we are dealing here with a phenomenon which requires the use of the principle of complementarity. This is the principle which we exploited in order to solve the problem of freedom of choice, and the problem of so-called self-determination of behaviour. We shall return to these issues below.

The example of hypnosis is one of the factors which convince us of the reality of the sphere of the non-conscious psyche, which has rather arbitrarily been given such names as the preconscious, the subconscious or the unconscious.

Let us say straight away that the use of the term "unconscious" to describe the non-conscious manifestations of human higher nervous (psychic) activity seems to us to be extremely unfortunate. The "unsuitability of the concept of the unconscious" was discussed earlier this century by D.N.Uznadze (1919:178), and current authors also object to

its use (Grigolava, 1984). We say that a person is in an unconscious state when as a result of severe trauma, syncope, poisoning, etc., he shows signs of life without any indication that higher psychic functions are maintained. The functioning of the non-conscious psyche (whether the subconscious or the superconscious, definitions of which will be provided later) is inextricably connected with conscious activity. In the course of man's evolution and his subsequent cultural and historical development, the subconscious and the superconscious arose together with consciousness and interact most closely with it. Without consciousness they simply cannot exist.

Historically, what has happened is that the non-conscious psyche (or the unconscious, the anteconscious, the preconscious, etc.) has become a sort of "rubbish bin" into which everything that an individual is unaware of is placed indiscriminately, from the effects on his psyche of hormones circulating in the blood to the crucial stages in scientific and artistic creativity. The dangers of such "generalisation" can be discerned in the theoretical miscalculations of Sigmund Freud himself. In the vast field of the non-conscious psyche, at least two classes of phenomena must be distinguished. To the first class belongs everything that *was once conscious* or can become conscious under specified conditions. This class above all includes skills which have become automatic and hence ceased to be conscious, as well as motivational conflicts which have been suppressed from the sphere of consciousness and whose essence only becomes clear with the specialised assistance of a psychotherapist. It is useful to maintain the traditional term *"subconscious"* for this class of phenomena.

The sphere of the subconscious also includes social norms which have been deeply assimilated by the individual and whose regulatory function is experienced as a "voice of conscience", a "feeling of obligation" or a "call of the heart". It is important to emphasise that the assimilation by the individual's internal world of social norms which are external in origin gives these norms the exceptional exigency which they previously lacked. "The judgement of others is not difficult to scorn," wrote A.S.Pushkin, "but one's own judgement cannot be scorned". "When no-one sees and no-one will know, but I nevertheless refrain - that is what conscience is" (V.G.Korolenko). "Conscience is the memory of society, assimilated by a single individual" (L.N.Tolstoi). The interpersonal origin of conscience is fixed in the very name for the phenomenon: con-science, i.e., knowledge in which one or more other persons who are initiated into its content invisibly participate. It is not

difficult to see that the "superego" of Sigmund Freud, which is a representation in the psyche of the individual of the demands of society, its prohibitions and its commandments, is absolutely unrelated to biological drives, totally belongs to the sphere of the subconscious, and cannot be considered as an analogue of the superconscious. This latter will be discussed in greater detail below.

The subconscious also includes those manifestations of intuition which are not connected with the generation of new information, but presuppose only the utilisation of previously acquired experience. When a famous clinician takes a mere glance at a patient and makes the correct diagnosis, he is frequently incapable of explaining precisely what external signs of illness caused him to arrive at his conclusions. In this respect he is just like a pianist who has long forgotten what exactly needs to be done with each individual finger. The physician's diagnosis, like the pianist's playing, is governed by his subconscious.

We must emphasise that previously conscious experience, whether this be a system of motor skills, knowledge concerning the symptoms of particular diseases, behavioural norms accepted in a given social environment, etc., is not the only channel which fills the subconscious with concrete material that is external in origin. There is also a direct path which bypasses the rational control of the conscious mind, namely, the mechanisms of imitative behaviour. Through direct action on the subconscious, the example of adults and peers in the immediate environment frequently shapes a child's character to a greater extent than explanations of the benefit and value of a particular act which are addressed directly to the intellect.

If the "language" of consciousness consists of the concepts and generalisations which are expressed in words, mathematical symbols, and works of art (we have in mind those aspects of works of art which are addressed to the conscious mind of the perceiver), the "language" of the subconscious consists of concrete sensory images in the widest sense of the term "image". For instance, when performing automatic (non-conscious) motor skills, the brain operates with kinaesthetic "images" of previously conscious movements. Thus, an experienced physician makes a diagnosis intuitively (non-consciously) because his brain stores traces of the signs which are typical of a given disease (coloration of the whites of the eyes, characteristic facial expressions, gait, skin colour, etc.). By imitation, a child non-consciously fixes the behavioural norms which govern its immediate surroundings, and these in time become the internal regulators of its actions.

In the long process of evolution, the subconscious arose as a means of *protecting the conscious mind* against excess work and unbearable loads. Whether we consider the motor skills of a pianist, a driver or a sportsman, which can be successfully performed without the intervention of the conscious mind, or a burdensome motivational conflict, the subconscious frees the conscious mind from stressful overloading. We can clarify this with an example borrowed from one of the works of I.S.Kon. One person envies another, but recognises that the feeling of envy is shameful and humiliating. He then begins unconsciously to look for the negative features, real and imaginary, which might justify his hostile attitude. He genuinely believes that his hostility is caused by the deficiencies of the other person, although in reality the sole cause is ill-wishing.

The subconscious always stands guard over what has been acquired and well assimilated, whether this be an automatic skill or a social norm. The conservatism of the subconscious is one of its most characteristic features. Thanks to the subconscious, what is individually assimilated (by a conditioned reflex) acquires the exigency and rigidity chaacteristic of unconditioned reflexes. This gives rise to the illusion that certain manifestations of the non-conscious mind are innate, for example, the illusion of the innateness of grammatical structures, which are assimilated by a child through imitation long before he becomes consciously aware of them during lessons on his native language at school. The similarity between the subconscious and the innate is even reflected in everyday language, having engendered such metaphors as "class instinct", "gut reaction", and similar figurative expressions.

We now turn to an analysis of the second variety of the non-conscious psyche, distinct from the subconscious and which, following K.S.Stanislavsky, we might call the *superconscious*. A similar term, the epiconscious, was used by M.G.Yaroshevsky (1973). The concept of the epiconscious "contains nothing mystic which detaches psychic processes from the material substrate in which they operate. The subconscious, the conscious, and the epiconscious are different levels in the spiritual life of the total human personality, which is primarily historical in nature and employs its essential forces in material and spiritual production using a hierarchy of psychophysiological systems" (Yaroshevsky, 1973:76). Henceforward we shall use the term "superconscious", since it is directly connected with creativity and Stanislavsky's ideas concerning the "supertask" and the "super-supertask" of the creative process. It is also the term used in our previously

published works (Simonov, 1975;1978).

The functioning of the superconscious, which generates new, previously non-existent information by recombining the traces of impressions received from outside, is not controlled by conscious effort of the will: only the results of its activity are presented for judgement to the conscious mind (Adamar, 1970). The sphere of the superconscious includes the initial stages of all creativity: the generation of hypotheses, conjectures, and creative inspirations. If the subconscious protects the conscious mind from excess work and psychic overloading, the non-conscious nature of creative intuition acts as *protection against the premature involvement of the conscious mind*, against the excess pressure exerted by previously accumulated experience. If it were not for this protection, the "ugly duckling" (a risky hypothesis, an original plan, etc.) would be stifled at birth by common sense, the obviousness of what is directly observable, or the dogmatism of rigidly assimilated norms. It would not be permitted to become the glorious swan of future discoveries. For this reason discursive thinking is reserved for the important functions of formulating a problem and presenting it to the conscious intellect, as well as making a secondary selection between the hypotheses generated by the superconscious, at first by means of logical evaluation and then in the crucible of experimental, productive, and social practice.

One specific manifestation of the activity of the superconscious is the mechanism of dreams. The adaptive significance of dreams is still unclear, although the hypothesis of V.S.Rotenberg (1982) that dreams are a variety of search activity seems highly plausible. When discussing the role of the superconscious in the genesis of dreams, we have tended to emphasise that "the content of dreams is only probabilistically determined by the character of the motivational dominant, which imparts a certain tendency to the content aspect of dreams, a direction within which traces are combined and varied quite randomly" (Simonov and Ershov, 1984:85-86).

As well as participating in the genesis of scientific discoveries and the creation of artistic works, the superconscious plays an important role in the origin of myths, superstitions, and religious beliefs. Although not an objective reflection of reality, these nevertheless become fixed in the human consciousness, satisfying the need to systematise concepts of the external world and to canonise social norms, satisfying the ineradicable need for "miracles, secrets, and authorities" (F.M.Dostoevsky).

Finally, we can also encounter pathologically altered

interactions between the conscious mind and the subconscious and superconscious. These involve the kinds of delirium, hallucinations and visions which arise under the influence of psychotropic substances like LSD and other hallucinogens.

Although probabilistic in nature, the superconscious is not a kaleidoscope, not a mere toss of the coin. Its activity is channeled in three directions: (1) previously accumulated experience, including the experience of preceding generations; (2) tasks set for the superconscious by the conscious mind when it comes across a problematic situation; (3) dominant needs.

The functions of the superconscious cannot be reduced to the mere generation of "psychic mutations and recombinations" (Simonov, 1966), i.e. to purely random recombination of traces stored in memory. Equally, the question of the randomness of genetic mutations is much more complicated than might be thought at first sight. "The randomness of mutations is relative," write S.V.Meien and Yu.V.Chaikovsky in the preface to a book by A.A.Lyubishchev. "They are random in the sense that their origins and results cannot as a rule be linked to the effects of the external environment. At the same time, mutations are in some way determined by the activity of the organism's own genetic system. Each mutation is random in the sense that it can lead to the realisation of any permitted allele, but it can also be considered determined, to the extent that the choice of alleles is itself regular" (Meien and Chaikovsky, 1982:17). Following as yet unknown laws, the superconscious makes the primary selection between occurrent recombinations and only presents to the conscious mind those which possess a certain probability of correspondence with reality. Therefore, even the most "mad ideas" of a scientist are in principle different from the pathological madness of the insane and the phantasmagoria of dreams.

Modern neurophysiology has identified a number of mechanisms which are capable of forming temporary neural links between the traces (engrams) of previously encountered impressions, whose correspondence or non-correspondence with reality will become clear only secondarily after comparison with objective reality. Amongst the mechanisms which we have previously discussed (Simonov, 1981), a special position is occupied by A.A.Ukhtomsky's principle of the dominant. At the present time it can be considered an established fact that the superconscious (creative intuition) is always "working" towards the satisfaction of a need which is dominant in the individual's hierarchy of motivations. For example, a careerist who longs for social success may be brilliant at the construction of his career, but is hardly

likely to endow the world with scientific discoveries or artistic masterpieces. However, it would not be correct to sink into simple one-dimensionality. A great artist (or scientist) can show signs of ambition or miserliness, and can gamble at cards or on the horses. He is a human being, and no stranger to anything that is human. All that is important is that at particular moments the dispassionate need to find out the truth captivates his whole being. It is precisely at these moments that the dominant need will trigger the mechanisms of the superconscious and lead to results unachievable by any rational means. "Until Apollo summons the poet to the sacred offering...", thus A.S.Pushkin brilliantly divined this dialectic of superconscious activity.

Just as imitative behaviour is capable of addressing itself to the subconscious and can bypass the control of rational thought, the most important method of training and enriching the superconscious is children's play. Since play is unconstrained by the achievement of utilitarian or, up to a certain age, socially prestigious goals, it is sufficiently self-motivated and self-sufficient to be directed at the solution of purely creative problems. Children's play is motivated almost exclusively by the need for knowledge and the need for preparedness, this latter to be understood as the need to acquire knowledge, skills, and capabilities which will only be required at some future time (see chapter 2). These two needs (the need for knowledge and the need for preparedness) feed the activity of a child's superconscious and turn each child into a dreamer, a discoverer, and a creator. As the child grows up, the need for knowledge is forced to compete more and more frequently with vital and social needs, and the superconscious is diverted to the servicing of a wide spectrum of diverse motivations. It is no accident that, as has often been noted, truly great minds are characterised by the preservation of childish features.

