

Psychophysiological Mechanisms of Grammatical Structuring in the Speech Activity of a Preschool Child

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Abstract: *Language as a means of implementing the speech process is an independent system with its own structure. In the context of our research, the concept of M.I. Zhynekin (1958) on the grid distribution of information in the grammatical space, which explains the mechanism of perception and awareness of speech. It is important for us to conclude that the sooner a direct connection is formed between the conceptual system and the basal ganglia, the better the child's awareness, assimilation and use of grammatical categories. To organize the normal functioning of speech requires a complex coordinated work of millions of neural elements of the brain, which are included in its various parts. It is proved that after ten years the ability to develop neural networks necessary for the construction of speech centers it disappears. The problem of forming grammatically correct speech in preschool children can be solved quickly and efficiently if you intensify the interaction of different analyzers. It is proved that the sensory information complex consists of auditory, visual and tactile images, which, complementing, amplifying each other, increase the number of useful signals, expand the speech space, which, in turn, limits the choice of adequate speech pattern during acquisition, perception and oral awareness. Children's learning of the elements of the grammatical system of language is influenced by two main factors, namely: the dependence on the simplicity or complexity of the language phenomenon and the degree of its communicative significance. The formation of grammatically correct speech (morphology, word formation, syntax) is based on a certain cognitive development of the child.*

Keywords: *neural elements of the brain, neural networks, psycholinguistic mechanism of speech, informative sounds, stages of ontogenesis, interaction of signaling systems, brain structure.*

How to cite: Kruty, K., Bohdan, T., Kozyr, M., Sviontyk, O., Shvaliuk, T., & Pinchuk, Y. (2021). Psychophysiological Mechanisms of Grammatical Structuring in the Speech Activity of a Preschool Child. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 12(3), 255-269.
<https://doi.org/10.18662/brain/12.3/230>

Introduction

Based on numerous studies in the field of neuropsychology and neurolinguistics, O.O. Leontiev (1969), I.O. Zymnya (2001) developed a model of speech generation. Using linguistic analysis and a number of personal neuropsychological studies (Luria, 1975, pp. 39-48) developed the foundations of a related discipline - neurolinguistics.

The psycholinguistic mechanism of speech finds its explanation in terms of a functional system and an action acceptor (Anokhin, 1997), anticipating reflection of the necessary future (Bernstein, 1966), orienting research activities and instance (Galperin, 1985), code transitions, the surface principle of processing speech information (Zhinkin, 1958).

Scientists such as Vygotsky (1956), Leontiev (1969, pp. 106-144), Melnyk et al. (2021), Melnyk et al. (2019), Sheremet et al. (2019), Behas et al. (2019) and others proved that the word (its generalizing meaning) is a unit of speech abstract thinking. Vygotsky (1956) and others bring the fact of the development of the meaning of the word with the fact of the development of consciousness: if the meaning of the word changes with the development of the child, the relationship of those connections that reflect the features of his consciousness changes (Leontiev, 1969).

These provisions, first, allow scientists to use the study of speech function (especially the child's assimilation of semantic units of speech) as an important means of categorical analysis of human mental activity. Secondly, in the context of the outlined problem, these provisions make it possible to use the study of the level of formation of the generalizing function of speech in preschool children to determine their readiness for school as a condition necessary for the development of abstract speech thinking. Thus, "engaging" in the practical activities of the child, speech is able "from within" to gradually restructure the process of his thinking and turn the practical action into a complex structure of mental action. Such mental action begins to unfold at the level of generalization of knowledge and is carried out by means of use of more generalized ways of operation by them. Accordingly, the type of thinking changes: from the active it gradually becomes concrete-figurative, and later - verbal-logical.

The results of psycholinguistic analysis of the genesis of children's speech show that the generalizing function goes through a number of stages of successive development. This staging is expressed in the child's assimilation of meanings of the same word, different in terms of the level of generalization - nominative, phraseological conditioned, generalizing meaning of a word (verbal concept), its logical relationship and abstractly

generalizing lexical meaning. On the basis of control the state of development of mental operations with lexical units of speech, it was proved that the levels of formation of the generalizing function of the word are the standards that allow using specially designed techniques to objectively assess the level of speech development.

