The Regulative Function of Speech in its Development and Dissolution

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Along with the semantic and syntactic functions of speech, one must also distinguish its pragmatic or directive function. This function manifests itself in behavior development by means of the fact that a word gives rise to new temporary connections in the brain and in this way directs the child's activity.

L. S. Vygotskii has formulated the thesis that speech as a form of communication with adults later becomes a means of organizing the child's own behavior, and that the function which was previously divided between two people later becomes an internal function of human behavior. (Vigotskii, 1934, 1956).

In the last thirty years the problem of the role of the word in the organization of mental life has been the subject of numerous Soviet investigations (Rozengardt, 1948; Ljublinskaja, 1955; Luria, 1956, 1957, 1958, 1961; Kol'cova, 1958; and many others).

The present paper is concerned with the further question of how this pragmatic, directive function of the word is formed and how it is disturbed in brain pathology, and presents a number of pertinent experiments.

A child at the beginning of his second year of life has already acquired a considerable number of words, and can without difficulty hand someone an object when it is named. The question can then be raised as to whether the pragmatic, directive function of speech at this stage is as stable as its significative, nominative function? Can the cited word always direct the child's activity with full effectiveness?

Some experiments which we have carried out in collaboration with A. G. Poljakova suggest an answer to this question. A child aged 14 to 16 months is fully able to select and give to an experimenter an object for which he is asked. If, however, a child of 12 to 14 months is presented with two objects -- a toy fish at some distance from him, and half way toward the fish a brightly colored toy cat -- and required to hand the experimenter the fish, his behavior will be different. The uttered word will evoke in him an orientational reaction, and although his glance will be fixed on the fish, the child will grasp the cat and offer it to the experimenter. While the word easily directs behavior in a situation that lacks conflict, it loses its directive role if the immediate orientational reaction is evoked by a more closely located, or brighter, or more interesting object. It is only at the age of 16 to 18 months that this phenomenon disappears and the selective effect of words is maintained even in conditions in which the components of the situation conflict with it.

The directive function of the word can be easily disturbed in still another way. It is known that the word physiologically excites a certain system of connections in the cortex. In the normal, mature nervous system these connections possess considerable flexibility and easily replace each other. As has been shown in many investigations (c.f. Luria, 1956, 1958, 1961; Khomskaja, 1958), the flexibility of the connections evoked by the word (or, as Pavlov called it, by the second signal system of reality) is even greater than the flexibility of connections evoked by immediate signals.

no ¶ However, the flexibility of nervous processes in a very small child is still quite inadequate, and connections evoked by the word possess a considerable inertia at the early stages of development. Taking this inadequacy of the flexibility of connections in the early stages of development as a premise, one can measure the stability of the directive function of the word.

If a child of 12 to 14 months is presented with two toys, a fish and a horse -- this time placed at the same distance from the child and having dimensions and colors that are equally attractive -- and asked to give the experimenter the fish, he does this easily. For the next three of four trials the child's performance remains the same. However, if the child is then instructed on the fourth or fifth trial to hand the experimenter the horse, the child may well hand the experimenter the fish again. We suggest, therefore, that although the child knows the meaning of the word, the directive function of the changed verbal instructions is here vitiated by the inertia of the connection that has been established.[1] The directive role of the word at an early age is maintained only if the word does not conflict with the inert connections which arose at an earlier instruction or which began with the child's own activity.

Further specificity can be obtained by considering some experiments which were designed to measure the relative effectiveness of verbal signals as compared to the directive role of immediate, visual signals. Two groups of children were used, one aged 16 to 18 months and the other aged 20 to 24 months. The first experiments, done with the younger group, were set up to determine the effectiveness of the orienting (attention-directing) and directive role of a visual signal and its trace alone. Two objects are inverted and placed before the child, a cup to his left and an opaque plastic tumbler to his right.

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1 In a number of cases such an experiment may not give the desired results. This happens when the dominant role in the child's behavior continues to be played by the immediate orientational response to objects. In such cases the child will alternately hand the experimenter now this object, now the other, and the directive function of speech will fail to be exercised from the start.

As the child watches, the experimenter hides a coin under the cup and asks the child to find it. Children in this group can do this without difficulty and on the succeeding three or four trials can maintain their performance. If however, on the following trial the coin is placed under the tumbler, a certain proportion of the children will again put out their hands toward the cup, carrying out the habitual movement reinforced in the previous trials, before they turn to the tumbler under which the coin is hidden. Such children are not following the changed visual signal (more precisely, its trace), but rather the influence of the inert motor stereotype.