E.L.Feinberg (1981) reviewed in detail the differences between the intuition of guesswork (the generation of hypotheses), and the intuition which directly perceives the truth without requiring formal-logical proof. An example of this second type of intuition is the conclusion of a scientist that a sufficient number of experiments have been carried out, or the decision of a judge that there is sufficient objective evidence of a person's guilt. Let us recall that the law requires a judge to deliver his verdict on the basis of "inner conviction", and does not prescribe in advance a particular quantity of evidence. It is no accident that the law has an intuitive "spirit" as well as a

discursive "letter". We suppose that the two types of intuition in principle have a common origin, namely a deficit of the information which is necessary and sufficient for a logically impeccable conclusion to be reached. In the first type (guesswork-intuition), this information *does not yet exist*, and must be discovered later as the emerging hypothesis is checked. In contrast, in the case of direct truth-perceiving intuition, it is *totally impossible* to obtain such information, no matter how many experiments the scientist sets up and no matter how many items of evidence the judge collects. We attach importance to the fact that the example of direct truth-perceiving intuition provides another justification for the term "superconscious". What happens is that rational thought supplies the material for decision-taking and presents a range of formal evidence to the conscious mind, but the *final decision* is taken at the level of intuition and cannot be formalised.

The superconscious draws the material for its recombinatory activity both from conscious experience and from the reserves of the subconscious. The superconscious nevertheless contains something "super", i.e. additional, beyond the sphere of consciousness itself. This added element consists of essentially new information which does not flow directly from past impressions. The force which initiates the activity of the superconscious and at the same time channels the content aspect of this activity is the dominant need. Motivational restrictions are placed on the activity of the superconscious from the very outset. This is the reason why intuition is no kaleidoscope, no game of chance: it is channeled from the very beginning by the quality of the dominant need and the quantity of previously accumulated knowledge. No "generation of ideas" could have led to the discovery of the periodic table without an extensive knowledge of the properties of chemical elements.

While the positive function of the superconscious is the generation of new information, its negative function is the surmounting of existing and generally accepted norms. A striking example of the negative function of the superconscious is to be found in humour and the external expression of humour in the form of laughter. Laughter arises involuntarily and does not require logical explanation as to why what is funny is funny. Laughter is a positive emotion, and its occurrence follows a universal schema in which prior knowledge (a prediction) is in conflict with the information received at a particular moment. This information however does not simply surpass the existing prediction, but cancels or reverses it. The

classical illustration is the structure of any anecdote, which always consists of two parts, a false prediction and a punch-line which cancels it. The motivational basis of humour is formed by the need for knowledge and the need for economy of effort. Wit in investigative thought not only brings us closer to the truth, but also provides an unexpectedly short path to the solution of logical problems. In humour, the supremacy of new knowledge always triumphs over the imperfection and cumbrousness of out-dated norms. The conjoining of the need for knowledge and the need for economy of effort with other accessary motivations (biological and social) gives laughter a number of additional nuances: it can become good-natured, malicious, arrogant, clever, stupid, carefree, etc., thereby turning laughter into "the truest test of the soul" (F.M.Dostoevsky).

The interaction of the conscious and the superconscious mind is comparable to the role of selection and unpredictable variation in the process of biological evolution. It must be emphasised that this is not just an analogy, but a *universal principle of all development*, manifested both in "the creativity of nature" (the origin of new species), the organisation of individual behaviour (see chapter 4), the creative activity of human beings, and the evolution of culture. However, it is ridiculous to speak of some kind of "transferal" of biological laws into socially determined psychology or the history of human civilisation as a whole. In science we often encounter universal principles of this kind. It suffices to recall the regulatory functions of feedback, which are found both in the regulation of blood pressure (even in biochemical processes!), and in the control of industrial production. This of course does not mean that we have "transfered" physiological experiments into economics, or the laws of social development into biology. We are dealing here not with "transferal", but with the existence of general laws in control theory.

The origin of *innovation* also has a general dynamic, no matter where it occurs: in the process of phylogenesis, in the individual (scientific, technological, artistic) creativity of man, or in the history of human culture. The process of innovation requires the presence of four essential components: (1) an evolving population, (2) unpredictable variation in the evolving material, (3) selection, (4) the fixation (inheritance in the widest sense) of the results of selection. In the creative activity of man, these four components correspond to:

(1) The individual's experience, which includes the experience assimilated from contemporaries as well as the experience of preceding generations.

(2) The activity of the superconscious (intuition), i.e., those transformations and recombinations of the traces (engrams) of past impressions whose correspondence or non-correspondence with reality is established only later.

(3) The activity of the conscious mind, subjecting hypotheses (special kinds of "psychic mutation and recombination") at first to logical selection and subsequently to checking by experiment in production or social practice.

(4) The reinforcing of the results of selection in the individual's memory and in the cultural inheritance of successive generations.

In the case of the development of civilisation, what evolves is culture as a whole. However, an innovation (an idea, discovery, invention, ethical norm, etc.) initially arises not in an abstract interpersonal and epipersonal space, but in an individual material organ, the brain of the particular person who is its discoverer and creator. A.A.Lyubishchev wrote: "...the creativity of nature has a great similarity to the creativity of man. In a variety of fields it has long been the practice to speak not just of the evolution of organisms, but also, for example, of the evolution of weaponry, technical appliances, machinery, automobiles, etc. These are all examples of creative evolution in the true sense of the word "creativity"... Between the successive stages in the evolution of a particular kind of weapon there is no direct genetic link; the primitive automobile did not change into the modern automobile through a sequence of stages, rather, the *idea* of the automobile underwent a transformation *in the minds* of a sequence of *inventors*, and from this 'rhizome of ideas' sprouted the successive stages in the perfection of the automobile" (Lyubishchev, 1982:180) (my italics - *P.S.*). The content of this statement can appropriately be compared with the fact that, although the evolving entity in biology is the population, selection can operate only through particular individuals. The unpredictability of discovery and the protectedness of "mutagenesis" and "psychic recombinations" against the interference of consciousness and will are necessary conditions for development, just as the unpredictability of mutations is essential for

biological evolution. Total rationality (formalisability) and arbitrariness of the initial stages of creativity would have rendered creativity impossible and would have meant the end of the development of civilisation.

Let us clarify this by an example. Suppose that the successes of genetic engineering and the perfection of the educational system permitted us to create ideal people. But these people would be ideal from the point of view of our present-day, historically transient and unavoidably restricted conceptions of what is ideal. Because of this, ideally programmed people may turn out to be exceptionally vulnerable when they encounter a future which requires them to have properties we have not foreseen. Fortunately, in the study of the psychophysiology of creativity we come up against one of those natural constraints which cannot be overcome without breaking one of the laws of nature, like the law of conservation of energy or the principle of complementarity. For this reason, all attempts to formalise and cyberneticise creativity are reminiscent of attempts to create a perpetual motion machine or determine the momentum and position of an orbital electron simultaneously.

Since the superconscious is nourished by material accumulated by the conscious mind and partially fixed in the subconscious, it is in principle incapable of generating a hypothesis which is totally free from this experience. The mind of a primitive genius could not have given birth to the theory of relativity or the plan for the Sistine madonna. A genius is often ahead of his time, but the extent of his antecedence is historically restricted. In other words, mankind only sets about solving those problems for which it is relatively prepared. Here again we encounter the unpredictable randomness of "psychic mutations". Equally, social development is achieved through the world-transforming activity of concrete individuals: in these individuals, the activity of the superconscious gives birth to scientific and technological discoveries, new ethical norms and plans for artistic works. A particularly individual discovery in the field of technology is later converted into an industrial revolution, which in turn alters previously existing industrial relationships. Thus, the higher nervous activity of man, at the heart of which lie his vital ("biological"), social and ideal (creative and epistemic) needs, has become, in V.I.Vernadsky's (1940) phrase, the greatest planetary and cosmic force of all.

A human being's incomplete, only partial awareness of the needs which drive him removes the supposed contradiction between the objective predetermination of human behaviour and the subjectively felt freedom of choice. An early

insightful discussion of this behavioural dialectic is provided by Benedictus Spinoza. "People only consider themselves free," wrote Spinoza (1932:86), "because they are conscious of their actions, but they do not know the reasons for their actions". A human being's behaviour is determined by his inherited disposition and the circumstances of his surrounding environment, above all, the circumstances of his social education. No third factor capable of affecting his choice of action is known to science. Equally, all ethics, and especially the principle of personal responsibility, is based on the unconditional recognition of absolutely free will (Hegel, 1970:120). Refusal to recognise freedom of choice would entail the collapse of any system of ethics and morality.

In his widely known book Beyond Freedom and Dignity, B.F.Skinner (1971) carries the idea of mechanical determinism to its logical conclusion. According to Skinner, an individual is not responsible for his actions, inasmuch as these are entirely predetermined by external circumstances and by conditions of upbringing. In classifying something as a vice or a virtue, society is simply determining what it will punish and what it will encourage. The concepts of free will and moral responsibility should be banished from the behavioural sciences just as physics once abandoned "phlogiston", astronomy rejected the idea that the earth is the centre of the universe, biology renounced "life force" and psychology the myth of the immortal soul.

Skinner's flat statements provoked a sharp reaction even amongst naturalists. "I believe that as human beings we possess freedom and dignity. Skinner's theory and the technique of instrumental conditioned reflexes are based on his experiments with pigeons and rats, and that is where they belong!" (Eccles, 1973:223).

At the same time it must be stated that the logical rigour of Skinner's argumentation generally surpasses that of the defenders of "freedom of choice". This, for example, is what K.A.Novikov writes in a special article devoted to the problem of freedom of choice: "...in concrete situations of choice the subject often 'manipulates' not towards the outcome which in the existing circumstances has the greatest probability of realisation, but towards the outcome which in its content most corresponds to the underlying dynamics of the social process" (Novikov, 1972:109). Since the "underlying dynamics of the social process" are themselves in need of clarification, the mechanism through which they influence the subject's choice is left hanging in the air. Neither has anything been contributed to the solution of the

problem by the widely advertised "cognitive revolution" in psychology. A specimen of the cognitive approach runs as follows: human behaviour is determined by (1) his genetics, (2) learning, (3) the situation, and (4) cognitive evaluation. The first three of these factors dictate the predetermined nature of behaviour, and the fourth allows for choice between alternative schemes of action (Knoweton and Rotschaefer, 1979). It is appropriate to ask: what is it that determines one or other "cognitive evaluation"? Why does the subject prefer one scheme of action and reject another? The essence of the problem is again obfuscated by terminology.

All attempts to disengage a person's acts from the satisfaction of his needs can succeed only if needs are interpreted in a very narrow way which ignores their multifarious transformation into secondary, tertiary, and other such derivative motivations. "Human acts," wrote L.S.Vygotsky, "which have their origin in the cultural and historical development of behaviour, are free acts, i.e., they are independent of immediate needs and immediate situations, and are directed at the future" (Vygotsky, 1984:85). But surely the advance manufacture of tools for hunting, fishing, and preparing the soil for a future harvest are motivated and dictated by the need for food, even if no hunger is felt at the time the tools are made?

One of the most recent attempts to overcome the real contradiction between determinism and freedom of choice is the resort to the concept of self-determination of behaviour. "Free choice," writes D.I.Dubrovsky (1980:210), "is a special type of determination: *self-determination*, which is present in a particular class of highly organised material systems". The contemporary natural sciences recognise two ways in which the behaviour of living creatures is determined. There can either be inborn forms of behaviour, determined by the phylogenetic process, or individually acquired experience, determined by the influence of the external (in the case of man primarily social) environment, i.e., by education in its broad sense. Where does the mysterious "third" factor come from, and how can it provide the basis for speaking of self-determination?

This third factor evaporates as soon as the investigator tries to discuss the origins of self-determination in any detail. As an illustration we can cite the reasoning of R.Sperry, one of the first to discover the functional asymmetry of the brain. "Decision-making in man is not undetermined, but self-determined. Every normal individual tries to control what he does, and makes his choice in conformity with his own *wishes*... Self-determinants include

the resources of *memory* accumulated in past life, the system of both inborn and acquired values, plus all the various psychic factors based on perception, rational thought, intuition, etc." (Sperry, 1980:200). But aren't both memory and the structure of needs ("wishes") in a particular individual determined, as Sperry himself recognises, by that individual's innate dispositions and "past life"? What is the use here of "self-determination"?

Behaviour is considered to be the freer, the more awareness there is of the objective laws of reality. But when there is awareness of objective laws, behaviour starts to be determined by this perceived necessity. Perceived necessity determines the choice of action and the making of decisions. What kind of "self-determination" and "freedom of choice" is this!