L.P. Fedorenko (1984) identifies several degrees of generalization of words in meaning: *zero* (from 1 year to 2 years), *the first* when the child learns the generalized meaning of the names of homogeneous objects, actions, qualities (from 2 years to 3 years), *the second* when the words are learned - generalization of generic concepts (at the age of 3 years), and the last, *the third*, at the age of about 5-6 years, when the child learns generic concepts.

According to N.M. Danilova (1999, p. 261), it is necessary to distinguish the stages of word formation as a "signal of signals". Showing a child an object and naming it gradually leads to the formation of an association, then the word begins to replace the object that was called. This replacement occurs at the end of the first and at the beginning of the second year of life. At this stage of the child's development, the word is a *first-order integrator*. The conversion of a word into a *second-order integrator*, or into a "signal of signals" occurs at the end of the second year of life. N.M. Danilova (1999, p. 261) argues that it is necessary to work out a group of connections (at least 15 associations) in order for a child to learn to operate with different objects that are denoted by one word. If the number of used connections is less, the word will remain a symbol that replaces only one specific object. Between the third and fourth years of life, concepts are formed - *integrators of the third order*.

Stages of ontogenesis of interaction of signal systems

In the process of ontogenesis, the interaction of two signaling systems goes through several stages. Firstly, the child's conditioned reflexes are realized at the level of the first signal system: the direct stimulus is associated with direct autonomic and motor reactions. These are connections of type D-D (direct stimulus - direct reaction). Thus, physiological, genetically inherited reflex motor manifestations are proto-signs, which together create, according to O.I. Isenina (1986), proto-language, i.e. the primary verbal system of communication. *Proto-speech* has a non-verbal paralinguistic basis (use of gestures, facial expressions, manipulation of objects, non-speech sounds, etc.).

In the second half of the first year of life, the child begins to respond to verbal stimuli with direct autonomic and somatic reactions, as a result,

conditional connections such as V-D are added (verbal stimulus - direct reaction).

K.V. Anokhin (1997) and others argue that at the end of the first year of life, namely after 8 months, the baby begins to imitate the speech of an adult, using individual sounds to denote individual objects, phenomena occurring nearby, as well as his condition, G.L. Rozengardt-Pupko (1963) and others. M.M. Koltsova (1967, pp. 39-58) proved that the word gets the role of a conditioned stimulus for 8-9 months of life.

However, according to Gorelova & Sedov (1998, p. 173), nonverbal proto-signs create the basis for the child's speech activity in the first two years of life. In the word, a small child seeks a literal reflection of reality, which is why in his nominations he unconsciously uses the laws of phonosemantics, I.N. Gorelova (1998, p. 167).

According to L.S. Vygotsky (1956), already at the second stage of the formation of functions, namely in infancy, a special type of consciousness "pre - we" arises, as well as a special complex of communication means, called "proto-language" or "*mother tongue*" (the last term was proposed by L. S. Vygotsky (1956).

Modern psychologist Zinchenko & Meshcheryakov (2000, p. 91) proposes to consider the problem of a special form of activity, which can be terminologically expressed as "pre-activity", which is formed and developed within the total activity. Note that the scientist does not oppose the term "collective activity" to the term "joint activity", because the former refers to earlier forms of interaction between child and adult, when it is not yet possible to talk about the symmetry of their relationship in the process of joint activities.

Zinchenko & Meshcheryakov (2000), after analyzing the approaches to the category of activity, came to the conclusion that the identification of pre-activity with the activity of communication is erroneous, although pre-activity really has the features of communicativeness..

Thus, *the speech development of a child in the first year of life* takes place under the sign of building a linguistic personality that will use language as a multilevel system. In addition to phonetics and vocabulary, the grammatical structure of the language is intensively formed.

Orientation to the word, attempts to operate on its meaning lead the child to the need to distinguish and recognize words in the speech flow. These points pose the need to master the phonemic perception, which is based on the ability to recognize phonemes. Some specialists in children's phonetics (Salakhova, 1973) proposed to consider the period from the

pronunciation of the first word to the last learned sound as the period of *mastering the sound basis of speech*.