If the experimenter then imposes a short, 10-second delay between the hiding of the coin under the cup and the execution of the movement, in order to weaken the influence of the visual signal, the child is forced to act according to the traces of the visual signal whose effectiveness we are considering. The majority of children in the younger group can successfully execute this task (only a few, the very youngest, cease to subordinate their actions to the visual instruction and begin to grasp both objects, losing track of the task of finding the coin that is hidden under one of them). If, however, after the third or fourth trial, the coin is again hidden under the tumbler located on the right, the overwhelming majority of children now repeat the movement directed toward the cup on the left. The 10-second delay turns out to be sufficient for the visual signal to yield its place to the decisive influence of the reinforced motor habit.

The orienting, directive influence of the visual signal is maintained better among children of the older group (20 to 24 months). Even when the execution of the movement is delayed, the children direct their search to the object under which they saw the coin being hidden. It can therefore be concluded that by the end of the second year the orienting, directive role of the visual image is well enough established to enable the child to successfully overcome the inertia of the motor connections which have arisen.

In the second set of experiments the immediate visual signals were replaced by verbal ones. The coin was hidden surreptitiously under the cup and the child was given the verbal instruction, "The coin is under the cup... Find the coin!". While the trace of an immediate visual impression caused all children of the younger group to reach with assurance for the cup under which they saw the coin being hidden, the verbal instruction was ineffective in directing their behavior. A considerable proportion of the children of this age lost track of the task and began to grasp both objects before them. When the experiment was repeated with a 10-second delay in the execution of the action, the loss of directed activity among the children of the younger group became almost universal.

If, during the experiment with no delay, the instructions were repeated several times, "The coin is under the cup... Find the coin!", the word achieved the required directive function, and the younger children reached for the object named. If, however, the verbal instruction was changed to, "Now the coin is under the tumbler... Find it!", only an insignificant proportion of the children changed their movements, while the great majority repeated their previous movement. When a 10-second delay was imposed on the execution of the task, all the children of the younger group failed to follow the changed verbal instruction; they continued to execute the stereotyped movement that had been reinforced on the previous trials.

The children of the older group (20 months to 24 months), who solved these tasks with uniform success when the directive role was played by a visual signal in experiments with delayed as well as with immediate execution, were able to follow the verbal instructions provided they were allowed to make the necessary movement immediately. However, if a 10-second delay were imposed between the verbal instructions and the execution of the movement, the directive role of the verbal instruction became ineffective. After three trials with the instruction, "The coin is under the cup... Find the coin!",the transition to another command -- "The coin is under the tumbler... Find the coin!" -- deprived the verbal instruction of its directive role, and the child continued inertly to execute the former habitual movement. In these cases the kinesthetic stereotype which had been established earlier overcame the insufficiently established effect of the word.

While the directive function of straightforward, "deictic" speech is already formed around the age of 2, the kind of speech that involves more complicated preliminary connections -- connections which (according to physiologists) precede the action and organize it in advance -- acquires a regulative function considerably later, and its development occupies the entire third and partly the fourth year of life.

An example of such speech can be found in the more complicated instruction, "When the light flashes, you will press the ball (rubber bulb)," or "...you will raise your hand." Such a verbal instruction, formulated this time in a syntactically complex, "conditional" sentence, does not require any immediate realization of an action. It must close a preliminary verbal connection, giving to the onset of a stimulus (light) a conditional meaning of the signal for action ("you will press the ball"). The directive role is played here not by a separate word, but by a relation, a synthesis of words entering into a sentence. Instead of an immediate, triggering role, speech acquires a preliminary, conditional, pre-triggering function.

It has been shown experimentally (Jakovleva, 1958; Tikhomirov, 1958) that the possibility of establishing such a pre-triggering system of connections on the basis of speech -- not to speak of the possibility of subordinating further conditional reactions to it -- is something unattainable for a child of 2 to 2½ years, and sometimes even for a 3-year-old child.

Children 22 to 24 months of age appear unable to realize that a synthesis of separate elements is required by the instruction formulated in such a sentence. Each word contained in the sentence evokes in the child an immediate orienting reaction, such that, upon hearing the beginning of the sentence, "When the light flashes...," the child begins to look for the light with his eyes; when he hears the end of the sentence, "...you will press the ball," he immediately presses the device in his hand. At this stage words have already acquired an effective triggering function, but not a preliminary pre-triggering function, which requires the inhibition of immediate reactions and their separation into individual fragments. This is why the onset of a flash of light does not at this stage lead to a conditioned movement, and evokes only an immediate orienting reaction: the child begins simply to inspect the light, which has not yet become for him a conditional signal for the pressing of the ball.