The real contradiction between determinism and freedom of choice can be dispelled only by invoking *the principle of complementarity*. The question whether man has freedom of choice or not lacks a unique answer, since this answer depends on the position of the observer. Man is not free (determined); from the point of view of an external observer, man's behaviour is determined by genetic and educational factors. At the same time, man has freedom of choice from the point of view of his own consciousness. This seems to be what Schopenhauer had in mind when he wittily observed that determinism, which denies freedom of choice, is a philosophy of those who have forgotten to take themselves into account (see Eccles, 1979:236). Evolution and subsequent cultural and historical development have created an *illusion* of freedom by hiding from a person's consciousness the motivations which drive him. Subjectively felt freedom and the personal responsibility which flows from it incorporate mechanisms which comprehensively and repeatedly analyse the consequences of a given action, making the final choice more well-founded (Simonov, 1982). The feeling of personal responsibility, like the mechanism which predicts consequences, is formed during ontogenesis. This is why up to a certain age we do not hold a child responsible for its actions, and transfer its guilt to parents and teachers.

A practical motivational dominant which directly determines an action (a "behaviour vector", according to A.A.Ukhtomsky) is an integral of a supreme need which consistently predominates in a particular individual's hierarchy of motivations (a life dominant, or super-super-task, according to K.S.Stanislavsky), and a particular situational dominant which is activated by a situation of emergency. For example, real danger to life activates a

situational dominant: the need for self-preservation, satisfaction of which often turns out to be in conflict with a life dominant: a socially determined need to conform to particular ethical standards. The conscious mind (generally with the aid of the subconscious) retrieves the consequences of particular actions from memory and mentally "plays them through". In addition, the mechanisms of will, the need to overcome obstacles in the path of achieving a major goal, become involved in the battle of motivations, the obstacle in this case being the instinct of self-preservation. Each of these needs will generate its own series of emotions, and the competition between them will be experienced by the individual as a struggle between natural fear and sense of duty, shame at the thought of possible cowardice, etc. The result of such a competition of motivations will either be flight, or steadfastness and courage.

What must be emphasised in this example is the fact that the idea of personal responsibility and personal freedom inhibits impulsive actions influenced by the instantaneously evolving situation, gives a time advantage to the evaluation of the possible consequences of these actions, and thereby leads to a strengthening of the paramount need, which turns out to be capable of withstanding the situational dominant of fear.

Thus, a particular act is determined neither by consciousness in itself, nor by will in itself, but rather by the ability of consciousness and will to strengthen or weaken one or other of competing needs. This strengthening is achieved through the mechanism of emotions, which, as was demonstrated above, depend not only on the magnitude of a need, but also on an evaluation of the probability (possibility) of its satisfaction. A need which has become dominant (a practical dominant) causes intuition (the superconscious) to search for the optimal creative solution to a problem, to search for a way out of the evolving situation which corresponds to the satisfaction of this dominant need. An analysis of the memoirs of distinguished World War II pilots shows that virtuosity in dogfighting, involving decisions which are unanticipated by an opponent and taken in a fraction of a second, is independent of the level of the pilot's professional qualifications (his reserve of skills), and is not accompanied by a state of fear (the need for self-preservation) or a state of anger (the need to destroy the enemy at any cost), but rather by an emotionally positive state of combative daring in which "games" are played with the opposition, i.e., with the involvement of components of an ideal need which is creative and cognitive in character, however strange this might seem

when the situation is not a struggle for life, but a fight to the death.

Let us recall that decision-taking material can be presented by the superconscious (creative intuition) in the form of recombinations of traces of preparatory accumulated experience which have never been encountered either in the previous activity of the given individual or in the experience of previous generations. In this sense, and only in this sense, we can think of the self-determination of behaviour as a special and rather unique case of what is created in the progress and self-development of the living world.

If a paramount need (a life dominant) is so strong as to be capable of automatically suppressing situational dominants, it will immediately mobilise the reserves of the subconscious and direct the activity of the superconscious towards its own satisfaction. The struggle of motivations is practically absent in this case, and the paramount need is directly transformed into a practical dominant. Examples of this kind of transformation are the numerous cases of self-sacrifice and heroism, when one person rushes to the aid of another without thinking. As a rule, what we encounter here is the clear domination of the needs "for others", either the parental instinct or altruism which has a more complex social origin.

The formation of a practical dominant can turn out to be a troublesome task for an individual when the paramount and situational dominants are approximately equal in strength and in a relation of conflict. This kind of conflict underlies many of the works of classical literature. On the other hand, the absence of a practical dominant (in pensioners and the unemployed) can be an exceptionally hard experience for some individuals. No less distressing in its consequences is the absence of a paramount need (a life dominant), as a result of which a person becomes a plaything of situational dominants. The "deviant" behaviour of teenagers, alcoholism, and drug addiction provide a number of examples of this. It must be emphasised that an individual is generally unaware of the real cause of the state which is distressing to him, and gives the most varied explanations for his goalless and empty time-wasting.

Thus, the higher nervous (psychic) activity of man has a three-level structure which includes the conscious mind, the subconscious, and the suoerconscious. While the subconscious can to a certain extent be compared with the "personal unconscious" of C.Jung and the "superego" of S.Freud, the superconscious has no analogies in previously proposed classifications of the non-conscious psyche.

Consciousness operates with knowledge which can actually or potentially be conveyed to another person and become the property of other members of the community. As has been shown in numerous investigations of the functional asymmetry of the brain, conscious awareness of external stimuli or events in the individual's internal life requires the involvement of the speech areas in the cerebral hemispheres. In the sphere of creativity, it is consciousness which formulates the issue to be decided and presents it to the cognisant mind.

The sphere of the subconscious involves all that has been conscious or can become conscious in particular circumstances. This includes well automated skills, deeply assimilated social norms, and motivational conflicts which are distressing to the individual. The subconscious protects the conscious mind from excess work and psychic overloading.

The activity of the superconscious (creative intuition) is revealed in the preliminary stages of creativity, which are not controlled by consciousness or will. The non-conscious nature of these stages serves to defend incipient hypotheses ("psychic mutations and recombinations") against the conservatism of the conscious mind, from the excessive influence of previously acquired experience. The conscious mind is reserved for the selection of these hypotheses through logical analysis, and by the use of practical criteria in the broadest sense. The neurophysiological basis of the superconscious is the transformation and recombination of traces (engrams) stored in an individual's memory, the initial formation of new temporary links whose correpondence or lack of correspondence with reality will only subsequently become clear.

The activity of the superconscious is always oriented towards the satisfaction of a dominant need, the actual content of which channels "psychic mutagenesis" in a particular direction. Thus "psychic mutations" from the outset have an unpredictable, but not random character. A second channeling factor is the previously acquired experience of the individual, which is fixed in his conscious and subconscious mind.

The interaction of the superconscious with the conscious mind is a manifestation, at the level of human creative activity, of the universal principle of innovation in the process of biological and cultural evolution. The functions of the superconscious and the conscious mind are paralleled by the interaction of unpredictable variation and selection in the origin of new species of living creatures. Just as an evolving population innovates through the selection of particular individuals, so culture as it evolves through

successive generations inherits ideas, discoveries, and social norms which initially arose in the minds of individual inventors and creators.

The failure of an individual to be fully aware of the needs which motivate him removes the supposed contradiction between the objective determination of human behaviour by inherited instincts and environmental and educational circumstances on the one hand, and subjectively felt freedom of choice on the other. This illusion of freedom appears to be an extremely valuable acquisition: it gives rise to a feeling of personal responsibility which stimulates people to undertake a comprehensive analysis of the possible consequences of a particular act. Mobilisation of this kind of information from the reserves of the memory leads to a strengthening of the need which consistently predominates in the particular individual's hierarchy of motivations, and as a result it acquires the ability to withstand situational dominants, i.e., needs which are activated by a situation of emergency.

Reducing human psychic activity to consciousness alone is incapable of explaining either the dialectic of determinism and freedom of choice, or the mechanisms of creativity, or the genuine history of culture. Only by recognising the vital functions of the non-conscious psyche, and distinguishing within it the essentially different phenomena of the subconscious and the superconscious, can we provide a scientific and materialistic answer to the key questions of anthropology.

Research into the non-conscious psyche as a *scientific object* must satisfy all the requirements made of any scientific investigation, including reproducibility of results, quantitative data analysis, use of up-to-date experimental techiques etc. As examples of truly scientific and strictly objective research into the non-conscious manifestations of human higher nervous activity, we can again cite the studies of G.V.Gershuni, E.A.Kostandov, R.Sperry, and other Soviet and foreign authors.

However, the non-conscious psyche is also reflected in art, which is one specific means of comprehending man, man's inner world, and man's interaction with the reality he perceives and transforms. Whereas the *results* of scientific study are directed *solely at the conscious mind* of other people, works of art are directed at the subconscious and superconscious of the perceiver, as well as at his conscious mind. Art evokes subconscious associations in the spectator, it mobilises his subconscious experience and causes him to make subconscious as well as conscious identifications with the heroes of artistic works.

An even more important role in the perception of works of art is played by their effect on the spectator's superconscious: what is presupposed is a response of joint creation on the spectator's part. The process of joint creation makes a distinguished work of art into a truly inexhaustible source of information. This information is extracted from it by every spectator as a bearer of individually unrepeatable life experience, and by every new generation which has addressed itself to great works of art over the course of millennia. It is to the superconscious of the spectator (reader, listener) that the artist's "message" is addressed, a message untranslatable from the language of imagery into the language of logic. This is what K.S.Stanislavsky called the supertask of a work of art. The presence of non-conscious components in artistic perception is reflected in the empirical observation that it is necessary, when contemplating (or listening to) a work, to *feel* rather than *think* one's way into its content, its hidden meaning. In art, according to V.E.Meierhold, it is more important to guess than to know. Since every object has a significance which is common for all representatives of a given culture as well as a purely individual "personal meaning", art, in the opinion of A.N.Leont'ev, "is the sole activity which meets the task of revealing, expressing, and communicating the personal meaning of reality" (Leont'ev, 1983:237).

As a specific means of comprehending reality, art possesses features which are distinct from the fundamental principles of modern scientific knowledge, namely:

- unreproducibility, since every genuine work of art is unique and unrepeatable;
- fundamental unquantifiability, since art operates with qualitative rather than quantitative measurement of the phenomena it treats;
- untranslatability into the language of logic, into the language of discursive thought;
- relative independence from "equipment", since the artist's "instrument" is above all the artist himself.

Just as scientific achievements, technological discoveries, social norms, systems of ethical values, etc. form what we call social consciousness, so works of art fix elements of the non-conscious, subconscious and superconscious psyche and convey them to subsequent generations. This permits us to speak of the existence of a "social non-conscious". If we add in the non-conscious experience which children assimilate through imitation, our conception of the "social non-conscious" can be opposed to the "collective unconscious" of C.Jung, which is acquired

from distant ancestors in ways unknown.

For this reason it is totally unnecessary to "replace" the paradigms of scientific knowledge with principles for comprehending the non-conscious psyche which are supposedly unique to Zen Buddhism, meditation and ancient eastern religions (Nalimov and Drogalina, 1984), inasmuch as these principles have been present in art throughout the thousands of years of its history.

In the cultural and historical process through which art has arisen, a gigantic if not decisive role has been played by the need (instinct) to imitate, which is not restricted to the reproduction of acts performed by other members of the social group. The need to imitate can involve the reproduction of sounds of nature, bird-song and other people's voices, and attempts to reproduce images of surrounding life in the form of pictures, sculptured figures, and body movements which repeat the actions of hunters or the behaviour of animals. This doubling of the surrounding world (its modelling, as we would now say) is one of the means of comprehending the world, since in the very process of reproduction man unavoidably analyses, clarifies and comes to understand the essence of the actions he is reproducing.

A minimum of three features characterise human activity in imitation of the surrounding world. Firstly, in reproducing a given phenomenon, man intentionally or involuntarily expresses his attitude to it, emphasising its meaning as something threatening, cheering, frightening etc. Reflection of the significance of a phenomenon is more important than literal resemblance to an object or formal accuracy in modelling it.

Secondly, reproduction often assumes a symbolic character involving abstract imagery. For example, the objective existence in nature of rhythmically recurring events is reflected in the shapes of conventional ornament, elements of which might retain traces of their origins and be reminiscent of flowers, leaves, etc., or might equally be transformed into purely abstract rhythmical designs.

