"REFLEXES OF PURPOSE AND FREEDOM" IN THE COMPARATIVE PHYSIOLOGY OF HIGHER NERVOUS ACTIVITY

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The most complex unconditioned "reflexes of aim and freedom," discovered by I. P. Pavlov, are compared with the "competence drive" and the "motivation of the resistance to coercion," respectively, described by contemporary ethologists. On the basis of the unconditioned "reflex of purpose," conditioned reflexes were developed in which positive emotions arising in connection with the perfection of a skill, irrespective of its pragmatic significance at a given moment, serve as the reinforcement. The unconditioned "reflex of freedom" is regarded as a phylogenetic precursor of the will, and its acute extinction as the physiological mechanism of hypnosis. It was demonstrated experimentally that the appearance of the state of "animal hypnosis" (immobilization catatonia) in rabbits is accompanied by the predominance of electrical activity and heat production in the right hemisphere, i. e., by symptoms which are found in hypnosis in man.

We wish to draw attention in this article to two urgent questions in the comparative physiology of higher nervous activity posed by I. P. Pavlov in his studies on the "reflex of purpose" and "reflex of freedom." It is known that these most complex unconditioned reflexes, which were first described by Pavlov, did not become a subject for special theoretical and experimental analysis in the works of his closest successors.

Pavlov propounded the idea of the reflex of purpose to the participants of the III Congress of Experimental Pedagogy on January 2, 1916, in Petrograd [5, p. 213]. He explained further, in a later letter to V. M. Vol'kenshtein of May 2, 1928, that, in essence, all of the primary tendencies, whether hunger, thirst, the sexual reflex, and so forth, can "also be called reflexes of purpose, since they also are directed to the achievement of a certain purpose of one individual or species or another" [6, p. 353]. P. K. Anokhin also shared the latter point of view, holding that the reflex of purpose is included in any behavorial act in the form of the formation of an acceptor of the results of the action [1].

However, data accumulated by contemporary ethology impel us to return to the original concepts of I. P. Pavlov regarding the reflex of purpose as an independent form of behavior having its own motivational base. We have in mind that set of observations which has led a number of researchers to the paradoxical conclusion that the development of conditioned reflexes is possible without reinforcement. There is a review of this type of data, for example, in D. MacFarlane's book, "Animal Behavior" [4], which was recently translated into Russian. Thus, the pecking movements of a chick or the action of the Australian eagle which breaks the egg of an ostrich with a stone, become ever more precise with each new attempt, even though they do not obtain food reinforcement for a long period of time [11]. In other words, the achievement of the end result, namely, the acquisition or the non-acquisition of food, cannot serve in this case as a criterion for the differentiation of correct or erroneous actions. From our point of view, the absence of reinforcement in the two cited examples, and similar ones, is an illusion: here the perfection of the skill to be developed itself becomes the reinforcement, impelled by a specific, inborn need to be capable, to be equipped in the broad sense of the word, a need which is independent in its origin. Various authors call this need either the striving to master events, or the competence drive.

It is not difficult to be convinced that conceptions of the independence of the reflex of purpose pass like a red thread through the original interpretation of this reflex by Pavlov. Pavlov asserted that, among the basic forms of innate nervous activity, or instincts, there "must be an established special reflex of purpose, a striving for mastery," and "the act of striving itself must be separated from the meaning and the value of the goal" [5, p. 214]. It is not by chance that Pavlov considered the passion for collecting, whether it be the collecting of money, of knowledge, of skills, of laws, of discoveries, of good

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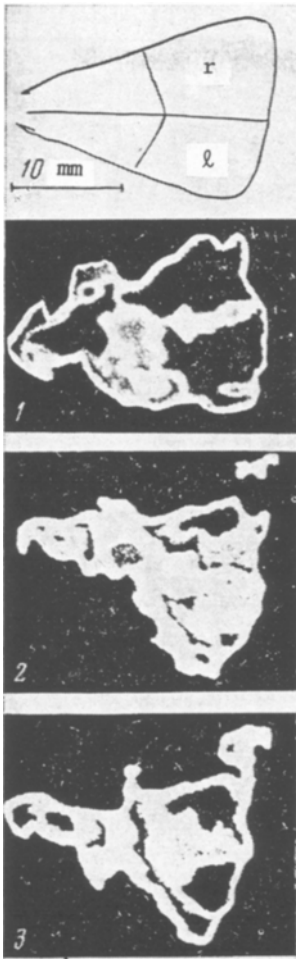