It is, however, not the case that the formation of this more complex form of directive speech -- the closing of conditional, pre-triggering connections -- depends entirely on the ability to synthesize the elements of a sentence into a single system. Even when a child, some time later, is capable of making such a synthesis and begins to "understand" the meaning of the whole sentence, the directive role of the sentence can still remain ineffective for a long time.

If children between the ages of 32 and 34 months are presented with such an instruction, they will, as a rule, make the required connection without particular difficulty, and when the light flashes will press the ball. However, they will be unable to stop the movements which have been triggered by speech and will very soon begin to press the ball regardless of the signal, continuing involuntarily to repeat the previous movements. Even repetition of the instruction or the reinforcement of the inhibitory link which is hidden in it, even the request to press only when the light flashes and not to press when there is no light, all turn out to be powerless to stop the motor excitation that has begun. On the contrary, the excitation is sometimes even reinforced by the inhibitory instruction which acts non-specifically, only strengthening the dominant motor response. At this age, it would appear that speech has already acquired an effective connection-closing triggering function, but it has not yet acquired an effective inhibitory role.

This weakness of the inhibitory function of speech, as was shown by the observations of Tikhomirov (1958), can be demonstrated by means of the following experiment. A child between the ages of 36 to 42 months is placed in a stimulus situation in which the verbal instructions demand a complex selective reaction, positive with respect to one signal and inhibitory with respect to another. The child is told to press the ball every time a red light goes on, and not to press it when a blue light goes on. The child is then required to repeat the instruction in order to establish the fact that all the information included in the sentence has reached him and has been retained. However, the child is unable to execute the task. Having acquired the semantic meaning of the sentence does not necessarily imply the simultaneous appearance of its directive role. The excitation provoked by the red signal becomes so considerable and diffuse that after only a few attempts the blue signal, too, begins to evoke in the child impulsive motor responses. These movements become increasingly unrestrained as the child's excitement grows and the directive function of the inhibitory verbal instruction weakens. It is not uncommon for the child, under the influence of his own impulsive reaction, to lose the inhibitory link contained in the verbal signal to such an extent that he begins to assure the experimenter that the instruction required him to press the ball in response to both signals presented to him. Thus, the insufficient mobility of the child's neurodynamics at first destroys the directive role of the verbal instruction and later distorts the entire system of links contained in it.

Experiments carried out by Paramonova (1956) showed that there are very simple means for heightening the directive influence of speech when the effect of the traces of a verbal instruction are insufficient. The value of such experiments lies in the fact that they yield information about certain mechanisms of the directive function of speech.

One such experiment was carried out with a 3-year-old child. The experiment was the same as above except that every flash of the red light was accompanied by the command, "Press!", and every flash of the blue light with the command, "Don't press!". What could not be attained through preliminary connections evoked by a verbal instruction, turned out to be easily attainable through the immediate influence of verbal commands. Since the directive function of speech has been fairly well established in 3-year-olds, its influence is capable of concentrating the course of nervous processes and of producing a differentiated habit.

A further investigation was then undertaken in an attempt to exploit the directive possibilities of the child's own speech in order to support the traces of the verbal instruction, which weaken relatively fast. As Vygotskii has shown, the function which at first is distributed between two people can easily turn into an internal psychological system.

The same basic experiment was used with the modification that the child was instructed to give himself supplementary verbal commands, accompanying each appearance of a red signal with the word, "Press!", and the appearance of each blue signal with the words, "Don't press!". The results showed that it was not simple to obtain a directive influence from the child's own speech in this case. Furthermore, if we examine the directive role of the child's own speech during the first years of life we find that it undergoes a complex course of development.

Using a simplified version of the experiment, children of 2 to 2½ years were instructed to respond to each flash of the red light by pressing the ball. In addition, in order to remove those excessive movements which are not subject to the control of an inhibitory instruction, the children were asked to accompany each motor reaction with the word, "Press!" (or even with something easier to pronounce, such as, "Now!", which can be characterized as a self-command). Experiments done by Jakovleva (1958) have shown that the active speech of a child at this age is so insufficiently developed, and the underlying neurodynamics so inert, that the child of 2 to 2½ years of age still finds difficulty in coordinating his verbal commands with the signal and frequently begins to utter unnecessary, stereotyped commands. In the present instance it is significant that even if the child succeeds and begins to say, "Press!" (or, "Now!") only when the signal appears, his entire energy is diverted to the utterance of this word, and the motor reaction which is supposed to be associated with it becomes extinct. Since the child at this age does not yet have a system of neural processes that includes both verbal and motor links, the word does not play any directive role.