It is known that at the end of the second year of life phonemic hearing in a normally developed language personality is fully formed. It is due to the fact that the child begins to recognize stressed syllables, she pronounces, first of all, them, that is, complex words appear in speech. Along with complex words can be formed a set of quasi-words (allegedly words), the sound composition of which is motivated by random consonances (Gorelov & Sedov, 1998, p. 177).

According to psycholinguists I.N. Gorelov, and K.F. Sedov (1998) and other *complex words* and *quasi-words* are the only verbal component of the utterance and are adjacent to the pointing gesture towards any object. Consequently, it can be argued that an object with a gesture creates in the child's utterance what linguists call a "theme," "known," namely a complex word or quasi-word "rheme", that is, new in speech, that "is said about topic" (Gorelova & Sedov , 1998, p. 178).

Later, at the age of 1.5-2 years, the baby in one word indicates not only the subject, but also the actions and experiences associated with it. Then there is a differentiation of words into categories denoting objects, actions, feelings. With the appearance of "normal" verbal speech, the non-verbal proto-sign does not disappear at all, but go deep into the linguistic consciousness of the individual (Isenina, 1986). It is the proto-language that forms the basis for the formation of a special language of intelligence, which M.I. Zhynkin (1958) called the universal subject code. Individual features in the use of words by preschool children - the names of objects, actions are quite noticeable. The reason for speech passivity is pedagogical neglect at this age, the reluctance of parents to communicate with the child.

Thus, a new type of D-V connection appears (direct stimulus - verbal reaction). At the end of the third year of life there is a new type of communication V-V (verbal stimulus - verbal reaction) - the child learns to speak. According to psychophysiolgists K.V. Anokhin (1997), N.P. Bekhterev et al. (1996) and others, with the development of speech in a child (age three to four years) complicates the integrative activity of the brain: there are conditioned reflexes to the ratio of quantities, distances , colors, etc.

Scientists L.S. Vygotsky (1956), J. Piaget (1969, pp. 15-39), O.O. Leontiev (1969) and others proved that verbal forms of thinking in a child occur first in the form of simple judgments, in operations of comparison of objects, in conclusions and questions that are asked by it first to the adult, and then to himself. Judgments and reasoning first take the form of a

statement of a fact or connection established by a child with the help of an adult, and then independently, J. Piaget (1969, p. 59). Thus, from the clearly given, concrete, single fact the child passes to operation of representations about it, and then and to more generalized conceptual knowledge. At the same time there is a development of both individual operations and methods of action (comparison, classification, generalization), and analytical and synthetic activities in general (Sukhodolsky, 1976).

To organize the normal functioning of speech requires a complex coordinated work of millions of neural elements of the brain, which are included in its various parts. It was proved that brain mechanisms "remember and actualize" words and grammatical forms, "see" reality in words, "can embody thought in a word and extract it from a word", "know", in which position to put the articulatory organs to pronounce sounds, etc. Certain approaches to solving the problem of speech research were proposed by I.P. Pavlov (1952) in his development of ideas of the second signal system.

Unfortunately, even in the manuals you can read statements about the ways of forming children's speech, where the main way is to imitate the speech of adults.

The concept of text generation proposed by M.I. Zhynkin (1958), who explained in detail the process of selecting elements of the text and the limitations that intelligence imposes on this process. E. Zhynkin (1958) believes that selection is the universal operation that goes through the entire chain of the mechanism of speech - from speech sound to thought. The author of this concept put forward a hypothesis: words are not stored in memory in full form, but are stored in a certain way in an organized form as "lattices of phonemes" and "lattices of morphemes" of their elements, from which, according to certain rules, the full form of a word is supposedly removed at the time of choosing the construction of an utterance.

During decoding, the words are arranged in a line, ie follow each other in time. Reflecting on the need to integrate words into memory, M. I. Zhynkin (1958, p. 44) came to the conclusion that there is an operational, iconic speech memory. The mechanism of language is built in such a way that anyone who learned it in childhood, even with disabilities, will receive speech exactly in the course of its time..