Thirdly, reproduction (modelling) of surrounding reality is complicated by one further human motivation, the need to play. The creator starts to play with the model he has created, changing its shape, transforming it, and enjoying the power which he holds over the model in contrast to the object that it models. For example, he can make a fearful enemy or terrible predator small, ridiculous, and insignificant, while making himself or the divinity which protects him mighty and invincible.

Nevertheless, we still lack an answer to the question

whether there is some need which can be satisfied solely by the information carried in a work of art. What kind of need might it be? By answering this question, we shall discover a class of emotions which are specific to the perception of artistic works.

In the search for an answer, let us compare two images of a tree: the first in a drawing which illustrates a botanical textbook, and the second in a landscape painted by an artist. The textbook drawing must reproduce the characteristic features of the given species of tree with maximal accuracy. The object whose reflection is an illustration in a botanical textbook is a tree. What is the object which is reflected in the artist's landscape? A tree? Under no circumstances! The object of the landscape is a person contemplating a tree, with a life experience which is individual but at the same time familiar to us, a person with moods, a world of associations, affections and cogitations. "O, I wish to live madly, to immortalise everything that exists, to humanise what is impersonal, to incarnate what has not occurred", wrote the poet Alexander Blok.

Art gives us a unique ability to see our surroundings through another's eyes, to double our own contemplation of reality, to compare our perception with the perception of another person, and to penetrate that person's internal subjective world. Art is one of the ways of comprehending that aspect of reality which cannot be comprehended in any other way.

This comprehension of the internal subjective world of other people is achieved by transferring it onto our own internal world. This transferal is made possible by the similarity of our physical organisation, our higher nervous functions and past life experience, including the assimilated experience of many generations. Here we see revealed the "cognitive function of co-experience" (Simonov, 1979).

F.Engels wrote that we will never find out what chemical rays look like to ants. Those who are worry about this, Engels observed with his characteristic humour, cannot be helped. Nevertheless, Engels's observation is true not only for ants, but also for any creatures, including highly developed ones, as long as they lack the properties which we possess. Let us clarify this idea with an example taken from D.I.Dubrovsky.

... Let us suppose that a highly intelligent alien from another planet has come to Earth to investigate what kind of thing pain is. Let us suppose in addition that the investigator himself lacks all sensation of pain (this

supposition is not all that fantastic, since absence of the sensation of pain can be encountered in humans in certain neurologic illnesses). He succeeds in establishing that when affected by a wide variety of stimuli of a certain intensity (mechanical, thermal, auditory, etc.) human beings regularly show a series of objectively measurable physiological reactions. Blood pressure rises, biologically active substances are secreted into the blood, and characteristic facial expressions, tears, and weeping occur. Even specific alterations in the activity of particular nerve cells can be recorded. Having collected all this data, our alien leaves to give a lecture on pain to the assembled academics of his own planet.

The question is, having all this information at his disposal, does the alien understand what pain is in the same way as we do? The answer is of course not. "Pain cannot be objectified," maintains J.Eccles. "Only interpersonal communication confirms to each of us that the pain which we feel is a reality and not an illusion. All other people possess similar feelings" (Eccles, 1979:176). The essence of the limitations with which we are faced here was well formulated by the American psychologist R.Liper: "... the basic difficulty is that even when there are subjectively distinguishable features which enable each of us to determine to a certain extent whether we are frightened, angry, suffering from loneliness, or having some other experience, *no-one possesses the means to describe these subjective states*, nor can anyone use such means to convey his knowledge to others. Instead, a person is forced to describe the situation which caused his emotional reaction, the content of the thoughts which arise in this situation, or the behaviour which is determined by it" (Liper, 1984).

In addition to consciousness as socialised, shared knowledge, we possess a no less important capability for co-experience, sympathy and compassion: a capability for a special kind of emotional resonance in which the factors determining the emotional state of one living creature activate the nervous mechanisms of another creature's emotions (Simonov, 1979).

Why do we speak of resonance, and not of a "transmission of feelings" through the external expression of emotions? Because the phenomenon of co-experience conforms to the universal law governing the arousal of emotions through information directed towards a corresponding need. However natural and plausible the tears a villain might shed when annoyed at the failure of his misdeeds, we will not shed tears with him. To co-experience is to share the source of a particular emotional state with an observed individual (in

real life or on the stage). Co-experience is based not on a similarity of emotions, but on a similarity of the needs which generate them.

It might be objected that we often respond to an expression of sorrow or joy on another person's face without knowing the cause of his joy or grief. However, such a "direct" transfer of feelings is only an illusion of everyday consciousness. The point is that we involuntarily and unconsciously attribute to the observed subject a motivation which we are ready to share. When we do this, our total life experience is immediately and intuitively mobilised: our attitude towards children, including our own (if a child is crying), and towards our parents (if an elderly person is in sorrow); situations which we ourselves were forced to experience are retrieved from memory etc.

Thus, in the world which surrounds us there are two realities. Firstly, there is the objective world which includes man as a corporal and material being with an extraordinarily complex organisation. This world is for science to discover with its whole methodological arsenal and its conceptual and theoretical apparatus. But there is also the subjective reflection of this world in the human brain, as an aspect or hypostasis of the essentially unitary neurodynamical reflectory brain process. The need present in man for knowledge of the surrounding world, including knowledge of other similar human beings, is not limited to scientific knowledge, analogous to knowledge of all other objects in nature. People have a wish to know how other people see, hear, and perceive the world in order to verify their own perception of the reality which surrounds them, and to enrich this perception with the perceptual experience of others. The restrictedness of scientific (verbalised, discursive) knowledge of the internal life of man can lead to the idea that this internal life is totally unknowable. "Each of us knows the uniqueness of his own internal world. The formation of each unique individuality *lies beyond the limits of scientific investigation*" (Eccles, 1979:144) (our italics - *P.S.*).

However, the process of discovery is not exhausted by science. Beyond the limits of scientific investigation lies... art.

Nothing is more absurd than the idea that the relationship of art to science is that of something simpler and less developed to something more complex and powerful. The system of images and the technical devices used by modern art to comprehend the internal world of man are no less refined than the theoretical apparatus and methodology of modern science. They simply embrace different aspects of

reality, their coexistence being based on a version of the complementarity principle which excludes the replacement of science by art, and of art by scientific knowledge of man.

The artist's message about the world and mankind, about the beautiful and the ugly, about the supreme and the insignificant, is only partially translatable from the language of imagery into the language of logic. Perhaps the most important and most valuable element of the message is inherently non-verbalisable, as is especially clear in the composition and perception of works of music. K.S.Stanislavsky called the message the artist's supertask, and the motivation of the message, the artist's super-supertask. However, it would be a mistake to believe that art is addressed solely to the non-conscious sphere of the human psyche, inasmuch as without doubt the conscious sphere is also involved. We have defined consciousness as knowledge which can be conveyed to another person, whereas knowledge of the world which is contained in the imagery of works of art belongs to the majority of people, sometimes for thousands of years.

Attempts to attribute the perception of artistic imagery solely to the right cerebral hemisphere also seem to be an oversimplification. The artist's message contains both discursive (verbalisable) and non-verbalisable components. Consequently, the perception of the message requires the coordinated activity of both hemispheres. The message (the supertask, according to K.S.Stanislavsky) is characterised by the features outlined below.

Although closely linked to the artist's general world-view, the supertask is not identical to that world-view, since it is a category which is specific to human artistic activity. The supertask does not entail the "translation" of a logically formulated idea into the language of artistic imagery: it arises from the outset as a system of images and can only to a limited extent be reformulated in words.

Just as the goal of scientific knowledge is objective truth, measurable by experimental criteria, so the objective goal of true art is verisimilitude. The verisimilitude of an artistic work, of the profundity and relevance of its human understanding, can be measured by the criterion of social consumption, i.e., by the number of people who over a certain period of time recognise the work in question as a great achievement of artistic talent. Neither short-lived mass popularity, nor long-lived esteem within a restricted circle is evidence of exceptional value in a work of art. Great works serve many generations over many ages.

The performance of a supertask, the creation of a work of art, characteristically involves all three manifestations

of a person's higher nervous functions: his conscious mind, his subconscious and his superconscious. The artist unconsciously uses his accumulations of life experience and professional expertise, including the artistic skills which he first acquired under conscious control, but which then became automatic and entered the sphere of the subconscious, ensuring creative emancipation and permitting full concentration on the fulfilment of the content aspect of the project.

Since art is a form of comprehending reality, it must contain within itself the revelation of something previously unknown to people. The absence of a revelation is a clear sign that the item in question cannot be considered a true work of art. For this reason, a vitally important role in the process of artistic creation is played by the mechanisms of the superconscious: the activity of the superconscious results in the emergence of fundamentally new information, information which until that time has no existence in the cultural accumulations of mankind.

In the creation of a work of art, the conscious mind, the subconscious, and the superconscious interact in highly diverse ways. Thus, many works, including great ones, have been commissioned with a quite precise indication of what should be depicted, and sometimes even the manner of its depiction. However, a commission of this kind, which belongs totally to the sphere of the artist's consciousness, is not yet a supertask, a message which will be carried to the spectator by the prospective work. Commissions arriving from the outside or projects which belong to the author himself merely circumscribe the area within which artistic solutions are to be sought. These solutions generally arise intuitively, and during the initial stages of their formulation are free from conscious control. In the majority of cases, what we have is a series of possible solutions which are subjected to conscious selection and exacting criticism, a stage which has often been described as "creative torment". However, the final selection again belongs to the superconscious.

Even if an artist attempts a logical explanation and justification of his selection, what he says must be treated with great care. We have already said that a supertask cannot be translated from the language of imagery into the language of logic, and consequently its selection cannot in principle have an exhaustive logical justification. It is true that there are cases of fully rational selection, dictated by factors of a non-artistic order. However, an artistic discovery can only be made by those for whom the motivational dominant is the need to discover "the life of

the human spirit" (K.S.Stanislavsky), and to communicate the results of their search to the spectator (listener, reader). If artistic activity serves as a means of satisfying any other needs, such as those connected with career, status, or material welfare, then creative intuition will be directed accordingly, sometimes with great success. K.S.Stanislavsky's appeal that people should love art in themselves, and not themselves in art, is based on this law.

The superconscious draws the material for its activity both from fully conscious experience and from the reserves of the subconscious, where the technical skills of professional expertise are concentrated. That is why particular importance attaches to the constant replenishment of these reserves, the wealth and diversity of life experiences, and the professional training so familiar to every true artist, no matter what heights he has achieved in his creative activity.

As far as the perception of artistic works is concerned, the artist's message is likewise directed not only to the the spectator's conscious mind, but also to his subconscious and superconscious. The appeal to the subconscious mobilises the experience of the spectator which has previously been under conscious control, but has then become so organically assimilated that the interference of consciousness is unnecessary. In fact the spectator (listener) is often unable to explain what it is in a work of art which evokes a particular emotional response, set of associations, or change of mood. No less important in perception is the role of the superconscious, the response of joint creation which results in each spectator perceiving one and the same work of art to a significant extent in a purely individual manner.

Scientifically established laws, deductions and mathematical formulae are the same in content to anyone who studies them, they are addressed solely to the conscious mind, and any vagueness, ambiguity or possibility of different interpretation demonstrates that the scientist's work is incomplete. A work of art permits an infinite number of interpretations and in this sense is inexhaustible[1]. Each generation of spectators includes the artist's message in the context of its experience, its culture, and its system of values. This ability to affect the spectator's subconscious and superconscious directly is one of the most

[1] The question of the "polysemanticity" of art and the "monosemanticity" of science is analysed in detail by A.N.Rubtsov (1985).

characteristic features of art: it gives art a special conviction and spares the artist the necessity of logically proving the truth of his message about the world and mankind. This is why, in distinction to science, which is limited to the pursuit of relatively objective truths, art is capable of satisfying the human need for absolute truth.The special conviction of artistic imagery was noted by H.Hegel. "Art," writes Hegel, "has the task of revealing truth in a sensual form, and consequently carries its final goal within itself... Its goal is the sensual depiction of the total absolute" (Hegel, 1938:50-52).

This, however, does not mean that every artistic message must be totally and uncritically trusted. In the same way that the criterion for the correctness of scientific knowledge is objective truth, the criterion for artistic knowledge is verisimilitude, as revealed in the way a work of art is perceived by society. Attempting falsehood in art is just as fruitless an occupation as trying to invent a perpetual motion machine which contravenes the basic laws of nature. "No-one can invent or contrive at will," maintained Gabriel Garcia Marquez, "since this is fraught with the danger of fabricating a lie, and lies in literature are even more dangerous than in life. Within the apparent freedom offered by creativity, strict laws operate" (Marquez, 1982:15).

