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ЭКСПЕРИМЕНТАЛЬНЫЙ АНАЛИЗ РАЗВИТИЯ ВОЛЕВОГО ДЕЙСТВИЯ РЕБЕНКА

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EXPERIMENTAL ANILYSIS OF THE DEVELOPMENT OF VOLUNTARY ACTION IN CHILDREN

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The study of the formation of voluntary action in children should be started with analysing the way in which the child can accomplish the verbal instruction of the adult. The capacity of the child to subordinate its movements to the instructions of other people subsequently turns into the capacity to subordinate its movements to orders which are formulated in its own internal speech. Thus, with the development of the regulatory role of speech, there arises the form of organization of action which we call voluntary movement.

Observations show that this regulatory role of speech is not formed at once.

At early stages of development, i. e., at the age of one and a half to two years, the verbal instruction of the adult may easily call forth an adequate movement of the child; every one knows, for example, that the child readily fulfils the instruction «clap your hands!», etc. However, the verbal instruction of the adult can call forth proper action only if it does not come into conflict with another, dominating action of the child. If this happens, the effect of the verbal instruction will be unspecific and can only intensify the action performed by the child earlier. For example, if a child of one and a half or two is busy removing rings from a bar, and you offer it to put one ring on the bar, this will only intensify the child's previous action (i. e., the act of removing the rings), although in usual conditions the child fulfils this instruction quite easily (observations carried out by N. M. Shchelovanov and his co-workers). At such early stages of development the verbal instruction of the adult can only

start the action of the child, but it can neither inhibit it, nor switch it over to some other action. It is still not able to form in the system of the child's speech a preliminary conditioned connection which would lead to action some time later, at the appearance of a conditioned signal.

Let us illustrate this by a simple experiment.

You give a rubber balloon to a child of two or two and a half, with the instruction to press it at the flash of a red electric bulb. On hearing the words «when the light appears» the child immediately begins to look for this light; with the words «you will press the ball,» it begins to press the balloon at once, without waiting for the emergence of the respective signal. Even when after definite training (of which we shall not speak here), the child succeeds in pressing the balloon only at the appearance of the signal, still in proves unable to limit itself to a single pressure. The continuous stimulatory action of the balloon which is in the hand of the child cannot be inhibited by the verbal instruction, and the child produces numerous involuntary, unceasing motor reactions, instead of waiting quietly for the signal (Fig. 1). It is interesting to note that all attempts to inhibit these superfluous movements vith the help of verbal instructions, such as «enough!» «No more!», etc., do not bring about the desirable effect at this stage; they either act unspecifically only intensifying the diffused involuntary pressures, or fully inhibit the movements of the child.

Is it, however, possible to overcome these involuntary movements and to obtain a model of a well-regulated voluntary action even in those cases when this cannot be achieved with the help of the directly inhibiting influence of speech?

Practice shows that this is quite possible, but for this purpose the conditions of the experiment must be changed. In our usual experiments the optical signal only started the movement; it is the muscular sensations originating from the child's own movement and reinforced by the additional influence of the verbal instruction («no more!») which served as an inhibitory signal for the discontinuance of the movement. But the neurodynamics of the child's motor reactions was here too diffused, its muscular sense too underdeveloped and the influence of the speech system too weak to crown our experiment with success. To ensure a desirable effect we had to rearrange our experiment, so that the motor reaction of the child could evoke a distinct exteroceptive stimulation which would serve as a signal of adequate action, and inhibit any further movements in accordance with the feed back principle.

Such an experiment proved to be quite feasible. We offered the child to press the ball and thereby to ring a bell, or to press the ball and thereby to turn off the light at the appearance of the optic signal; in this way we ensured experimental conditions under which the child's motor reaction itself called forth such an exteroceptive signal. Observations carried out by S. V. Yakovleva on children at the age of two to two and a half have shown that in most cases in the course of such experiments it proved possible to obtain distinct movements coordinated with the signal and to prevent superfluous involuntary impulses (fig. 2).

The exteroceptive signal called forth by the child's own movement acted here according to the feed back principle, serving as a signal for the discontinuance of the action and inhibiting all further motor excitation. Consequently, this obvious signalization of the discontinuance of action was a means of obtaining the simplest model of voluntary action and produced the effect which could not be achieved with the help of direct verbal instruction.