Tikhomirov (1958) showed that it is only at 3 years of age that the neurodynamics which underlie the speech processes are sufficiently mobile for the child to time his own verbal command with the signal and for the command to exert a directive influence on the motor response. At this age, although the child is unable to control his unnecessary, diffuse presses of the ball according to the preliminary instruction, he easily achieves this control when he begins to give himself commands. In concentrating the diffuse excitation, the child's own verbal responses, functioning on a feedback principle, here demonstrate their directive function.

However, this directive function of the child's own speech is not yet fully developed. Control experiments have demonstrated this, and have permitted a closer examination of the mechanisms of the early forms of the directive function of speech. If a child of 3 to $3\frac{1}{2}$ years of age is instructed to press a ball every time a red light flashes and to refrain from pressing it when a blue light flashes, and given the possibility of accompanying each red signal with his affirmative command, "Press!" and every blue signal with his own inhibitory command, "Don't press!". The results disclose some very substantial peculiarities of the regulating effect of the child's own speech. The verbal responses, "Press!" and "Don't Press!", turn out to have a complex structure. Physiologically they are, first of all, motor responses of the speech apparatus and are thus always connected with the positive phase of an innervation. But with regard to their meanings they are systems of connections which, in the former case, have a positive, and in the latter case, an inhibitory signal value.

The experiments of O. K. Tikhomirov (1958) are relevant. The children easily respond to each light signal with the required word. However, in uttering the command, "Don't press!", in response to the blue signal, they not only fail to restrain their motor responses, but press the ball even harder. Consequently, the child's own verbal reaction, "Don't press!", exerts its influence not by means of its semantic aspect, but by its immediate "impulsive" impact. This is why the directive influence of a child's own speech at this stage still has a non-selective, non-specific character.

It is only at the age of 4 to 4½ years that the directive role of the word changes over to the selective system of semantic connections, and the verbal response, "Don't press!", actually acquires the inhibitory effect specific to speech. At this stage of development, i.e., when the semantic aspect of speech becomes dominant, external speech becomes superfluous. The directive role is taken over by those shortened inner connections which lie behind the word, and they now begin to display their selective effect in directing the further motor responses of the child. This system of shortened connections evoked by internal speech is the highest level that regulates behavior and is typical of the human. Developing in late phases of ontogeny, it begins to play the leading part in the interpretation of subject matter reaching the individual; it creates the complex semantic pattern that determines the structure of behavior.

The study of the formation of the pragmatic or directive function of speech opens up new possibilities for analysis of pathology of the most complex forms of human activity. Many physiologists, attempting the scientific analysis of the mechanisms underlying pathologic behavior changes, have suggested using the conditions of force, mobility, and equilibrium of neural processes as basic criteria in the evaluation of clinical pictures of behavior disturbances in pathophysiologic terms. They presumed that establishing a connection between pathologic conditions of the brain and the reduction in neural processes, loss of mobility, and disturbances in equilibrium might create an excellent foundation for analyzing such mechanisms. It was felt that a scientific classification of basic forms of pathologic changes in the psyche would also become possible.

These investigations yielded information concerning weakening of neural processes, overactivity of unconditioned inhibition, loss of concentration in neural processes and their pathologic tendency to irradiation, as well as descriptions of manifestations of pathologic inertia found in existing conditions. It was also established that some pathologic conditions are characterized by the predominance of certain inhibitory processes, whereas others are characterized by heightened excitation. These investigations both enriched the study of pathology and had great influence in substituting scientific physiologic explanations for descriptions of clinical pictures.

However, this introduction of pathophysiologic concepts into clinical medicine had some drawbacks. Observations showed that the neurodynamic changes which were described were to be found in the same measure in diverse clinical pictures, while the indicated pathophysiologic conceptions were too broad and reflected too general a formulation. While pointing out pathophysiology which was equally applicable to many pathologic conditions, it did not take into account the particularity of the various forms of disturbances in the higher neural processes. It also failed to create a basis for establishing a scientific classification of clinical pathology and then proceeded, despite this, to analyze the various forms of pathologic changes in human psychologic activity.

It becomes essential, therefore, to find new criteria for analyzing pathologic changes in higher nervous activity of the human, which will permit not only the generalization, but also the differentiation of various clinical pictures. The formulation of such criteria became possible only after a thorough analysis revealed how the mechanism regulating psychic processes in the human is formed and described the mechanism typical for basic forms of human behavior.