Fig. 1. The dynamics of the heat fields of the rabbit brain during "animal hypnosis." 1) Before hypnosis; 2) during hypnosis; 3) after emergence from hypnosis. More warmed areas are darker. The disposition of the skull in the frame is shown in the diagram. r, right; *l*, left hemisphere.

deeds, etc., to be the "purest, most typical" form of the reflex of purpose in man, "and therefore especially convenient for analysis." But what is collecting if it is not the striving towards being equipped potentially with the means of the satisfaction of the most diverse needs in the circumstance in which the possession of these needs acquires a self-satisfying significance, becomes a goal in itself, as happened in the case of Skupoi in Pushkin's well-known tragedy.

Note that the acquisition of the first, most elementary skills by a young child is not associated with his being hungry or thirsty, or with the avoidance of aversive stimuli. Moreover, hunger, discomfort, and chilling interrupt and inhibit the process of the acquisition of skills, which in essence the child will need much later. Children are capable of repeating the same actions tens and hundreds of times, actions the only meaning of which (of course, of which the infant is not aware) is the training of the psychophysiological apparatus. The need to be equipped, which is guided by adult stimulation to actions, underlies play activity, in the process of which the child masters beforehand those spheres of activity which at that time are inaccessible to him, and skills which at that time he does not need. The need for the completion of an action once begun, which varies individually in different people and which sometimes acquires the force of an insurmountable imperative, takes its origin in this very ontogenetic root.

The need for competence acquires with age ever more complicated and diverse forms in man. Here we have the striving for education, and the pull towards the perfection of one's own occupational mastery. The satisfaction of this need is capable of engendering its own positive emotions, which impart attractiveness to work activity by virtue of the precision, perfection, and artistry involved in the performance of even routine operations long before the final result is obtained. Unfortunately, ped-

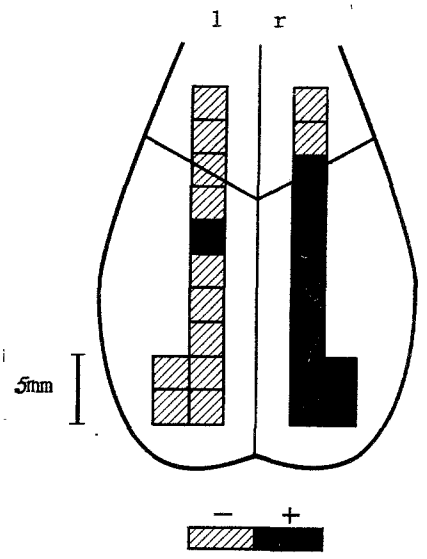

Fig. 2. The changes in high coefficients of correlation occurring during hypnosis, as compared with the background. The "+" sign indicates increase in the interdependence; "–," decrease. The individual squares correspond to the disposition of 24 electrodes on the skull.

agogical practice is not aware in full measure of the reality and the significance of this need, although the joy of knowing how and being capable cannot be substituted for by the satisfaction of any other motivations [10].

Thus, we arrive at the conclusion that Pavlov, having distinguished the reflex of purpose from among the other most complex unconditioned reflexes, discovered that special motivation which is independent in its origin, and which can in our day be defined as the need to become equipped with skills, know-how, and knowledge irrespective of their pragmatic significance at the given moment. The satisfaction of this need, or rather, those positive emotions which arise in connection with its satisfaction, in fact serves as the reinforcement for the development of new conditioned reflexes in which the act of the perfection of the skills to be developed, the increase in the probability of the achievement of the goal, themselves becomes the reward. Like the will, which we will deal with later on, the need to become equipped (or the need for competence) belongs to the group of auxillary needs, which are supplemental to the motivations which primarily initiate behavior. The degree of independence of this need apparently increases in the process of phylogenesis, and achieves its maximum in man.