We have described the simplest process of formation of a voluntary action. Is it possible, however, to pass to the next stage and to obtain a considerably more perfect process of formation of a real voluntary movement of the child? Shall we be able to pass from external signalization, with the help of which we have obtained the simplest model of voluntary action, to a system of internal signalization which is always at the disposal of the child, and thus to make a step forward to the transition to more perfect forms of self-regulation?

Let us try to replace the system of additional external signals originating from the movement of the child by the child's own speech signals which can reinforce the necessary movement and, according tho the feed back principle, inhibit all superfluous impulses.

We shall offer the child (which must respond with motor

reactions to the conditioned optical signal) to accompany each movement performed in response to the verbal instruction by its own verbal command «go!». If the dynamics of the nervous processes, on which the system of speech is based, proves more perfect, more concentrated and mobile than the dynamics of the nervous processes which underlie the motor reactions, then the inclusion of additional speech signals issuing from the child's own speech will serve as a means of regulating its motor responses.

All attempts to disclose a similar effect in children at the age of two to two and a half (as well as in three year-old children brought up in conditions of insufficient speech practice) ended in failure: the speech system of children of this age proved to be too weak; their speech reactions became extinct too rapidly and were inductively inhibited by the motor reactions. Therefore, all attempts to introduce at this stage the child's own regulatory speech into the experiment only led to a still greater derangement of its motor reactions.

Quite different results were obtained in experiments with children of three to four years of age brought up in conditions of kindergartens where their speech is systematically and thoroughly trained.

As shown by the experiments of M. R. Peskovskaya and later by the experiments of O. V. Tikhomirov a child of this age practically was unable to respond with distinct motor reactions to the signals presented, and produced numerous inter - signal reactions of which it was hardly conscious and which it could not inhibit at will. However, the neurodynamical processes on which the child's speech reactions are based proved at this age so perfect and mobile that the child could easily react to the corresponding signals with the words «go!», «go!», without giving any superfluous or persevering answers. Precisely because of this, when we united the two reactions and offered the child to pronounce the word «go!» and simultaneously to press the balloon at the appearance of each signal, the situation radically changed: the verbal reactions which are neurodynamically more perfect began to regulate the less concentrated and mobile motor reactions, the superfluous involuntary movements disappeared, and we obtained a model voluntary movement, this time regulated by the speech system of the

child itself. When we reverted to the initial experiment with silent motor reactions all the defects appeared anew (fig. 3).

Similar results were obtained by us in more complex experiments when the child had to react to each signal with two pressures of the balloon and when the verbal accompaniment of these reactions made their regulation quite easy (fig. 4).

What then is the mechanism of the regulatory influence of speech? Does it act in virtue of its elective connections, or is its action at this stage even much more elementary and its regulatory influence is determined by the fact that the verbal reactions of the child create and additional system of innervation impulses which exert the regulatory influence?

It we try to separate these two factors from each other in a special experiment we shall obtain a definite answer to this question.

We have just seen that a child reacting to an optical signal with the words «one, two!» is unable to perform a distinct double movement which is demanded by the verbal instruction. However, this regulatory influence originating from two separate verbal impulses cannot be retained if we offer the child to react to each optical signal with the words «I shall press twice!»; in this case the regulatory influence will come not from the elective side of speech, but from its innervatory (impulse) side, and the child when pronouncing these words will accompany them by a single protracted motor reaction. For the same reason, attempts to obtain in a child at the age of three or three and a half a regulatory influence of the significative side of speech during the eladoration of elective differentiated motor reactions prove to be very difficult. For example, if a child of this age after the instruction to press the balloon in response to a red signal and to inhibit his motor reactions to a green signal exhibits the tendency to produce motor reactions to boths signals (fig. 5a and b), the addition to these motor reactions of the verbal response «press!»at a red signal and «no press!» at a green signal does not yet produce any regulatory influence: the child accompanies the inhibitory green signal by the words «no press!» and at the same time presses the ballon; the louder it pronounces this inhibitory command, the more intense becomes the accompanying motor reaction (fig. 5b). Consequently, here the regulatory influence comes not from the significa-

tive, but from the impulse side of speech; and only if we eliminate the conflict between these two sides of speech and offer the child to pronounce the word «press!» exclusively in response to the red signal and silently to inhibit its movement at the appearance of the green signal, the regulatory role of speech will become strongly pronounced (fig. 5 c).