Now we are in a position to discuss the nature of the emotions which arise in the perception of art. One version which has been published in hundreds of works goes roughly like this: the artist experiences certain feelings; he codifies these feelings in the imagery of his work and conveys them to the spectator (reader, listener); the spectator is imbued with these feelings and shares the experience with the author. However Schopenhauer long ago noted that real musicians do not express feelings in music, but convert music into feelings. "The experiences and emotions of an actor," wrote L.S.Vygotsky, "are not a function of his personal spiritual life, but a phenomenon which has an objective social meaning and interpretation, acting as an intermediate step between psychology and ideology" (Vygotsky, 1984:328).

How can this be?

As we have attempted to show above, the artist's task is not to experience feelings and to arouse these same feelings in the spectator, but rather to comprehend and thereby humanise the surrounding world, to discover its unknown bounds, and to convey the results of his knowledge to other people. Inasmuch as the spectators possess an analogous need for knowledge, including knowledge of the internal world of

another person, the information contained in a work is capable of satisfying the spectators' needs. According to the information theory of emotions, an increase in the level of informedness evokes the positive emotions of satisfaction and enjoyment, which are usually called "aesthetic emotions". If the spectator's prior level of informedness eclipses the artist's message, if the spectator fails to receive something which is new and which exceeds his expectations, he will remain indifferent or experience negative emotions: disappointment, boredom, irritation. The ability of a work of art to generate emotions whose origin is far from being always obvious to the perceiver is described in common language as an address to the heart of the spectator, as well as to his intellect.

Since art is addressed to a whole range of human needs, and the satisfaction of any of them can generate its own emotional response, the result is a complex polyphonic emotional chord. For example, cult works of art lose their religious meaning for subsequent generations, and cease to evoke the corresponding emotions whilst maintaining their aesthetic value. An analogous role is played by social needs, including the kind of social need which can be defined as the need for justice. The historically transient and class-determined norms for the satisfaction of this need are capable of generating the extremely strong emotions of indignation, admiration for the hero of an artistic work, and contempt for his enemies. The ability to appeal to the social needs of man has at all times made art one of the sharpest weapons of ideological battle. In the fray, some works have been burnt on bonfires, and others have become battle standards, like the Marseillaise and the Internationale.

How though can we account for the repetition of emotional experience when a single work is appreciated again and again? What in this case is the source of the increase in informedness essential for aesthetic enjoyment? We have already said how the interpretation of great works is practically inexhaustible. Each time the spectator repeats his appreciation, new sides, new facets, and new nuances are revealed in the artistic message. These revelations are also affected by changes in the spectator's prior level of informedness connected with the acquisition of life experience and aesthetic understanding. If we consider the performing arts (music, dance, drama), novelty is also introduced by the personality of the performer and the individuality of his interpretation. Thus, emotionality is maintained even in the appreciation of well known works.

Consider now the experiences of the artist, who remains

cold and cannot himself agitate the spectator. What is understood in this case by the everyday description is the presence in the artist of a relatively strong need to know and to perform. In addition, of course, the artist must be armed with natural abilities and professional expertise. This truth was well understood by K.S.Stanislavsky, who rejected the "art of feelings" in favour of the supertask and "physical actions". In Stanislavsky's case, the art under discussion was drama, but by analogy to action for the dramatist we have the spoken word for the poet, sound for the musician, and paint for the painter. Stop worrying about feelings, Stanislavsky appealed, they will come by themselves if the supertask is significant and the actions are performed with verisimilitude.

It must also be added that the appreciation of art is profoundly dialectical. The information contained in a work of art not only satisfies the corresponding needs of the spectator, but also actualises, forms, and awakens them. A person who goes to the theatre to be entertained or to see a famous artist may come out shaken by the truth which has been revealed to him about the world, about people, and about goodness and evil. In this we see the educational function of art, its ability to enrich, expand and elevate the sphere of human needs. The emotions which arise in this case will be the truest indicator of the presence (or absence) of newly awakened needs and the extent to which they are satisfied or unsatisfied, but are by no means themselves the goal of the artistic endeavour.

Chapter 7

EDUCATION AS MOTIVATION

An investigation of the laws and brain mechanisms of human emotions, the dependence of emotions on needs and drives, and conditions for satisfying needs which are multifaceted, continuously developing, and increasing in complexity, is of paramount importance in the formation of a scientific basis for education from the earliest possible age. As school reform progresses, we become ever more aware of the gap which exists between training and education, between the accumulation of knowledge and the formation of emotional and motivational orientations in children and adolescents.

The existence of any human society cannot occur without the observance by its members of historically conditioned norms of behaviour which regulate a variety of rights and obligations. The goal of education in the widest possible sense is that every young citizen who enters into society should know these norms and follow them. In other words, education appears to be a special case of training.

However, the evident similarity between education and training hides unexpected paradoxes and gives rise to serious difficulties. The point is that knowledge of norms does not in itself guarantee that these norms will be followed. The philosopher A.Kharchev writing recently in the journal Kommunist says: "... the system of social values which is presented in the classroom has an insufficient influence on the actual behaviour of pupils. In other words, while giving instruction on values, schools fail to engage in (or engage very little in) the formation of individual value orientations in their pupils, and have neither methodology, nor systematic and scientifically based experience in this field" (Kharchev, 1984:48). A similar evaluation of the situation can be found in a Pravda leading article devoted to the education of feelings. "The education of feelings cannot be reduced to the assimilation of particular rules and moral norms. The reason is as follows: a person may know the rules but not follow them in his actual behaviour. The life force of the norms and rules of socialist society is revealed when they are "transformed" into an active feeling and have become a direct stimulus and

motivation for personal activity" (Pravda, 1984, No 330: 1).

As in all training, the requirement to follow existing norms is reinforced by encouragement and punishment, i.e., by positive and negative emotions. It is here that the source of the serious deficiencies in everyday educational practice is to be found.

Emotions themselves have no social (and hence educational) value, because their value depends totally on the need whose satisfaction or lack of satisfaction causes the particular emotional state to arise. We often show very poor discrimination in choosing the means to encourage observance of the norms accepted in our community. Without knowing and generally without questioning what the most important values for a particular child at a particular age are, many parents are deeply convinced that such things as tasty food, fine clothes, pocket money, tape recorders and books are fully sufficient for a child to repay them with gratitude and undeviating observance of the norms which characterise an educated person.

The paradox is that the means we have selected to mould desirable behaviour can easily become its goal. The need for economy of effort plays a not insignificant role in attempts to shorten the path to the receipt of a desired reward or to avoid a possible punishment. "In thirty years working in the classroom," reminisces V.A.Sukhomlinsky, "I had to sort out a hundred seemingly identical acts: e.g., an adolescent hiding unsatisfactory marks from his parents. But each case has its own causes, its own moral and emotional motivation..." (Sukhomlinsky, 1979:49). What we have said applies not only to the avoidance of punishment or the receipt of material incentives. When it is transformed into a goal, even social approval or praise on the part of adults can engender a deliberate demonstration of obedience, ingratiation and obsequiousness. V.A.Sukhomlinsky correctly pointed out this danger: "... it is very important that a positive social evaluation of individual worth should not take the form of prizes and rewards, or a comparison of one individual's worth with another's faults. Instead of collectivism, an evaluation of this kind fosters careerism in children, dangerous in that it can carry enough spiritual charge for a lifetime: a young careerist develops into a grown-up scoundrel" (Sukhomlinsky, 1979:58).

Thus, the first principle of a productive theory of education must be a decisive switch from training in the mere knowledge of behavioural norms to the deeper fundamentals of behaviour: to the formation in the pupil of a hierarchical set of needs which are most favourable for the progress of society and for the development of

personality in all its potential richness.

But how can we form a socially desirable structure of needs when by their very nature needs are not subject to the direct influence of consciousness and will? When, quoting Schopenhauer's pertinent remark, man can do what he wants, but he cannot want what he wants? When the world of needs to a significant extent belongs to the non-conscious psyche?

In the familiar sense, it can be said that in contrast to training, which addresses itself almost exclusively to the individual's consciousness, education is directed primarily at the pupil's subconscious. It is because of the subconscious that social norms which are external in relation to the individual are converted into internal regulators of his behaviour, and become unusually categorical in the process of internalisation. How can we succeed in making a socially valuable norm of behaviour into a sense of duty, a decree of the heart, a voice of conscience? This is the question which a scientifically based theory of education must answer.

Thus far, only one method has been known for directly affecting the subconscious: the force of direct example, based on the need to imitate which is especially vividly expressed in early childhood. The power of the behavioural models which a child encounters in his immediate surroundings is well illustrated in an incident quoted by S.Soloveichik. "A colleague of mine once gave the following answer to a question about his education: «My father did not bother with me. But whenever I woke up in the middle of the night, I could see a gleam of light under the door of his room. He was working... That gleam was what educated me!'" (Soloveichik, 1985:194). On the other hand, imitative behaviour (especially group behaviour) easily prevails over any reasoning which we address to a pupil's consciousness, or any explanation concerning the advantage of what is "good" and "useful" over what is "bad" and "harmful". If from early childhood a child were only to encounter examples of well-adjusted behaviour consistent with the norms, the cultivation of a socially valuable personality would cease to be a problem of special concern. However, reality is far from this Utopian ideal. At this point, what springs readily to mind is Karl Marx's appeal not to forget "that the educator himself must be educated" (K.Marx and F.Engels, Works, 2nd Edition, Vol 3:2).

The fact that the methods of directly affecting the subconscious are restricted, as well as their openness to criticism (inasmuch as imitative behaviour easily duplicates and consolidates examples of socially unacceptable behaviour), causes us to seek out indirect ways of

approaching needs and motivations. We have emphasised above that the emotions generated by information about the means and methods of satisfying particular needs are the most important mechanism involved in the transformation of motivations and the competition between them. This means that needs must be approached through the conscious mind of the individual, or to be more precise, through the process of arming him with information which will assist in the development and consolidation of socially valuable motivations, and prevent them from being transformed in a socially unacceptable and personality-deforming manner. A precise comment is once again provided by Sukhomlinsky: "The contradiction between a wealth of desires on the one hand, and limitations of strength, experience and means of bringing them to fruition on the other, represents a complex process of self-affirmation" (Sukhomlinsky, 1979:55).

The "unprepared" state of the vital, social and ideal needs seething in every adolescent is the real and only reason for the objective and subjective "difficulty" of the teenage years, the topic of hundreds of publications. The question "Would you like to be sixteen again?" was given the following answer by academician E.Andronikashvili: "I would not, because at that age I experienced a terrible feeling of dissatisfaction caused by the chasm which existed between the magnitude of desires on the one hand, and the possibilities of satisfying them on the other" (Andronikashvili, 1979:2). Consequently, the first task of education is to arm the child with such means of satisfying his natural, inalienable, and intrinsically organic needs as are of equal benefit both to society and to the individual. Let the child compete, but in work and sport rather than in street fighting. Let him assert himself in the eyes of his peers through acts of generosity, and not through hooligan pranks. Let him demonstrate his adulthood by the maturity of the decisions he makes, and not by his smoking and the amount of drink he can take. The necessity for children's needs to be "channelled" in a socially acceptable direction, instead of battling against needs themselves, was aphoristically formulated by Yanush Korchak: "You are hot-tempered, I say to the child. Fine, go on fighting, but don't hurt anybody. Get angry, but only once a day. These few words, if you like, sum up my pedagogical method" (Korchak, 1978:13). Reason does not condemn natural instincts, Hegel maintains, but directs and ennobles them. This idea is developed by I.I.Lobachevsky: "It is becoming commoner and commoner to hear complaints about passions, but as Mably correctly observed, the stronger passions are, the more useful they are in society; only the direction of

passions can be harmful" (Lobachevsky, 1976:41).

Channelling the satisfaction of needs in a direction desirable to the educator is made easier by the fact that a supplementary *need for preparedness in itself* occupies a dominant position in the motivational hierarchy of children and adolescents throughout many years of their lives. When a child is training his motor coordination in what seems to us to be an "aimless" effort to imitate adult actions and to reproduce adult behaviour in his play, he is *continuously preparing himself* for the sake of being prepared, non-consciously accumulating skills and abilities, most of which will be needed only later in life. Unfortunately, we by no means always recognise this specific need and use it in our pedagogical practice, although the need *to have abilities and power* is no less strong than the need *to know*, and the satisfaction of this need can be a source of positive emotions which are no less vivid than the satisfaction of childish curiosity.