The research results of M. I. Zhynkin (1958, p. 32) made it possible to conclude that the composition is a pronounced unit, and the word is semantic. That is why "words can be accepted and understood without skipping. Composition and word are units of different plans. Composition is a speech unit, and a word is a linguistic unit", M. I. Zhynkin (1958, p. 32).

And although speech implements language, the motor speech code is primary, and speech, letter - secondary. Language is created in speech and is constantly reproduced in it. Thus, according to M. I. Zhynkin (1958), the word must be mastered in the dynamics of syllable distribution before it becomes a letter code.

From the above considerations, significant conclusions can be drawn: 1) on the basis of dynamic temporal connections, the child has the possibility of a fundamentally different - compared to the reflex - way of learning new words of the language; 2) with the help of dynamic specializations can be distinguished not only words that denote the realities of the environment, but also others, including the most abstract and formal elements of speech that can not be explained by instructions (word roots, prefixes, suffixes, endings, etc.). Apparently, on the basis of these processes and formed "lattice of morphemes", the existence of which insisted M. I. Zhynkin (1958), emphasizing the role of this chain in the general system of speech communication.

The importance of informative sounds for the correct perception of words

In the process of speech perception, learning grammatical space can significantly reduce the time of receiving information, compress the zigzag of grammatical moves and reveal an opinion. According to M.I. Zhynkin (1958, p. 45), the listener does not try to make a grammatical analysis, but only perceives the opinion contained in the message.

Thus, the grammatical analysis by the speaker was made at the time when the grammatical structure was developed in the brain. Using the rules of the subject code laid down in this structure, the listener understands the thought, Isenina E. I. (1986).

As evidenced by the results of the experimental work of P. Orleron & Danset (1963, p. 8), not all elements of the word are equally informative in perception. Scientists have proven that the beginning of a word is the most important for recognition. E.I. Isenina (1986, p. 162) found that the most informative for speech recognition are signs that indicate the method of creation, rather than the place of formation of sounds. The same data give P.B. Denes (1963) and other authors.

Research has shown that the most important informational sounds for the correct perception of words have been proven:

a) the first sound of the word and several root sounds, if they are under the voice, are informative;

b) the sound of the word is importantly marked;
c) the consonant of the suffix can be informative;
d) in short words, all the sounds of a word have a large informational load, Isenina E. I. (1986, p. 165).

Scientists also distinguish the levels of word selection by the speaker - composing words from sounds and composing a message from words.

The first level of selection is composing words from sounds. The fact that in mastering the word change the child focuses on the sound outline of morphemes, is confirmed by the fact that the primary clarity of pronunciation is manifested in the endings. To learn grammatical forms, a child must form an orientation to the sound form of the word. This orientation is part of the selection activity as a specific component (Aksarina, 1964, pp. 31-59). Simple accumulation of experience, as evidenced by special studies of A.V. Zakharova (1975), do not give tangible results without the activity of the child.

The second level is composing a message from words. It is at this level that special semantic rules apply, which have nothing to do with the sound structure of a word or the syntactic connection of words. According to M.I. Zhynkin (1958), these rules are a kind of filter that passes into the intellect only conscious language expressions.

The concept of M.I. Zhynkin (1958, p. 45) suggests that in the first phase of integration the original (zero) words from the speech of the speaker "fall in the field of speech on word forms (microwords)", and this is the analysis needed by the speaker to get the material to integrate numerous full words that can be combined with each other. *Grammatical space* comes into force only in the second phase of integration of language units. The previous step in each phase is the analytical step.

The main material for "contraction" (term of M.I. Zhynkin 1958, p. 46) of words in grammatical space are inflections, word-forming suffixes, postfixes, and also forms of the verb "to be". Just as phonemes differ binary in differential features and are binary opposed in words, so do binary different word forms in words that are binary integrated in grammatical space. Sharing the opinion of a prominent scientist, we believe that in order for the dynamics of change of words in their connection was natural, there must be an accurate account of the actual material of word forms and their changes. It is under such conditions that it will be possible to predict the appearance of word forms in perception, as well as to wait for the appearance of certain forms.

