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Development of Hand Functions in the Human Being Ontogeny

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ABSTRACT

The authors of the article research the problem related to developing the functions of the human being's hand in ontogeny in the context of defining physiological basis of the art activity and comparing biodynamical and sociocultural components of the motor function. The article content is made up at the confluence of biology, zoo psychology, physiology, and age psychology. The authors reveal such functions of the human being's hand as inspection, life support, orientation in space, creativeness, protection, communication, experimenting, etc. They analyze basic types of activity (orienting, transitive, instrumental) and give their characteristics (amplitude, volume, power, adequacy, accuracy, expressiveness).

Key words: hand functions, hand actions, ontogeny, motion experience.

INTRODUCTION

It is known that the human being's child is born helpless because since its birth it is "handed" considerably more loosely than cubs of the majority of animals. Basic actions and behavioral reactions of animals are "recorded" in their brain, have biological nature and appear at once after the birth or as soon as cubs grow. The baby's brain contains few ready "records". That's why it masters various human being's actions and forms of behavior in the process of acquiring sociocultural experience (Vygotskiy 1991, Muhina 1980). Hands play the most important role in the human being's acclimating of the environmental space and the establishment of the system of relations with him. F. Engels advanced an extremely important idea on the importance of the hand in the process of turning the monkey into the human being and showed the importance of an instrument (Engels 1934, 50-51). It is possible to challenge this hypothesis about the origin of "homo sapiens" as biological specie. However, the opinion about the importance of the instrumental activity in the human being's evolution is true. Numerous archeological finds persuasively prove it.

To a large extent the first baby's behavioral reactions in the early ontogeny as well as its further psycho-physical development are defined by timely gradual formation of both motor and speech functional system. Each of them is characterized by specific regularities of the development at all age stages of the ordinary ontogeny. The external expression of active functioning of these two systems has the form of various motor and speech reactions that firstly have an involuntary character, and then acquire higher voluntarism due their social stipulation. Thus, the development of movements in ontogeny is defined by anatomic and functional maturing of nerve fibers and adjustment of the work of coordination levels. Anatomic maturing of central nervous substrates (the newest organs of movement – a pyramidal motor system and frontal systems of hemispheres build over it) finishes by the age of 2-2.5 years.

N.A. Bernstein writes the following about it: "Natural ontogeny of motor consists of two bitterly asynchronical phases. The first phase includes anatomic maturing of central nervous substrates that finishes by the age of 2-2.5 years. The second phase that sometimes goes over the puberty age is the phase of functional maturing and adjustment of the work of coordination levels. At this phase the motor is not always developed directly progressively: temporary breaks and even regressions that create complicated wavering of proportions and balance between coordination levels may occur at some moments and in relation to some classes of movements (i.e., levels)" (Bernstein 1997, 139).

It is interesting to compare these provisions with the results of the comparative research of Ioni anthropoid's (chimpanzee's cub) and Rudi child's behavior made by the zoo psychologist N.N. Ladygina-Kots (Ladygina-Kots 1935).

Besides, the research includes a theoretical analysis of works of a number of the most leading Russian researchers, particularly A.V. Zaporozhets. He came to the definition of the "internal picture" or internal form of movement (Zaporozhets 1986). According to the researcher, this picture contains the course of the situation and those actions that can be made within this situation. A.V. Zaporozhets was the first researcher in the world who included the course of the situation and the course of action, i.e., a sort of sensuous tissue in biodynamic tissue of movement, motion experience. Mastering new actions (not acquiring objects by actions or activity) is real enrichment of a human being. It means the development of not only operative and technical peculiarities but also his/her personality, really human life style. Simultaneously with the analysis of fundamental resources, children aged 2 months–7 years were observed (512 children participated in the research) in order to study the hand movements made in everyday life and in the process of various types of art activity.

Besides, there were observations of animals' cubs in various zoos of the world (Great Britain, China, Russia, and Thailand, Philippines) in order to study the character of the hand movements and compare them with the movements of the human being's hands.

According to the authors, the functions that are formed in the long process of evolution, above all, include orientation in space, inspection of objects and materials in order to reveal their features, life support (eating, drinking, combing, self-massage of the wounded place by stroking, scratching, and rubbing), creativity (producing instruments of labor, household items, weapon), protection (the human being can push off the attacker, scratch, threaten with fists), communication (touching, stroking, gestures, greeting, pointing at oneself or an interlocutor), etc.