The transformation of creative work into a vital need, a source of enjoyment and pleasure in life, into a means of developing abilities, is correctly regarded as the most important manifestation of the Leninist "law of heightening needs" (Pechenev, 1976). In the hierarchy of human values, working according to one's abilities occupies one of the highest positions (Mazur, 1984). However, it is no secret that at the present stage in the development of socialist civilisation society has an objective need for a significant amount of non-creative, routine, and "non-prestigious" work. Does this mean that the only motivations for work activity of this kind are material reward and social duty? We suppose not.

A high level of skill and professional expertise, satisfying an individual's need for preparedness, is capable of becoming a source of positive emotions in the performance of any task. As a rule, when we speak of professional prestige, we are comparing one profession with another. Much less attention is paid to "vertical" prestige within a single profession. Although it might be objected that there are such things as "professional contests", for example, in lumberjacking, milking, and hairdressing, these contests generally lay stress on social motivations, on work as a means of achieving a goal, and are not connected directly with the actual working process. What we are talking about is the pleasure which arises out of a sense of expertise, free mastery of the tools of production, and stylishness in performing what seem to be the most commonplace and routine operations.

A high level of professional preparedness has a

significant influence on the formation of a person's character, self-assertiveness, and feelings of dignity. From an early age it is essential to form in children and adolescents the conviction that being a first-class representative of any occupation is not only more honourable but also more pleasurable and enjoyable than being a mediocrity with a prestigious diploma in one's pocket.

Thus, the need-informational approach to the theory of education is based on the following propositions. There are no good and bad needs, high and low needs, or reasonable and unreasonable needs. All basic needs are organically present in every human being: they cannot be annihilated or artificially implanted. What is reasonable and unreasonable, or lofty and base, can only be the way in which these needs are satisfied, the way they are transformed or harmoniously combined, or the abnormal predominance of certain motivations to the detriment of the satisfaction of others.

Thus, the foremost task of education is to channel needs in such a way that the abilities of the individual are maximally developed, and that this development is consistent with the actual achievements of the whole community and the prerequisites for its future evolution. There are two ways of channelling the satisfaction of needs in a direction which is desirable for the community: (1) directly influencing the conscious and subconscious mind of the individual by encouraging the imitative reproduction of behavioural models, and (2) arming the individual with socially valuable means and methods of satisfying his needs.

Now the central question must be posed: which needs must be armed in the first instance and to the greatest extent, thereby ensuring their domination in the individual's motivational structure? Clearly this question cannot have a universal answer. Each epoch and each society creates an ideal personality which most distinctly embodies the system of values accepted in that society. For our society, this ideal is to be found in the moral code of the builder of communism. Inasmuch as man has historically accumulated the highest achievements of human civilisation, we can use for further analysis L.N.Tolstoi's conception of the good person as one who lives primarily by others' feelings and by his own thoughts.

The "dominant towards another person" which A.A.Ukhtomsky (1973:384) wrote about is essentially the predominance of the need "for others", a developed capability for sympathy and co-experience. We said earlier that the phylogenetic roots of this capability can be found as early as in the pre-human stages of evolution in the form of so-called emotional resonance. In a polemical exchange

with sociobiologists, J.Eccles suggests distinguishing between inborn pseudoaltruism and genuine altruism, which has to be learnt in the same way as one learns a language (Eccles, 1980). The sharing of food, according to Eccles, is the first sign of genuine altruism known to anthropologists. Another of his examples is the maintenance of the life of one individual through the efforts of other members of the group. In 1971 two skeletons were discovered of Neanderthal men who lived sixty thousand years ago and survived for two years after a trauma only because they were looked after by their fellows.

The following experiment demonstrates the role of training in developing the ability to recognise signals of the emotional state of another individual. Out of a hundred mothers with children aged 8-12 months, only a third observed the emotional reactions of their children and could give a good account of what these reactions meant. Another third learnt how to recognise the signals after instruction. It is most important to commit oneself to the development in children of the capability for co-experience, compassion and sympathy which V.A.Sukhomlinsky graphically called "the work of the soul". "The 'work of the soul'," wrote Sukhomlinsky, "is suffering, bearing the pain of another person's misery and torment, especially that of a mother, father, sister, grandfather or grandmother. Do not be afraid to open young souls to this suffering, they are grateful for it. Let a nine-year old son stay awake at night at the bedside of his sick father or mother, let another's pain fill all the nooks and crannies of his heart. One of the most agonisingly difficult tasks in teaching is imparting to a child the hardship of love" (Sukhomlinsky, 1971:4). It is important that the child should not simply feel mere emotional discomfort at the sight of a sick or unjustly offended individual, that he should not simply try to get rid of this burdensome "co-experience", but that he should try to help and experience the positive emotions which follow from successful actions aimed at relieving the lot of another person. "Dreamy love," said Dostoevsky, "thirsts for rapid feats bringing quick satisfaction and the attention of all... Active love is exertion and restraint, and for others, in all probability, not an easy subject to follow" (Dostoevsky, 1958:75).

It is absurd to contrast the needs "for self" and "for others" as mutually exclusive, not only because they can objectively coexist, but also because the need "for self" has very important social functions. While the need "for others" makes a person benevolent, i.e., from the outset he expects good from every new encounter (although this

expectation may of course not be justified), the need "for self" generates feelings of individual worth, independence of judgement, and originality of thought. It should be remembered that in Tolstoi's opinion the "best possible person" lives by others' feelings, and not by others' thoughts.

The importance of developing moral independence and a crtical attitude to the behaviour of others was well formułated by the husband-wife team, the Nikitins: "We aim to bring up a child in such a way that in complex situations he has learnt not to act out of fear or with a view to advantage, not out of revenge or with a desire to have his own way, but out of a sense of *justice*. He should be able to *evaluate* each situation, decide who is right and who is wrong, and which side to join. He should know how to orient himself in relation to moral values" (Nikitina and Nikitin, 1979:6-7). This is how the young boy Seriozha behaved in the film "Sun in the Pocket": when the whole class voted to punish Vera, a first-former who had altered her marks from "satisfactory" to "excellent", he rose and said: "I want her to be forgiven!" Later in the film the heroine Anya talks at home how she raised her hand like everyone else, and how Seriozha behaved. "What a lucky mother Seriozha has!" observes Anya's mother.

Seriozha's choice was dictated by his motivational dominant. Perhaps this was sympathy, perhaps an assertion of the right to a different opinion, and perhaps something else. But in any event the motivational dominant caused the superconscious to become involved in the search for a non-standard, non-trivial solution, an "independent idea" about what was happening.

In the formation and development of the superconscious (intuition, creative imagination), enormous importance attaches to the play activity of children. Competitive games require the child to be daring, to look for unexpected solutions which can stalemate an opponent with stereotyped ideas. Undervaluation of the need to play, especially at a particular age, can have very serious negative effects. Even in higher animals an inability to play sharply and sometimes irreversibly leads to a subsequent deterioration in the ability to acquire complex skills. Play is valuable because it teaches the child to accumulate independent knowledge about the surrounding world, to actively seek answers to the questions which arise rather than passively make use of knowledge attained by others.

No matter how significant the future successes of a scientifically based theory of education are, its practice will always remain an art, and the activity of the educator

will preserve features which resemble the creativity of an artist. This resemblance is based on at least two factors.

Firstly, in distinction to training, which is addressed exclusively to the child's consciousness, education like art is destined to affect the pupil's subconscious and superconscious. A state of genuine education presupposes not just a knowledge of the norms and an observation of socially accepted rules with the aim of being rewarded or of avoiding punishment, but an inability to violate principles which have become the regulators of activities and actions. In the subjective unawareness of the objective advantages of pro-social behaviour lies the essence of the moral dialectic.

Secondly, the individualisation of educational influences is incomparably greater than in training. Every pupil has a unique, unrepeatable personality, and the way this personality is formed genuinely suggests the creation by the educator of a unique "work" of intellect and talent. For this reason it is necessary to make a clear distinction between the "technology of education", which is more or less universal and therefore capable of being put forward as a collection of scientifically based rules, and education as creation which is oriented towards each individual pupil. In the latter case the compilation of a set of generally applicable prescriptions is as senseless as it is unproductive. The arsenal of a genuinely talented educator must always contain intuition, unexpected "moves", and a modus operandi which is uniquely applicable to the given situation.

THE NATURAL SCIENTIFIC BASIS OF KEY CONCEPTS OF GENERAL PSYCHOLOGY* (IN PLACE OF A CONCLUSION)

> The science of human higher nervous functions must be considered one of the social sciences... As the science of higher nervous functions develops, it will show even closer links with the social sciences. ... Only on this scientific basis will it be possible to create organisations for the correct education and training of people. Only on this scientific basis will it be possible to seek the correct forms of organisation for human work and leisure. And most important, only on a scientific basis will it be possible to create a healthy and effective structure of society.
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> P.L.Kapitsa (1981:419)

Most complex unconditioned reflexes, instincts: a form of behaviour which is innate and specific to a given species of animal, and whose formation is completed in postnatal ontogenesis under the influence of and in interaction with conditioned reflexes. Most complex unconditioned reflexes are an integral behavioural complex, a systems morphophysiological formation which includes both motivating and reinforcing components (preparatory and executive reflexes, according to Konorski).

The most complex unconditioned reflexes can be divided into three groups. The actualisation of vital reflexes does not require the involvement of another individual of the same species, and a failure to satisfy the corresponding

*The concepts defined here do not follow alphabetic order, but the order in which they are introduced in the book.

need leads to physiological destruction. Examples of vital reflexes are the food, drink, sleep-regulating, defensive, and economy of effort reflexes. Role (zoosocial) unconditioned reflexes can be actualised only through interaction with individuals of the same species. These reflexes underlie sexual, parental, territorial, hierarchical and other such behaviour in which the individual animal plays the role of marriage partner, parent or offspring, "master" of a territory or "newcomer", leader or follower. Unconditioned self-development reflexes are not connected with individual and species adaptation to the current situation prevailing at a particular moment, but facilitate the mastering of new spatio-temporal environments, whether it be exploratory behaviour, the freedom reflex (resistance to coercion), the imitation reflex or the play reflex. The most complex unconditioned reflexes of animals form a phylogenetic prehistory of human needs, which are qualitatively transformed by the process of cultural and historical development.

Need: a specific (essential) force of living organisms which facilitates their link with the external environment for self-preservation and self-development, and a source for the activity of living systems in the surrounding world. The preservation and development of a human being are manifestations of this force, which is possible only because the world contains "***objects*** of his ***needs***; ... ***objects*** which are indispensable for the activation and consolidation of his essential forces" (Marx and Engels, Works, 2nd Edition, Vol 42:163). Because of the neurophysiological mechanism which activates traces (engrams) of the external objects capable of satisfying a need present in the organism, and of the actions which previously resulted in its satisfaction, the need is transformed into a motivation, becoming an "objectified" need. Human needs can be divided into three basic groups which are independent from each other in origin: vital needs, social needs, and ideal needs for knowledge and creativity. Within each of these groups, preservation and development needs can be distinguished, and in the group of social needs, needs "for self" (rights) and "for others" (obligations). The satisfaction of any of the needs listed above is aided by additional needs, the need for preparedness (in means, knowledge, and abilities), and the need to overcome obstacles on the path to a goal, usually called the will. The need for preparedness is to a significant extent satisfied through imitation and with the aid of play, especially during the early stages of individual development. "The magnitude of so-called essential needs, like the magnitude of the means for

satisfying them, is itself a product of history" (Marx and Engels, Works, 2nd Edition, Vol 23:182). Needs are a fundamental phenomenon of higher nervous (psychic) activity, and a motive force for behaviour up to and including the world-transforming activity of man.