Only at a further stage of development (children 5 to 6 years old) the predominating influence of the unspecific, impulse side of speech disappears, and the child's motor reactions become regulated by the system of elective connections which by that time assume decisive significance.

Precisely at this age the child begins to intermediate its responses to signals by v e r b a l r u l e s which it formulates itself during the elaboration of motor reactions; and just at this age the child begins to form that kind of really voluntary movements which is directed and regulated by its i n t e r n a l s p e e c h. Therefore, as demonstrated in special experiments, the regulation of movement by pronouncing the meaning of the signal becomes here unnecessary; it often suffices to train, in the course of special experiments, the adequate verbal reactions of the child, and its subsequent motor reactions, now already regulated by the internal speech, begin to proceed quite normally.

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We have considered some experiments which show that in normal conditions the regulation of voluntary movements in children of 5 to 6 can already be effected without the decisive participation of their external speech. However, as soon as these conditions are complicated, the self-regulatory system becomes deranged and the compensatory influence of the child's own external speech acquires again a strongly pronounced character.

This might be most convincingly illustrated by cases of abnormal development of children with weakened cortical processes leading to the cerebro-asthenic syndrome.

If the child has suffered at a relatively early age from a trauma, infectious disease or protracted dystrophy the dynamics of its cortical processes may radically change: the force, stability and power of concentration of the nervous processes are affected, the balance between the excitatory and inhibitory processes becomes deranged. In such cases the child

manifests the heightened impulsiveness of eaxhaustibility which markedly complicate its normal education at the school age.

Without overstepping the limits of our experiment, we can see that such a child, not revealing any appreciable intellectual defects but exhibiting a considerable instability of the nervous processes, possesses peculiar neurodynamic defects. The child preserves distinct differentiated systems of motor reactions to positive and inhibitory signals, if these signals are presented at an optimal rate. But if the signals are presented at an accelerated rate and become shorter, i. e., if greater demands are made of the force and mobility of the child's nervous processes, the picture considerably changes: the child begins to produce inadequate impulse reactions to inhibitory signals, or does not manifest proper reactions to positive signals. In individual cases the number of wrong motor reactions may amount to 40 or 50 per cent.

It is in these cases that the regulatory influence of the child's own speech may come to the fore.

As shown by the observations of E. D. Homskaya, the neurodynamical processes, on which the speech activity of such children is based, often prove to be much more concentrated and mobile than the neurodynamics of their motor reactions. Therefore, if the motor reactions to signals are replaced by verbal responses (for example, by the response «press!» at the appearance of the positive signal and «no press!» at the appearance of the inhibitory signal), the child will be able to give correct responses even when the conditions of the experiment are similar to those under which it produces a considerable number of erroneous motor reactions.

It is the greater stability of the neurodynamics of the speech system which can be used by us as a compensatory factor. Therefore, if we unite in such children their motor and verbal reactions (offering them to respond with the word «press!» to positive signals and simultaneously to press the balloon, and with the words «no press!» to inhibitory signals, simultaneously refraining from any motor reactions), the inclusion of motor reactions into the new functional system normalizes the course of these reactions. In some children it strengthens the inhibitory processes and in others it increases the tone of the excitatory processes; this leads to a considerable decrease in the number of erroneous reactions.

While regulating the course of motor reactions by means of external speech, an excitable child with weakened cortical processes retards its reactions and inhibits the superfluous impulse responses to negative signals (fig. 6). In similar conditions, a child easily passing into a state of diffused inhibition strengthens its motor reactions also with the help of the regulatory role of speech; the child accelerates its reactions, makes them more intense and does not fail to produce adequate positive responses (fig. 7). In both cases the external speech of the child, being of a stable character both as regards its connections and neurodynamics, normalizes the course of the nervous processes; by including movement into the new functional system it becomes a powerful means of compensating the neurodynamical defects.

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We have analysed the complex process' of development of voluntary action in the child, and cited a number of experiments showing the respective role of the second signalling system which, according to Pavlov, «introduces a new principle of nervous activity» and gradually becomes «the highest regulator of human behaviour» There is no doubt that these investigations, which bear only a particular character approximate us to the solution of important poblems, relating to the mechanism of formation of voluntary movements in man and compensation of its derangements. New broad vistas open up before us, and the psychologistis ensured new possibilities scientifically to elucidate the mechanism of human behaviour.

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