It was noted that the higher -- and specifically human -- forms of psychic activity include an interaction between two levels of neural processes: one arising from the direct analysis of, and reaction to, external stimulation, and the other formed on the basis of speech and founded on the signal system of the word. I. P. Pavlov spoke of the interaction between two signal systems, pointing to the role played by speech as the "highest regulator" of human behavior. Hebb stated that, applied to the human CNS might be taken to mean "conceptual nervous system." The preceding developmental survey indicated just how complicated a course the higher nervous activity of the child takes before establishment of the system where the directive linguistic connection begins to play a leading part.

The above formulation suggests that specific criteria for various pathologic conditions are to be found not only in general pathophysiologic indicators (changes in force, mobility, and equilibrium of neural processes), but also in changes in interaction between the two aforementioned levels of neural processes. Changes in neurodynamics underlying elementary and speech processes might be different in the various pathologic conditions. It follows that pathologic changes in 'general' neurodynamics can be compensated for successfully by the more intact neurodynamics of the higher (symbolic) level. In other words, we can expect that in some pathologic conditions the directive influence of speech remains so intact that it can compensate for disturbances in general neurodynamics; in other pathologic conditions the damage is so extensive that the possibility of regulating the disturbances in general neurodynamics with the help of the pragmatic function of speech becomes impossible.

The results of studies which investigated this hypothesis are detailed in Luria (1956, 1958, and 1961). A brief summary of the work follows: Two groups with pathology of higher neural processes were chosen for a comparative analysis. One group of children, with previous systemic intoxication or brain trauma, can be characterized as a group of children with the cerebroasthenic syndrome. These children, while intellectually normal, had pronounced disturbances in general neurodynamics: they were debilitated and emaciated; their exhaustion was apparent in pronounced disturbances in stimulatory and inhibitory processes -- some children showed signs of increased impulsiveness and general restlessness, while others displayed certain signs of restraint and lethargy. It was apparent that the further psychologic development of these children was arrested due to instability and unbalance in their neurodynamics.

The second group consisted of oligophrenic children. In this case the neural processes could show either a certain force and stability or present symptoms of weakness and unstableness; on the other hand, symptoms of disturbances in mobility of basic neural processes (in other words, their pathologic inertia) were to be observed most frequently in these children (Luria, A. R., 1956; Pevsner, M. S., 1960). However, what distinguished the children of this group was a pathologic underdevelopment of higher nervous activity, which led to their classification as retarded children.

The method described above, requiring simple and complex motor reactions, was used in examining both groups of children. The basic series of investigations was conducted by Khomskaya (1956, 1958), Lubovskii (1956) and Martsinovskaya (1958). These studies yielded very clear results. Khomskaya (1958) showed that 9-12-year-old children with the cerebroasthenic syndrome could as easily respond to a given signal by a simple motor reaction as to react appropriately in a choice situation; they press the ball when a red signal appears and refrain from pressing when a blue signal appears. However, when the experiment is repeated in a different and, for the child, more difficult form by shortening the duration of the signal as well as the intervals between signals, the situation changes. The new situation taxes the strength of children with weakened neural processes to such an extent that they are unable to respond to frequently changing signals with the appropriate reaction, and they either omit the response to positive signals or begin responding with impulsive movements to inhibitory signals. The number of erroneous responses frequently reaches 40-60%. Such children do, however, remember the instructions and are conscious of their mistakes. The equilibrium and mobility of the excitatory and inhibitory processes are so disturbed in these children that an adequate execution of the corresponding instructions becomes impossible.

If the neurodynamics underlying the linguistic reactions of these children is, as a rule, much more intact than the neurodynamics of the motor reactions, it should be possible to strengthen the directive function by speech therapy so that the children can compensate for the defects in their neurodynamics. E. D. Khomskaya (1958) conducted some experiments in which the child's motor reactions were excluded and he was instructed to respond to the presented signals with a linguistic response, saying "Need" in response to red and "Don't need" in response to blue signals. The results of these tests indicated that even when the signals were shortened, children whose motor reactions had been as high as

40-50% incorrect, continued to give correct linguistic replies. It was concluded that mobility of the neural processes underlying the speech system was preserved. Therefore, an attempt was made to utilize the unimpaired speech system for strengthening the signal stimuli in order to compensate for the defects of the motor reactions. For that purpose the motor and linguistic reactions were combined. Using the above-mentioned method, the children were asked to respond to a red light with "~~Need~~ press", while at the same time producing a motor reaction, and to respond with "Don't ~~need~~ press" to a blue light, while withholding a motor reaction. It was found that children who previously gave 40-50% incorrect motor responses when the trials were given in quick succession, were now giving only 5-10%.