The satisfaction of the most varied needs would prove to be impossible if in the process of evolution the inborn surmounting reaction, discovered by Pavlov and called the reflex of freedom by him [5, p. 237], had not appeared and developed. Pavlov viewed the fact that an animal resists attempts to limit its motor activity as something significantly greater than a variety of defensive reaction. The reflex of freedom is again an independent form of behavior for which an obstacle serves as no less adequate a stimulus than food does for the food-procuring search, or pain does for the defensive reaction, and a new and unexpected stimulus does for the orientation reaction. "Did it not exist (the reflex of freedom)," wrote Pavlov, "the slightest obstacle which an animal would encounter on its path would completely disrupt the course of its life" [5, p. 239].

The Pavlovian reflex of freedom has been rediscovered repeatedly by other investigators, and has been described as the motivation (drive) to resist compulsion by ethologists, a drive which is most highly expressed in wild animals, in which it is found to be stronger than sex, hunger, and thirst [15, 17]. The prolonged evolution of the unconditioned reflex of freedom has been completed at the human level by the formation of the neurophysiological mechanisms of the will [9]. The acute extinction of the reflex of freedom underlies the so-called hypnosis of animals, the state of catalepsy which appears when they are forceably immobilized [6].

I. P. Pavlov considered beyond-limit inhibition to be the physiological basis of animal hypnosis. He wrote that "extreme external stimuli of very great intensity or of a highly unusual type elicits rapid reflex inhibition above all of the motor area of the cerebral cortex, which directs the so-called voluntary movements" [5, p. 250].

However, subsequent investigations do not permit us to agree with such a hypothesis [8, 18, 19]. First, a disturbance of the dependence of the magnitude of the reaction on the intensity of the external stimulus is characteristic for beyond-limit inhibition, when weak stimuli are still capable of eliciting a response, while stronger stimuli only exacerbate the emerging inhibition. Precisely such a pattern is observed, for example, in the state of traumatic shock. With regard to animal hypnosis,

the dependence of the magnitude of the respiratory and motor reactions on the intensity of the stimulation is preserved in rabbits.

Secondly, the duration of hypnosis in rabbits increases with the administration of only small doses of caffeine, which intensifies the internal inhibition of conditioned reflexes in these animals (extinctive and differential inhibition), whereas excitatory doses, which intensify extreme inhibition, decrease this duration as compared with control experiments in which the animals are administered physiological solution.

Further, the duration of hypnosis increases with repeated immobilization of rabbits over the course of the same experiment and on subsequent days, and the latter effect is observed only in animals with an intact cerebral cortex.

The entire aggregate of data obtained in these investigations has led us to the conclusion that the acute extinction of the unconditioned reflex of freedom as the result of the unsuccessfulness of the animal's attempts to free itself and to resume the natural position of the body in space constitutes the basis of the hypnosis.

When the total electrical activity of the brain is recorded during the induction of hypnosis, two characteristic stages can be observed in which the forced immobilization of the animal is accompanied by the marked activation of the majority of the brain structures and by the acceleration of the heart rate. A second phase appears later, with slow high-amplitude activity and with a tendency to the decreased frequency of the heart-beating, although the pulse never achieves the background values which were recorded in the quietly sitting rabbit. The electrographical shifts which are characteristic for hypnosis appear earliest of all in the red nuclei, and the electrographical features of awakening appear first in the hippocampus.

The method of thermal imaging in combination with digital processing of the images obtained has been substantially perfected in recent years in the Institute of Radioelectronics of the Academy of Sciences of the USSR [AN SSSR] [2]. Colleagues of our institute have used this method of studying the spatial-temporal dynamics of events in the cerebral cortex of animals [12]. When the thermoencephaloscopic shifts which appear in the cerebral cortex of rabbits as animal hypnosis develops are examined (Fig. 1), it is established that the state of hypnosis is accompanied by cooling of the cortex of both hemispheres; however, invariably the right hemisphere remains the most warmed [2]. If the heat production, apparently caused both by the microcirculation of blood and by metabolic shifts, is considered an index of the active state of brain structures, we are correct in speaking of the relative functional predominance of the right hemisphere as a characteristic symptom of animal hypnosis.