Personality: the individually unrepeatable composition and internal hierarchy of the basic (vital, social, idealogic) needs of a given person, including the varieties which exist for preservation and development, "for self" and "for others". The most important characteristic of personality is its dependence on which of these needs occupies a dominant position in the hierarchy of competing motivations and for how long, and which of these needs is "worked on" by the mechanism of creative intuition (the superconscious in K.S.Stanislavsky's terminology). The true nucleus of personality, its most essential characteristic, is the supreme need, i.e., the need which dominates more frequently and more long-lastingly than other needs, the super-super-lifetask of the given individual (Stanislavsky). "If a person carries out a particular moral act, he does not thereby automatically become virtuous; he is virtuous only in the event that this kind of behaviour is a constant feature of his character" (Hegel, 1934:186). That is why personality tests must be a system of methodological devices which permit an answer to the question of the extent to which the value orientations of the given personality are determined by its vital, social, and ideologic needs, its directionality towards self and towards others, and its inclination towards preservation and development. Just as the needs of mankind as a whole are a product of world history, the assortment and interrelationship of needs in every individual is a product of that individual's own life history, the particular circumstances of his upbringing, and his ontogenetic development. Despite the importance of natural dispositions and abilities, personality is formed under the decisive influence of a particular social environment.

Will: the need present in man to overcome obstacles on the path to the satisfaction of any need which was the primary initiator of behaviour. The independence of will as a specific need is demonstrated by its ability to generate its own emotions in connection with success or failure in overcoming barriers prior to the achievement of the final goal. The phylogenetic precursor of will is the freedom reflex discovered by I.P.Pavlov in higher animals and later described by ethologists as the "motivation to resist coercion". For human beings, a competing need can itself become an obstacle on the path to a goal. In that case, the

dominance of one of the competing needs will be determined not only by its strength, but also by the emergence of the activity to which the subordinate need is an obstacle, an "internal blockage". The activity stimulated by the obstacle is capable of relegating the initial motivation to the background, in which case overcoming becomes a goal in its own right, and will is transformed into obstinacy. The antipode of will seems to be suggestibility, including predisposition to hypnosis. This allows suggestibility to be used as a test for evaluating the volitional characteristics of personality.

Character: the individual intensity and composition of the additional needs present in a given person, including the need to overcome, the need for preparedness, the need to imitate, and the need for economy of effort. The need to overcome underlies the volitional qualities of the individual, and the extent to which the need for preparedness is satisfied imparts confidence, decisiveness, and steadfastness in extreme situations. A high level of preparedness, whether the individual is consciously aware of it or not, makes him calm and independent and allows him to maintain self-control in complex and quickly-changing circumstances. Depending on which of the basic needs is dominant, insufficient preparedness results in a character with features of anxiety, preoccupation with status, an envious attitude to the successes of others, and dependence on their patronage and support. The tendency to imitate determines the extent to which the individual's acts are carried out independently, and the need for economy of effort makes the character energetic and purposeful, or, conversely, passive and lazy. "The strength of the nervous system (temperament)," wrote I.P.Pavlov (1954:618) is an inborn property, but character (form of behaviour) largely consists of acquired habits".

Emotion: a reflection in the brain of human beings and higher animals of some actual need and the probability (possibility) of its satisfaction. The individual carries out this evaluation of probability on the basis of inborn and previously acquired experience, involuntarily comparing information about the means, time, and resources predicted to be necessary for the achievement of a goal (satisfaction of a need) with information arriving at a particular instant. Prediction of the probability of achieving a goal in man can be achieved either at a conscious or a non-conscious level of higher nervous functions. An increase in the probability of achieving a goal which results from the arrival of new information generates positive emotions which are actively maximised by the individual in order to

strengthen, prolong, and repeat them. A decrease in probability in relation to a prior prediction leads to negative emotions which the individual tries to minimise, i.e., weaken, interrupt, avoid. Thus, an emotion in the neurophysiological sense of the term is an active state of a system of specialised brain formations which stimulates the individual to alter his behaviour so as to maximise or minimise that state. This determines the reinforcing, switching, and compensatory (substitutional) functions of emotions in the organisation of goal-directed behaviour. The need-informational approach to the study of emotions has permitted us to single out, amongst the brain structures which participate in the generation and activation of emotional reactions, both so-called executive centres (hypothalamus, central gray matter), and structures which are primarily connected with the motivational (amygdala) and informational (frontal regions of the neocortex, hippocampus) components of emotions. The secondary nature of the emotional specialisation of the cerebral hemispheres, masking complex informational processes, has also become obvious, as has the primary connection of the right hemisphere with the motivational and the left hemisphere with the cognitive components of emotions. An individual with a left-hemisphere lesion has a rich assortment of needs and an insufficiency of means for satisfying them, while a patient with a right-hemisphere lesion has an excess of means for satisfying a greatly impoverished set of drives. This gives rise to a secondary tendency towards the predominance of negative or positive emotions.

Behaviour: those forms of life activities in humans and animals which alter the probability and duration of contact with an external object capable of satisfying a need present in the organism. The interruption or avoidance of a harmful influence on the organism, satisfying the need for preservation of the individual, its offspring, or the whole species, is a special case of behaviour. The most complex unconditioned reflexes (instincts), which consist of excitatory and reinforcing reflex links, are innate forms of behaviour. A functional unit of individually acquired behaviour is formed by the interaction of a dominant (A.A.Ukhtomsky) and a conditioned reflex (I.P.Pavlov). The synthesis of the mechanisms of a dominant with the formation mechanisms of a conditioned reflex provides for the two factors which are necessary and sufficient in the organisation of goal-directed behaviour: its active, creative character (the dominant), and its accurate correspondence with objective reality (a consolidated, finely specialised reflex). The dominant, the conditioned

reflex, and the memory play the same role in the organisation of individual behaviour as variation, selection, and inheritance in the process of phylogenesis.

Type of higher nervous activity (temperament): the totality of the individual characteristics of a person's psyche and behaviour, manifested mainly in his attitude to the surrounding world and to himself. The type of a given individual is based on so-called general properties of the nervous system, according to the following parameters: (1) extraversion-introversion; (2) emotional stability: neuroticism (similar to Pavlov's scale of strong to weak nervous system); (3) the parameter which Pavlov called mobility of nervous processes (or its opposite, inertness). Experiments on animals involving successive destruction of a series of macrostructures in the brain, and the breeding of lines with different volumes of brain formations, permitted the hypothesis that the individual characteristics described as temperaments by ancient authors, types of nervous system by Pavlov, and parameters by Eysenck, are based on individual characteristics of the interaction between the frontal regions of the neocortex, the hippocampus, the amygdala and the hypothalamus. The correlation of the "informational" system (the frontal cortex and the hippocampus) with the "motivational" system (the amygdala and the hypothalamus) determines the degree of extraversion-introversion, whereas the correlation of the "frontal cortex-hypothalamus" with "hippocampus-amygdala" systems determines the level of emotional stability, or strength of the nervous system in Pavlov's terminology. Of great importance for the mobility (inertness) factor in its Pavlovian conception is the activity of the "hippocampus-hypothalamus" system and its correlation with the macrostructural system "amygdala-frontal cortex". One of the indices of mobility can be the range of alterations typical for the particular individual in the frequency and amplitude of the theta-rythm, and the markedness of this rhythm in comparison with other EEG rhythms. The Pavlovian "specifically human" types can, it seems, be treated as the result of individual variations in the functional asymmetry of the cerebral hemispheres, where the "artistic type" corresponds to a relative predominance of the right ("non-verbal", concrete-imagery) hemisphere.

Consciousness: a specifically human form for reflecting reality, operating with knowledge which, with the aid of the second signal system (words, mathematical symbols, the images of artistic works), can be conveyed to other people, as well as to other generations in the form of cultural memorials. When one individual conveys his knowledge to

another, he thereby separates himself both from this other individual and from the world, knowledge of which he is conveying. The communicative origin of consciousness makes it possible for an individual to have a mental dialogue with himself, i.e., leads to the emergence of self-consciousness. The internal "ego" which judges an individual's own acts is simply an internalised "alterego". Recent research, including research on the lateralisation of the cerebral hemispheres, has shown that the maintenance of links between the gnostic areas of the cortex and the language structures of the brain is a necessary condition for the functioning of consciousness.

The subconscious: a variety of non-conscious psyche which includes all that was once conscious or can become conscious in particular circumstances, i.e., well automated skills which have therefore ceased to be conscious, motivational conflicts which have been excluded from the sphere of consciousness, deeply assimilated social norms whose regulatory function is experienced as a "voice of conscience", "call of the heart", "feeling of obligation", etc. The subconscious also includes manifestations of intuition which are not connected with the generation of new information, but use only previously accumulated experience. The subconscious protects the conscious mind from excess work and psychic overloading. As well as through previously conscious experience, which fills the subconscious with concrete material that is external in origin, there is also a direct channel of influence on the subconscious, in the form of imitative behaviour. For example, through imitation a child non-consciously consolidates those models of behaviour which are to be found in his immediate surroundings, and which will in time become internal regulators of his acts.

The superconscious (creative intuition) is found in the very first stages in creativity, which are not controlled by consciousness or will. The non-conscious nature of these stages serves to defend incipient hypotheses ("psychic mutations and recombinations") against the conservatism of consciousness, against the excessive influence of previously acquired experience. The conscious mind is reserved for the selection of these hypotheses through logical analysis, and by the use of practical criteria in the broadest sense of the word. The neurophysiological basis of the superconscious is the transformation and recombination of traces (engrams) stored in an individual's memory, the initial formation of new temporary links whose correpondence or lack of correspondence with reality will only subsequently become clear. The activity of the superconscious is always oriented

towards the satisfaction of a dominant need, the actual content of which channels "psychic mutagenesis" in a particular direction. A second channeling factor is the previously acquired experience of the individual, which is fixed in his conscious and subconscious mind. The interaction of the superconscious with the conscious mind is a manifestation, at the level of human creative activity, of the universal principle of innovation in the process of biological and cultural evolution. The functions of the superconscious and the conscious mind are paralleled by the interaction of unpredictable variation and selection in the origin of new species of living organisms. Just as an evolving population innovates through the selection of particular individuals, so culture as it evolves through successive generations inherits ideas, discoveries and social norms which initially arose in the minds of individual inventors and creators.

Freedom of choice (will): a conception, opposed to determinism, of the only partial, incomplete dependence of an individual's behaviour on his inherited dispositions and the formative influences of the surrounding social environment. The real contradiction between determinism and freedom of choice can be dispelled only by invoking the principle of complementarity. Man is not free (he is determined) from the point of view of an external observer who sees his behaviour as determined by genetic dispositions and circumstances of upbringing. Equally and at the same time, man has freedom of choice from the point of view of his own consciousness. Evolution and subsequent cultural and historical development have created an illusion of freedom by hiding from a person's consciousness the motivations which drive him. Subjectively felt freedom of choice and the personal responsibility which flows from it include mechanisms which comprehensively and repeatedly analyse the consequences of a given action, making the final choice more well-founded. Mobilisation of this kind of information from the reserves of memory leads to a strengthening of the need which consistently predominates in the particular individual's hierarchy of motivations, and as a result it acquires the ability to withstand situational dominants, i.e. needs which are activated by a situation of emergency. The feeling of personal responsibility, like the mechanism which predicts consequences, is formed during ontogenesis. That is why up to a certain age we do not hold a child responsible for its actions, and transfer its guilt to parents and educators. When actions are selected, the superconscious can present decision-making material in the form of recombinations of traces of previously accumulated

experience which have never been encountered either in the previous activity of the given individual or in the experience of previous generations. In this sense, and only in this sense, we can speak of the "self-determination of behaviour" as a special and unique case of what is created in the progress and self-development of living nature.

Education: the development in the pupil of a hierarchical set of needs which are most favourable for the progress of society and for the development of personality in all its potential richness. There are two ways of channelling the satisfaction of needs in a direction which is desirable for society: (1) directly influencing the conscious and subconscious mind of the individual by means of the imitative reproduction of behavioural models, and (2) arming the individual with socially valuable means and methods of satisfying his needs, and preventing them from being distorted in socially unacceptable ways. In distinction to training, which is addressed exclusively to the child's consciousness, education (like art!) is destined to affect the pupil's subconscious and superconscious. A state of genuine education presupposes not just a knowledge of the norms and an observation of socially accepted rules with the aim of being rewarded or of avoiding punishment, but an inability to violate principles which have become the regulators of activities and actions. In the subjective unawareness of the objective advantages of pro-social behaviour lies the essence of the moral dialectic.

Soul, spirituality: from the materialistic point of view and in the contemporary usage of these words, what is understood is the individual expression in the structure of a given personality of two fundamental human needs: the ideal need for knowledge and the social need "for others". By spirituality we primarily mean the first of these two needs, and by soul the second.