In an attempt to determine whether the directive influence was made possible through the specific signal function of speech, Khomskaya substituted a monotonous repetition of one response, "See See", for the selected 'signal' responses, "~~Need~~ Press" and "Don't ~~need~~ press", and found that the directive influence of speech disappeared.

These experiments show that in a group of children with the cerebroasthenic syndrome, the neurodynamics of complex (speech) levels of psychic processes remain more intact than the neurodynamics of motor processes, and the comparative unimpairedness of higher level nervous activity may be utilized for compensation of pathologic conditions.

The examination of oligophrenic children produced different results. The experiments of Lubovskii (1936), Khomskaya (1936), and Martsinovskaya (1958) showed that simple motor reactions of oligophrenic children did not necessarily differ substantially from the motor reactions of children with the cerebroasthenic syndrome. Only in cases of extremely severe oligophrenia did the children present pathologically inert reactions, pressing the ball even in the absence of any signal and giving monotonous motor reactions that could be interpreted as a primitive time reflex. In transition to more complex forms of selective reactions, grave pathology could, however, be observed. Even where the linguistic instruction was retained, (for instance, to press the ball in reply to red and not to press it in reply to blue light), they substituted for the selective system of motor responses a monotonous sequence of positive and negative reactions which were independent from the given signal, or they continued motor reactions in response to any signal.

The basic difference in this group of children became apparent, however, as soon as the experiments involved linguistic replies. These experiments showed that the speech reactions of oligophrenic children were as inert as their motor reactions. The child, retaining the instructions to reply with the word "~~Need~~ Press" to a red light and with the words "Don't ~~need~~ press" to a blue light, began to respond to both lights indiscriminately. The signal function of speech was grossly impaired in this case. The defects of neurodynamics underlying the basic speech processes were even more pronounced than the neurodynamics of the motor reactions.

Further experiments carried out by ~~Kh~~Homskaya (1956) and Martsinovskaya (1958), which attempted to utilize the directive function of speech, yielded negative results. The oligophrenic children were incapable of giving themselves the command of "Need" and simultaneously pressing the ball when a red light appeared and the command of "Don't ~~need~~ press" and not pressing the ball in response to a blue light. Some of these children were even unable to say "~~Need~~ Press" and press the ball at the same time; or when they responded linguistically with "Don't ~~Need~~ press", they submitted to the direct influence of the speech impluse and pressed the ball. The signal directive function of speech was grossly impaired in their case. This type of pathology basically separates oligophrenic children from the children with the cerebroasthenic syndrome, described above.

There is no doubt that the method applied in these examples will also prove useful in analyzing other pathologic conditions. It should also be helpful in defining the criteria for specifying nonidentical disturbances in neurodynamics which underly the various levels of behavior, and provide a way to facilitate the physiologic description of the various pathologic forms involving higher neural processes in the human.

The description of the basic facts of development and dissolution of the directive function of speech still leaves unanswered the question of what nerve mechanism triggers the directive influence.

It is evident that the nerve apparatus permitting realization of the signal or directive influence of speech is located in the cortex. The following investigations were concerned with the question of whether the entire cortex participates equally in this process, or whether particular areas in the cortex of the cerebral hemisphere can be isolated as the locus of that action.

Early work in the area was conducted jointly with L. S. Vygotskii. It is known that the involvement of subcortical motor ganglia, as observed in Parkinson's disease, limits the possibility of voluntary movements. Gross disturbances in elementary motor automatism and gross tonus changes make it impossible in such cases for the patient to continue walking after taking one or two steps. The necessary leg movements become superceded by diffused tonus, agonists and antagonists come into play, and the result is a general tremor of extremitities. For that reason the patient is unable to perform several manual movements, press a key, or tap his fingers rhythmically.

However, study showed that gross disturbances in successive automatic movements may be compensated for temporarily if they are transferred to the cortical level, and if the continuous movement is superceded by a cycle of isolated responses to individual stimuli. Such a patient cannot take several steps on a smooth floor but can easily cross several lines marked on the floor or several objects placed on the floor.

A series of experiments was conducted using the directive function of the patient's own speech to compensate for the defective motor automatism. The patient was told to use his own blinking movements as autostimulation, and the instruction "Blink and Press" resulted in considerable ease of movement. Even better results were obtained when a patient who could not continue tapping the table rhythmically was told to use his own tapping movements to answer the question, "How many points in a star?" or "How many spikes in the machine?" (Luria, 1932, 1948). Changes in the function of digital movements and their transfer to higher cortical levels, changed the functional possibilities of the motor apparatus and created substitute circuits in compensating for the patient's movements. Having established the fact that defects in subcortical ganglia might be somewhat compensated for by utilization of the unimpaired linguistic regulation, the question of which areas of the cortex make such a transition possible must be considered.