A similar pattern was observed when E. V. Petrova and T. I. Luchkova recorded the electrical activities picked up from 24 points of both cerebral hemispheres, and determined the coefficients of correlation for each point in relation to all the others. It was found that the number of high coefficients of correlation increases in the right hemisphere in the state of hypnosis, whereas the interdependence of the recorded points decreases in the left hemisphere as compared with the period of wakefulness. The averaged data obtained in four rabbits, which demonstrate the increase in the indices of interdependence in the central and occipital divisions of the right hemisphere along with their decrease in the left, are shown in Fig. 2.

It is interesting to compare these data with the results of study of the electrical activity of the brain, of the vegetative reactions, and of the solution of psychological problems in man in the state of hypnosis, in which primary inhibition of the left hemisphere was found along with the functional predominance of the right [13, 16]. The dynamics of the electroencephalographic shifts coincide strikingly with the pattern described many years ago by I. P. Pavlov: "in the very first stages of the hypnotic state, instead of the usually predominating operation of the second signal system in the awake state, the activity of the first, ... freed from the regulatory influence of the second system, comes into play. Hence the chaotic character of this activity, which ignores reality more, or takes little account of it, and which is subject mainly to the emotional influences of the subcortex" [5, p. 412]. If one accepts that the activity of the second (speech) signal system is associated in right-handed individuals primarily with the structures of the left hemisphere, then the data of recent years regarding the functional asymmetry of the hemispheres during hypnosis can be considered an experimental confirmation of Pavlov's hypothesis.

We are coming to a conclusion regarding the profound phylogenetic kinship of the brain mechanisms of hypnosis in animals and man. In both cases we are dealing with the inhibition of the inborn reflex of freedom, which at the human level appears as the brain mechanisms of the will. Motoric immobility which blocks the aggressive reactions of an opponent is a result of this inhibition in animals. With regard to man, a transition to imitative behavior, to a refusal of independence, and the shifting of responsibility for the situation to the hypnotist-leader are more characteristic [14].

The question can be posed: why is inactivation specifically of the left hemisphere associated with a shift to passive-defensive behavior, whether in a form of catatonia in animals or in passive following of a leader in the case of human hypnosis?

In experiments [3] which have turned out to be a unique control for experimental hypnosis, the thermoencepheloscopic pattern was recorded in rats who were in a state of stress as the result of the "conflict" of the elementary and defensive reflexes.

Fig. 3. The dynamics of the heat fields of the rat brain during acute stress. 1) Before the stressor effect; 2, 3, 4) 40 sec, and 10 and 15 min after a "conflict." Remaining designations as in Fig. 1.

The clear predominance of the activity of the left hemisphere was established (Fig. 3). According to the data of M. N. Rusalova [7], such electrographic indices as the focus of maximal activity of the alpha rhythm and the latent period of the evoked potentials attest to the functional predominance of the left hemisphere in man each time that elements of novelty, complexity, and the necessity for non-stereotypic decision-making arise in the ideational activity performed. As this activity becomes automatized, the level of activation shifts in the direction of the right hemisphere.

The impression is created that in animals and in man the right hemisphere is primarily associated with the realization of inborn and acquired automatisms, whereas the left hemisphere is involved in activity each time that the analysis of a new situation and the search for solutions which are optimal in that situation is required.

We are once again convinced, on the basis of the example of the reflex of purpose and freedom, of the correctness of Pavlov's assertion that "the systematic study of the store of inborn reactions of an animal will tremendously facilitate our understanding of ourselves and the development in us of the capacity for personal self-direction" [5, p. 240]. Directing our attention particularly to these reflexes and acknowledging their independence will allow us to trace the phylogenetic prehistory of two very perplexing manifestations of the higher nervous activity of man: the self-directed striving for the perfection of his skills, of his being versatilely equipped, and of his need to overcome obstacles on the pathway towards a goal, which is usually called the will. It is remarkable that contemporary psychology does not give any answer of substance to either of these questions.

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