Thus, this is the compression of time in grammatical space. The material of word forms is quite voluminous, therefore, classification is

needed to take into account the dynamics of word forms. According to M.I. Zhynkin (1958), binary word forms constitute a system called a paradigm that cannot be imagined as a sequence of phonemes. The scientist proposes to imagine the system of paradigms in the grid as a table, which indicates the admissibility of the compatibility of forms in the process of speech development. It is the fact of the existence of grid processing of information contained in word forms, indicates the uniqueness of the second phase of integration of the speech process.

In the context of our research, the concept of M. I. Zhynkin (1958) on the grid distribution of information in the grammatical space, which explains the mechanism of perception and awareness of speech.

Language as a means of realization of the speech process is an independent system that has its own structure. But the functioning of language is inextricably linked to speech, because speech itself is the sphere of its use. That is why, M. I. Zhynkin (1958) notes, it is impossible to sufficiently adequately and effectively learn a language apart from speech. Only in the living process of speech is it possible to realize such phenomena as polysemy, synonymy, meaning, etc. (Bugrov, 1996). Conversely, it is impossible to study the patterns of the speech process apart from language. Even the well-known psychologist S.L. Rubinstein (1946 pp. 48, 90) in his early works noted the separation of two leading functions of speech - communicative and significant, and later the scientist calls only one function of speech - to serve as a means of communication, specifying that speech communication is quite specific, because it is communication thoughts. O. R. Luria (1975) names the nominative and predicative functions of language / speech as the main ones. But from the point of view of linguistic research, these functions are the semantic characteristics of the cognitive (cognitive) function of language, not speech. In other classical works on neuropsychology, special attention is not paid to the basic function of speech.

Unlike psychologists and neuropsychologists, psychophysicists N. N. Danilova (1999), Khomska & Batova (1998) and others distinguish three main *functions of speech: communicative, regulatory and programming*.

The communicative function of speech provides communication between people through language. Speech is used to transmit information and awaken to action, N. N. Danilova (1999, p. 262). The motivating force of speech significantly depends on its emotional expressiveness, E. D. Khomska (1998). A person learns a language throughout his life, but there is also a critical period for learning. It is proved that after ten years the ability

to develop neural networks necessary for the construction of speech centers disappears.

The regulatory function of speech realizes itself in higher mental functions - conscious forms of mental activity. The concept of higher mental function was derived by L. S. Vygotsky (1956, p. 512), developed by O. R. Luria (1975) and their followers. A distinctive feature of higher mental functions is their arbitrary nature. Speech plays an important role in the development of arbitrary behavior of the child. The results of research of O. R. Luria (1975) and E. D. Khomska (1998) proved the connection between the regulatory function of speech and the anterior hemispheres. The important role of convex departments of the prefrontal cortex in the regulation of arbitrary movements and actions, various intellectual processes is also clarified.

The programming function of speech has its expression in the construction of semantic schemes of speech utterance, grammatical structures of sentences, as well as in the transition to external expanded utterance, N. N. Danilova (1999, p. 265). The basis for this process is internal programming, which is carried out using internal speech. According to the views of O. R. Luria, neuropsychologists distinguish two groups of brain structures with different functions of speech activity. The anterior divisions of the left hemisphere are "responsible" for the dynamic organization of speech utterance, and the posterior divisions of the left hemisphere are responsible for speech codes (phonemic, articulatory, semantic, etc.). The anterior parts of the speech zones of the cortex include the Brock center, located in most people in the lower parts of the third frontal gyrus. It is this zone that controls the implementation of speech reactions. The Wernicke center refers to the posterior sections of the speech cortex. It is located in the temporal lobe and provides speech comprehension. Violation or underdevelopment of the Wernicke center affects the awareness, first of all, of logical and grammatical structures.

The study of the structure of the brain allows suggesting that speech can be considered as a three-component system - the creation of words, the formation of concepts and intermediate processes that play the role of an intermediary between the first two. Further research by these scientists has shown that the brain structures that provide the naming function should be considered as a system of intermediaries in which concepts are presented with structures that form words and sentences. The authors of this approach proved that the naming function for general concepts is localized in the posterior left temporal lobes, and for special - in the anterior, near the left temporal pole.