This problem was dealt with in a series of experiments which attempted to ascertain how the directive use of speech could be employed with patients with various local brain traumata in different sites (Luria, 1947, 1948, 1962, and 1963; Luria, and Khomskaya, 1966). The results indicated that local brain traumata which interfere with sound production and the grammatical aspects of speech do not necessarily interfere with the signal, directive function of speech. When the perception of differentiated ~~linguistic~~ phonematic sounds is disturbed (due to involvement of the left temporal lobe), or difficulties arise in mastering complicated grammatical combinations (because of involvement of the inferior parietal cortical area of the left hemisphere), patients are still able to respond to ~~linguistic~~ verbal instruction and can even utilize their own speech, which, even if impaired, has retained its directive importance.

Similar data were obtained in a study of patients with involvement of the premotoric area of the cortex. Such patients, showing definite signs of disturbance in higher automatisms and motor patterns, retained the suggested speech instructions and tried, with occasional success, to compensate for their motor deficiencies with the help of improved speech (Luria, A. R., 1948, 1963; Shkol'nik-Yaross, E. G., 1946).

More specifically, patients having such local involvement, i.e., injury or tumor, in the temporal, parietal, occipital, or even in the premotor area of the brain, were able to respond to a given signal with a simple motor reaction. A more complex task -- responding to one signal by pressing with the right and to another signal by pressing with the left hand, or placing two white figures and one black figure in a row -- was also within their capacity. If they understood the instructions, they were also able to carry out easily a more complex conditioned movement: for instance, pressing lightly in response to a strong signal and pressing strongly when the signal was weak or forming a fist in response to a raised finger and raising a finger when a fist was displayed. If these patients made mistakes when the regimen was made more complicated, they were very conscious of them and corrected them.

Furthermore, the ~~linguistic~~ verbal direction of motor processes remains intact even when the site of the trauma is the limbic area, which leads to gross memory loss.

The picture shifts considerably with patients having extensive traumata in the frontal lobe and a pronounced so-called 'frontal syndrome'. The sound and grammatical structure of their speech remains intact in such cases, but the linguistic system loses its signal directive role. Such patients stop responding to external spoken instructions as well as to the directives of their own speech. Furthermore, they cease to display the characteristically human signs of selectivity and direction. Superficially, the behavior of these patients does not show gross signs of dissolution. They follow the physician intelligently with their eyes, shake hands, and answer questions although they do this slowly and monosyllabically. Their speech is fairly intact phonetically and grammatically. Paresis and dyspraxia are absent. However, as soon as their simplest motor reactions are analyzed, the first impression they created changes.

Patients with extensive (frequently bilateral) tumors of frontal lobes are unable to produce persistently even simple motor reactions. They can repeat the instruction, "When the bell rings, press the ball." However, after responding once or twice, they stop pressing the ball and, although they accompany each signal with the words, "Yes, yes, I should press!", they do not perform the corresponding movement (Merhcheryakov, 1966). As the experiment proceeds, a new pattern supervenes and the patients begin to suggest that the experimenter should press the ball, or claim that they themselves had already performed the task before.

Patients with less pronounced involvement of frontal lobes may successfully carry out simple reactions, but dissolution sets in again when they are confronted with more complex reactions of choice. As M. P. Ivanova (1966) showed, they well understand the instructions, "When a red light appears, press with the right hand, and if a green light is shown, press with the left hand," and easily repeat it. However, the instruction does not determine the further course of their actions and they quickly either substitute repetitious pressure from the same hand for the necessary motor responses or press alternately with the right and left hand, disregarding the signals.

The disturbances in the signal (directive) function of speech observed in these patients manifest themselves by the fact that, even having learned the correct answers by heart ('right' in response to red and 'left' in response to green), they are unable to direct their motor reactions by their own instructions, and continue giving completely independent repetitious motor reactions. The disparity between the linguistic and motor responses becomes, in this instance, so great that controlling the system of choice movements by means of instructions becomes impossible.