During the research *the method of theoretical matrix* was developed and tested. Data received by N.N. Ladygina-Kots acted as the *matrix* of the fundamental principle. The later data received by other researchers: B.G. Ananiev (Ananiev 2001), N.A. Bernstein (Bernstein 1997), A.V. Bakushinskiy (Bakushinskiy 2009), A.V. Zaporozhets (Zaporozhets 1986), L. Levy-Bruhl (Levy-Bruhl 2002), A.N. Leontiev (Leontiev, Zaporozhets 1945), V.S. Muhina (Muhina 2000), T.P. Chrizman (Chrizman 1973) et al. was gradually built in this matrix. The research resulted in the *theoretical model of the human being's hand development in ontogeny.*

MATERIALS AND METHODS

The research of the results related to testing the theoretical model was focused on the correlations between the model and the real level of the hand development with children aged from 2 months to 7 years. For this purpose original research methodologies were developed.

1) "Methodology of researching objects without the participation of visual analyzer" assumed the recognition of various objects (materials, objects, safe instruments) by children only by using their hand. The objects were placed in the non-transparent bag where the child moved down his hand and recognized the content according to such features as "form" and "structure".
2) In order to reveal the children's capacities to define the relation between the instrument

and the result of applying it in the person's activity, "the method of pair pictures" was used. In this method we used the "Logic-baby" didactic board with six movable buttons of various colors (red, orange, yellow, green, blue, and purple). They could be easily replaced in channels and adjusted in front of the answer picture with the opportunity of result self-control on the opposite side. There is a question: is it possible to create such experimental terms and conditions under which mutual directionality between objects according to the form as the meaning bearer (irrelevant irritant) affects the subject at the discretion of the experimenter, while the testee's attention and cognition as a whole are not focused on this mutual directionality. In order to create such experimental terms and conditions, we used the "method of recognizing an instrument". It enabled us to confirm the fact of the testee's perception of the irrelevant irritant and to reveal the track of impact the irrelevant irritant (even if unconsciously) in the testee's memory. "The method of recognizing an instrument" is also interesting by the fact that it enables to assign the subject's activity only in one specific direction.

3) "Methodology of movement actualization" was developed in order to study the level of understanding the motion experience through the material of traditional instruments. The methodology bears a variable character that takes into account peculiarities of the age. Pictures were alternatively showed to children of younger preschool age (3-5 years old), individually for every child. The child saw the whole plot. The child was studying the picture during 5-10 seconds, then answered the researcher's questions: "Who is it? How did you guess? What is this man doing? What does he have in his hands? Why is he doing it?" The answers were documented. Then the children were offered to "help" the man to do the job (cook supper, dig a hole, draw a picture, play drums, etc.) in the play form. Firstly, the researcher asked the child to show movements without instruments (pantomime as if in a theatre) and then select the suitable instrument from the offered ones and make the action with its aid. We fixed the accuracy of the answer, orientation in labor activities drawn on the picture, understanding of the plot, ability to reproduce actions of the imitation character (accuracy of movements or a series of movements), selection of a suitable instrument (selection adequacy), ability to reproduce labor actions with the aid of an instrument (reasonability, adequacy and expression of movements).

7-8 pictures were simultaneously demonstrated to children aged 5-6, and 9-10 pictures to children aged 6-7. Herewith, the exposition frame closed a part of the plot enabling to see only the conceptual part – man's hands with an instrument. The child was studying the picture during 3-5 seconds, and then answered the researcher's questions: "What is happening here, in your opinion? How did you guess? What and why is this man doing? What does he have in his hand (hands)? Can you tell me the man's profession?" The answers were documented. In addition to the general criteria that allowed to estimate the actions of younger preschoolers, we also noted: 1) succession and motivation of selection, 2) ability to determine analogies between similar instruments (hairdresser's scissors and sewer's scissors) and to adequately make movements that correspond to the concept of a profession, 3) ability to refer various movements of hands to various professions and instruments related to them (for example, a needle or sewer's scissors).

RESULTS

In the process of the theoretic research the following results were achieved:

1) Development of a theoretical model of the process of the child's hand development in ontogeny (from 2 months to 7 years old),
2) System analysis of the content of contemporary educational programs with respect to the compliance of the declared criteria related to the development of the child's hand with the parameters described in the theoretical model; as for the

parameters, a number of inconsistencies were revealed, their causes were analyzed in partnership with 10 independent experts (physiologists, hygienists, children's doctors, and psychologists),

3) Psychological and pedagogical diagnosis related to the correlation of criteria described in the theoretical model with real indicators of the children's hand development was carried out, a number of divergences were revealed according to the following parameters: "lacing shoes by itself" (divergence is from 6 months to 1 year old), "using scissors with certainty" (considerable divergence in 1-1.5 years is revealed in the group of so called "home children", i.e., the ones who do not attend a kindergarten).