Although we have rejected religious and mystic conceptions of the soul, repudiating its divine origin and ability to survive beyond the grave, we cannot avoid using such concepts as "soul" and "spirituality" in everyday life. We are surrounded by people with soul (i.e., caring people) and people who are soulless (i.e., indifferent). We value a rich spiritual world and are disturbed at the lack of spirituality in certain people. We admire magnanimity (Lat. *magnus* 'great' + *animus* 'soul') and look with pity on pusillanimous (Lat. *pusillus* 'weak') reactions to complicated situations in life.

In published articles there are many references to "spiritual factors in creativity", "spiritual richness", "spiritual culture", "spiritual life", "spiritual

development", "spiritual growth", "spiritual mastery of the real world". Amongst the various types of human activity, three basic groups can be distinguished: material (productive), socio-political, and spiritual. Giving embodiment to the "life of the human spirit" was seen by K.S.Stanislavsky as the main task of artistic creativity. Many years ago, the philosopher A.Schopenhauer wittily observed that denying the soul is the philosophy of those who have forgotten to take themselves into account.

It cannot be doubted that behind the concepts of "soul" and "spirit" lies something real which the world-view of dialectical materialism cannot pass over. "I do not reject psychology as knowledge of man's inner world," maintained the great materialist I.P.Pavlov. "Even less am I inclined to reject some of the deepest tendencies of the human spirit" (Pavlov, 1973:881). So what is "soul" from the point of view of contemporary scientific materialism? According to the encyclopaedias of the last few years, the word "soul" is used in dialectical materialism solely as a synonym of the word "psyche", and its meaning corresponds to that of "psyche", "internal world" and "experience", whereas the concept of spirit is usually used as a synonym of consciousness. Although by and large correct, these definitions need to be made more concrete and precise. After all, "psyche" itself is an extremely broad concept which encompasses all the forms of reflective activity: feeling, perception, representation, thinking, emotion, will, reason, intellect, etc. Does a "soulless" person not think? Does the blatant absence of spirituality in a morally bankrupt person prevent him from enjoying his base pleasures? Psyche and soul, in the contemporary understanding of the word "soul", cannot be equated.

The difficulties which arise with the term "consciousness" are no less great. The mastery of a large body of knowledge, especially in some specialist field, is not necessarily linked to generosity or to spiritual richness. On the contrary, an illiterate who has lived all his life in some god-forsaken "bear's corner" can turn out to be capable of unprecedented generosity of spirit. Classical Russian literature is full of characters of this type.

Of course, primitive interests, ignorance of the richness of human culture, and limited intellectual horizons are incompatible with the formation of a spiritually rich personality. Equally, however, the simple appropriation of knowledge attained by other people does not in itself lead to spiritual heights. In the concepts of spirit and soul, in addition to the desire for truth and for knowledge of the

surrounding world, we intuitively sense the presence of the category of goodness.

The concept of soul is exhausted neither by the sum total of human knowledge, nor by human thinking, nor by consciousness. Intelligence in itself not only offers no guarantee of high spiritual qualities in a person, but often obligingly provides the conscious mind with highly convincing justifications for unseemly acts. For example, after abandoning a comrade in trouble, people are capable of trying to make others believe, and what is most important, genuinely believing themselves in the necessity and expediency of their behaviour. The kind of justification given is that they were trying to summon help, that it would be senseless to perish by remaining with the victim, that they needed to preserve themselves for some important task etc.

We shall not get any closer to a clarification of the essence of soul and spirit if we simply try to replace them with the concepts of "psyche" and "consciousness".

There might be an impression that in its modern sense the concept of "human soul" coincides with the concept of "personality". Earlier, we defined personality as the individually unrepeatable composition and internal hierarchy of all the basic needs of a given person. However, the vital ("biological") and multifarious secondary needs (needs for such things as food, clothing, housing, and the means for producing them), are without doubt distinct from spiritual needs. Moreover, not every social need of human beings is associated with their soul.

It seems that we can only include those properties of personality which are of undisputed social value, since the fact that the categories of soul and spirit have existed throughout almost the entire history of human civilisation (with historical variation in actual content) is an indication of their fundamental significance and enduring value.

The first property is the variety of human social need which we have called the need "for others". This frequently stimulates an individual to act in spite of and to the detriment of his own personal interests, which are dictated by his vital and material needs, as well as the need for social prestige.

The second property to be associated with the concept of spirituality, with richness and nobility of spirit, is the need for knowledge, or more precisely, that variety of the need for knowledge which is connected with development, not content with the mere assimilation of existing knowledge, not restricted to the framework of existing norms, but

seeking to push aside these norms and to conquer new frontiers of reality.

Characteristic of human spiritual activity is the fact that it is unselfish, and unselfish in two distinct ways. Activity "for others" is carried out without concern for immediate social reward, and the drive for knowledge does not pursue concrete pragmatic goals.

We understand full well that without unity of effort, without collaboration and mutual aid, the existence of society is impossible. Equally, knowledge of the surrounding world results in improvement of the techniques, means and methods for producing the material benefits necessary for the satisfaction of vital and social needs. However, the objective utility of human spiritual activity is dialectically combined with its subjective unselfishness. This "liberation" of cognitive and socio-altruistic activity from the search for immediate goals, from the question "what is the point?", creates the opportunity for civilisation to develop, for new phenomena to be discovered (which will later have practical uses), for new norms of social life to be formulated in correspondence with the changing circumstances of existence.

Thus, the need-informational approach leads us to the hypothesis that from the materialistic point of view the concepts of "soul" and "spirituality" in man refer to the expression in the structure of a given personality of two fundamental needs: the ideal need for knowledge and the social need "for others". By spirituality we mean primarily the former of these two needs, and by soul the latter.

In fact, each time we speak of soul and soullessness, we mean the **attitude** of a person to the people surrounding him, i.e., concern, attention, love, affection, readiness to assist, to provide a shoulder to lean on, to share joys and sorrows. This attitude extends secondarily to deeds, which are performed with care, with concern, with love, i.e. with "soul". Since the needs "for self" and "for others" are present in all of us, the correspondence between them is reflected in notions of "strength of soul". To be pusillanimous ("weak-souled", lacking in courage) is to shy away from achieving an important but distant and inaccessible goal in favour of maintaining one's personal well-being, social status, or a generally accepted norm. Note that we do not call a person who refuses to achieve a goal pusillanimous if his action is dictated by concern for others rather than for himself. We are prepared to reproach the leader of a group of explorers about extreme caution and indecisiveness if he refuses to risk his colleague's lives, but not about cowardice.

Magnanimity always involves the preeminence of higher ideal or social needs, the preeminence of truth and goodness over concern for self, over concern with appearances and accepted norms. Magnanimity always involves an act which advantages another person (or other people), a rejection of a habitual, familiar norm of behaviour in favour of a norm of a higher order which can lead to improvements and developments in human relationships.

Related to the category of spirituality is the need for knowledge, of the world, of oneself, of the meaning and purpose of one's life. "If a person does not know why he is alive, he might as well destroy himself, even though his larder is full... The secret of human existence is not just in living, but having a reason to live," writes Dostoevsky in "The Brothers Karamazov". The great and eternal questions of existence and necessity, of truth and justice, are presented by reality to the human mind. A person is spiritual to the extent to which he thinks about these questions and tries to obtain an answer to them.

It might seem as if, by reducing the concepts of spirit and soul to cognition and altruism, we are impoverishing the truly boundless internal world of human beings. But this is not so. After all, the need for knowledge and the need "for others" coexist and continually interact with all the other needs of the given personality, with its consciousness, subconscious, and superconscious. As a result of this interaction, an infinite number of nuances, facets and aspects of spiritual life can occur. Thus, the dominance of the social need to affirm norms can transform the need for knowledge into a continual search for new corroboration of the correctness and unshakability of previously established postulates. It is difficult to deny the spirituality of a preacher who is dogmatically devoted to the symbols of his creed, as long, of course, as his message does not pursue purely social goals, and his devotion to his creed has not become a means for personal advancement.

These comments are fully applicable to what might be called the intellectual, cognitive hypostasis of the soul, which is not at all reducible to its need-motivational and affective foundation. After all, human motivations are reflected in a reflective consciousness, although for thousands of years this reflection took the shape of mythological conceptions about the spritual world of man, about his eternal soul. The difficult path to self-knowledge which is imprinted in these conceptions is a special subject for anthropological science. However, the unconscious nature of the complex totality of forces which drive human beings played a decisive role in the emergence of conceptions of

the soul and the spirit as categories distinct from the body and opposed to its needs. This point was made in all forcefulness by F.Engels: "People have become used to explaining their actions by their thoughts, instead of explaining them by their needs (which thereby of course are reflected in their heads and consciously apprehended), and in this manner with the passing of time an idealistic world-view has arisen which has captured minds, especially since the demise of the ancient world" (Marx and Engels, Works, Vol 20:493).

The need-informational approach to the spiritual world of man, and the discovery that the concepts of soul and spirituality are founded on the needs for knowledge and altruism, have created the possibility for a materialistic understanding of those manifestations of higher nervous (psychic) activity which were for a long time beyond the bounds of scientific analysis. The time is therefore right to try to lay bare, underneath a shroud of conceptions which took thousands of years to form, the rational nucleus, the reality which causes us to be concerned about the formation of a personality which is rich in spirit and generous of soul.

In the preface to the last edition published during his lifetime of his classic work The Integrative Activity of the Nervous System (Leningrad, Nauka, 1966:26), the distinguished twentieth-century neurophysiologist Charles Sherrington wrote: "... the principle of self-preservation which has been a property of organisms since time immemorial is apparently being replaced by a new order of things: new forms of existence are denying the forms which preceded them; new moral values are appearing on the horizon. The principle of altruism is emerging... This new spirit seems to correspond in significant measure to the development of man on our planet. Lord Acton intended to create a "History of freedom", however it would have been just as worthwhile to create a "History of altruism". This might be thought to be a departure from physiology, however I do not think that this is the case... To the extent to which physiology includes man as a physiological factor on our planet, this contradiction, in which he is the leading player, does not lie beyond the bounds of physiological science".

As we demonstrated in Chapter One, higher mammals have two "unselfish" needs which can be seen as phylogenetic precursors of the need for knowledge and the need "for others". These are exploratory behaviour and the capability for emotional resonance in response to signals concerning the emotional state of another individual of the same species, i.e., the capability for co-experience.

At this point we need to pause and clarify the issue of unselfishness. We are using this term in the sense that the actions stimulated by the need for information and the need to stop or evade a flow of signals concerning the unfortunate state of another individual are not connected with the satisfaction of any other vital or zoosocial needs. Both types of action can only receive internal reinforcement, comparable with sympathy in man or the pleasure which he derives from the process of finding out about the surrounding world. We have already mentioned that exploratory behaviour is accompanied by activation of nerve cells in the centres for positive emotions and by an increase in the endogenous opiates contained in brain tissues. On the other hand, our colleague L.A.Preobrazhenskaya has recorded signs of emotionally negative tension in dogs observing the painful stimulation of another dog: an increase in heart rate and an increase in total output of electrical activity in the hippocampus (its theta-rhythm). The removal of this tension when the "observer" dog switches off the stimulation of its partner by a special lever is precisely a "reward" for the action, a reinforcement of a conditioned reflex.

In other words, the "selfishness" in the exploratory or altruistic behaviour of an animal consists in the occurrence of positive emotions or the removal of negative emotions, just as following the dictates of the soul generates in a human being a feeling of satisfaction at having fulfilled a duty, or a feeling of remorse if he has remained deaf to his conscience.

However man does not only act when stimulated by his needs, including the needs for knowledge and for altruism. Possessing a reflective consciousness, a capability for reflecting his own motivations, he tries to understand the causes of his actions and to place this understanding at the basis of his social practice, his influence on the behaviour of other people, and the education of new generations.

Having equipped ourselves with the need-informational approach, we propose a future investigation into the qualitatively new characteristics acquired by the needs for knowledge and for altruism in the process of anthroposociogenesis and the subsequent cultural-historical development of man. We shall investigate the reflection these needs have received in human consciousness, and the conceptions which human beings have of their own nature and of the forces which have driven them at different stages of historical development. Finally, we shall investigate how spiritual needs are stimulated and developed in a child, and what factors aid or hinder the formation of a spiritually

rich personality which is capable of preserving and improving the surrounding world.

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Chapter 1

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Chapter 4.

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Conclusion

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Dr. Simonov has researched emotional reactions in man and animals for 20 years. He approaches the problem of individual differences from a need-information theory to study the organization of behavior. He is currently the director of the Institute of Higher Nervous Activity and Neurophysiology.

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