These patients, a less pronounced 'frontal syndrome', present a similar picture when the same tests are repeated in a more complicated pattern, i.e., when the direct influence of the stimulus comes into conflict with its conditional meaning expressed by the linguistic instruction. If the patients are instructed to respond to a weak signal with strong pressure and to a strong signal with weak pressure (Khomskaya,) or to a long signal with a short movement or to a short signal with a long movement (Marushevskii,), it becomes apparent how easily the patient's movements begin to be controlled by the signals received directly from the stimulus, 'echopractically', and how easily the excitant agent loses its conditioned meaning. As a rule, such patients do not long retain the instructions regarding their response to signals. They begin pressing hard when the signal is strong, and weakly when the signal is weak, responding with protracted pressure to long signals and with short pressure to a short stimulus. The attempt to strengthen the signal meaning of the stimuli with introduction of auto-command proved unsuccessful. Patients with the massive 'frontal syndrome' can neither submit their reactions to the conditioned meaning of the signal nor coordinate their movements with the conditions of the instruction. Therefore, they cannot evaluate or correct their mistakes.

Other examples of this behavior are found in studies by Luria ( ), Pribram ( ), and Khomskaya ( ) as well as by Lebedinskii ( ). These show that when a patient with an extensive involvement of the frontal lobes is asked to lift a finger when he is shown a fist, and to make a fist when he is shown a finger, he will perform this task only once or twice. His movements will then become progressively slower, and soon the necessary movements will be substituted with echopractic repetition of the experimenter's gesture. The capacity to submit to the conditioned meaning and not to the directly perceived signal appears severely damaged, and the patient, even though he correctly retains and repeats the instructions, again submits to the direct influence of the stimulus.

Another series of experiments conducted by the author's collaborators V. V. Lebedinskii, L. S. Tsvetkova, and others (1966) showed that patients have similar difficulty in controlling their behavior by means of spoken instructions and prefer to substitute more elementary patterns for these complex forms.

The basic fact is clear, namely, that involvement of the lobes, without substantially influencing the sound and grammatical aspects of speech, produces gross disturbances in the signal (directive) function and the patient's behavior is reduced to a more elementary level. He submits to the influence of directly acting stimuli or previously established inert repetitiousness. The nonspontaneous patient with severe 'frontal syndrome' presents a well known clinical picture and can be evaluated as an example of this basic mechanism.

The question then arises as to the physiologic basis for the specific function of the frontal lobes and, furthermore, what neurophysiologic mechanism, triggered closely through them, might explain the clinical picture described above. Numerous studies showed that the frontal lobes, which are closely linked to the reticular formation, are extensively involved in every active function of the organism. The experiments of Livanov and his collaborators (1964, 1966), who used the toposcopic method, showed that every mental effort activates a large number of synchronically functioning points specifically in the frontal lobes. Grey Walter (1966) showed that every expectation of whatever reaction or every active fixation provokes the appearance of specific slow electric vibrations, which the author names 'waves of expectation' and which become especially pronounced in the frontal lobes.

These data lead us to the assumption that the frontal lobes play an important part in maintaining cortical tone; they participate in each active function of the organism, determining the selectivity of its reactions. This hypothesis is confirmed by a series of experiments conducted by Khomskaya and her collaborators (Luria, and Khomskaya, eds., 1966). These experiments show that each linguistic instruction activates the cortex; the following manifestations are typical for the normal individual: restoration of the vegatative components of the orientating reflex (Khomskaya); prolonged change in the spectrum of the encephalogram (Baranovskaya); changes in the slow potentials, connected with the fluctuation in the asymmetry in the rising and falling fronts of α-waves (Genkin, Khomskaya, and Yu.Artem'eva); and increase in the evoked potentials Simernitskaya).

Patients with damage in the posterior region of the brain show the same influence of linguistic instruction as normals. However, the activating influence of linguistic instruction disappears when the pathology involves the frontal lobes. In patients with gross involvement of the frontal lobes, one cannot observe constant influence of linguistic instruction upon the stabilization of vegetative components of the orientating reflex or the above-mentioned signs of stable changes of electrophysiologic indicators.

These experiments enable us to assume that the signal (directive) function of speech, disturbed when the frontal lobes are involved, can function only with the closest participation of the frontal area of the cortex. This is due to the part that the frontal lobes play in stabilizing the impulses arriving from the reticular formation and in the organizational choice of the impulses which they receive, thus enabling the healthy cortex to produce stable action.

Furthermore, the fact that the final formation of the directive function of speech is observed at the age of 4 to 5 years, when the frontal lobes mature sufficiently and begin to function, confirms this hypothesis with new data.

A new and very important chapter in the science of psychology opens up to us when we study the formation of the signal (directive) function of speech, and analyze the basic forms of its dissolution. The most important questions in psychology and psychophysiology, when reality is reflected consciously and human behavior is regulated voluntarily, may be then approaches from a new angle. It opens new perspectives for the study of the most complex forms of human behavior, the form which, as Pavlov says, is the highest self-regulating system. It also permits us to approach those sides of psychic activity which for many years remained outside the confines of scientific analysis.

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