In the process of the experimental research where 512 children aged from 2 months to 7 years participated, the following results were received:

1) Developing the original methodology to research functions of the human being's hand at the early stage of his life,
2) Defining functions of the child's hand in accordance with the functions of the grow-up's hand (inspection, life support, orientation in space, creativeness, protection, communication, experimenting, etc.) and the character of these functions correlation depending on the testees' age,
3) Describing basic types of activities performed by the hand in everyday life and under various types of the art activity (orienting, transitive, instrumental),
4) Revealing parameters that characterize the hand actions (amplitude, volume, power, adequacy, accuracy, expressiveness); these parameters are described as criteria for the psychological and pedagogical diagnostics,
5) Stipulating the comprehended role of speech, idea, sign, symbol in the process of manipulative actions turning into "rational" related to setting a goal and task of the activity as well as with elements of reflexive self-organization (self-control and self-estimation).

DISCUSSION

Basic results of the research are related to describing the dynamics related to the development of the hand in ontogeny as well as revealing stimuli and amplifiers of the development of the motor function of the human being's hand.

The basic peculiarity of the newborn baby is boundless opportunities to acquire new experience, mastering human forms of behavior and various types of activity. The child's hands movements required for his full psychic development and interrelation with the environment are formed on the basis of capturing that happens due to the fingers irritation. However, it is possible to observe atavistic grabbing reflex in the first days of life. It is expressed in the fact that the hand is clenched in a fist as a respond to the palm irritation. Soon this reflex decays.

It is important to note the importance of hands for moving in space, too. The child reaches out for an object that attracted attention. Herewith, in this intention he/she steps over with his/her hands and step by step moves forward. That's why real crawling starts with hands movement but not starting out from the bearer with feet as sometimes pedagogues and parents think by mistake. Lifting in the sitting position is also performed with the aid of hands the child uses to grasp the objects that hang above him (a stick, a rattle) and buckles.

This is infancy when the child "discovers" his/her hands, learns how to grasp objects and then manipulate them following home adults or by himself. These actions always aim at using external features of familiar objects. That's why the child manipulates a spoon or a comb in a similar manner as a rattle, stick, and shred.

The first manipulations with objects are not accurate and are attended with synkinesia. When the child is 5 months old, he/she can take an object with two hands. At the age from 4 to 6 months spontaneous regulation of eyes movements is developed. At the age of 7-10 months the visual and motor coordination achieves high development: the child can already open and close

the box cover, insert a ball in an empty block, take one object that attracted attention with the aid of another. However, plays with objects by children of up to 10 months old still have an entirely manipulative character: objects are placed from one hand to another; they are thrown, and knocked with, etc. At the age of 12 months fine motor skills become more perfect. The child can take small objects, and watch them pressing between a thumb and index finger. In the period of the early childhood (up to 3 years old) visual and motor coordination continues being improved. At the age of 2-3 years old the children's psychomotor system is developed rather well. At the age of 6-7 years old the fine motor skills are improved.

Human instruments and methods to use them have social origin. That's why for a child they act as objects for mastering, something he/she must master in the process of his development. Mastering instrumental operations is a long and complicated process. Mastering a hand as a natural instrument creates prerequisites for turning it into an "instrument of instruments"; it gives a strong incentive for further development. One of the basic requirements to the action we bring up is its rationality. It lies in the fact that the subject focuses its action on significant relations of the task. If we bring up the action, we must do our best for these relations to clearly appear before the subject; for the subject of the action itself to be rationally introduced. As a matter of fact, an object can be shown differently: so that its essential features and relations act clearly and exactly and in such a manner that they will happen to be in a deep shadow and hidden. In the latter case the action may happen to be correct. However, psychologically it will become irrational. It is revealed under little change of conditions. Thus, in spite of the fact that the requirement of rationality is directly related to the action subject, above all it is not explicit but it is purposefully addressed to its tutor as a requirement of rational exposition of the object of this action.

CONCLUSIONS

The development of hands as the most important human receptor and instrument of instruments has an important meaning for life support, adaptation, learning, and general development of the human being. The first stages of ontogeny - infancy, early and pre-school childhood – are especially dynamic stages of ontogeny.

As a whole, the analysis of the results of the experimental research proves the provisions of the cultural and historical concept of L.S. Vygotskiy (Vygotskiy 1991). He states that there is the three level scheme in the consciousness ontogeny. The adult uses words signs (incentive words) and thereby stimulates the child to active actions (to take or bring something, etc.). Having cognized the sense and content of these words, the child organizes a feedback by transforming incentive words addressed to him/her in impact words addressed to the adult. Finally, there is such level of communication when impact words are successfully addressed to him/her and regulate his/her behavior. Thus, in ontogeny the development of the hand functions happens to be stipulated by the social environment. Consequently, the essence of the motor development in the normal ontogeny of the child is not only in biologically stipulated maturing of relevant morphological substrates of the brain, but also in accumulating individual motion experience acquired in the process of verbal and non-verbal communication with surrounding people as well as in cultural practices and experimenting. As a whole, insufficiency of motion means, immaturity of the hand functions and psychomotor negatively affect the activity and character of communication, and movement behavior of the growing human being as well as performing a lot of types of activity that requires a specific level of the motor and speech development.

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