Modern neuropsychologists and neurophysiologists as N. N. Danilova (1999), E.D. Khomska (1992) and others, proved that the posterior speech system is connected with the motor and premotor areas of the cortex both directly and through the subcortical pathway. The latter covers the left basal ganglia and the nucleus of the anterior thalamus. It is through these pathways that the double pronunciation of speech sounds is controlled. The analysis of brain lesions, which lead to certain complications in mastering verbal codes, is thoroughly presented in the classic works of O. R. Luria (1975). Developing the fruitful ideas of I. Filimonov (1974) about simultaneous and successive syntheses and structural organization of language (respectively paradigmatic and syntagmatic by R. Jakobson (1975, pp. 193-230), O. R. Luria (1975) made a discovery about the various brain mechanisms that ensure the functioning of these forms speech communication. Note that at the present stage of development of psychophysiology of speech, the problem of brain responsibility for synthetic structures does not have a single consistency in the scientific literature. Thus, if traditionally it is a question of providing simultaneous systems with temporal and occipital departments of bark mainly of the left hemisphere, the data of modern neurophysiology testify to their providing with back departments of the right hemisphere, (Dubrovinskaya et al., 2000).

Conclusions

Thus, the subcortical pathway is activated during the formation and performance of speech skills, while the cortical pathway is associated with more conscious control of the speech act. Empirically, scientists predict that during the speech act, the cortical and subcortical systems operate in parallel with each other.

In the context of our study, this conclusion is of conceptual significance. Thus, in the process of learning the word "*white*" or "*blue*" in a child simultaneously activates the area responsible for color concepts and the system of word formation and motor control (through the cortical and subcortical pathways). Over time, there is a direct connection between the conceptual system and the basal ganglia, of course, and the role of intermediary will decrease. If an adult suggests the words "*whitish*" or "*bluish*", it will obviously be necessary again to actively involve the intermediary's system to find out the coincidence of auditory, kinesthetic and motor phonemes (*white* – *whiteness* - *whitish* - *whitish* - *blond* - *white* - *white*, etc.).

The following conclusion is important for us: the sooner a direct connection is formed between the conceptual system and the basal ganglia,

the better the child's awareness, assimilation and use of grammatical categories.

The problem of grammatically correct speech formation in preschool children can be solved quite quickly and efficiently if you activate the interaction of different analyzers. It is proved that the sensory information complex is made up of auditory, visual and tactile images, complementing, reinforcing each other, increasing the number of useful signals, expanding the speech space, contributing, in turn, limiting options when choosing an adequate speech pattern during perception, recognition and awareness of the oral speeches.

Our approach is based on the doctrine of the multifunctional property of cortical functions, the result of which is the successive and simultaneous provision of different types of cerebral activity. According to this doctrine, all types of human activity (both internal and external) are provided by two plans of activity (successive and simultaneous), which presents the sequence of any acts and their simultaneous combination.

In the context of the research we are interested, first of all, in the internal program of the speech process and its implementation in language means. However, there is no doubt that the stages of this process are quite complex and can be divided into smaller processes that occur in a certain sequence: one after another (successively) or simultaneously, in parallel). Thus, at each stage, at each particular moment there is a different probability of the speaker's choice of certain language units.

Classical and modern neuropsychological research of O.R. Luria (1975), E.I. Simernytska (1985) and others it is proved that the level of development of various mental functions depends on the state of their formation and maturity: constructive praxis, visual thinking, awareness of inverse logical and grammatical structures, etc. Loss or underdevelopment of this factor leads to underdevelopment, violation or disintegration of these functions.

It is important for our study that a sufficient level of formation of successively simultaneous operational processes contributes to the formation of two groups of operations that underlie speech activity. Thus, *the first group - operations* that provide the compilation of internal schemes of varying degrees of specificity, resulting in an internal plan and build schemes of expression. This group of operations forms the basis of the next speech activity and is a combination of elements in a sequential complex. The formation of combining operations is ensured by sufficient maturity of successive activities.

The second group of operations is the selection of elements for speech activity. Their formation is provided by a sufficient level of development of simultaneous operational processes.

Thus, mastering the grammatical structure of the language requires placing the elements in a simultaneous scheme and synthesizing them in successive series and ensuring their integration. The idea of the famous psychologist P.Ya. Galperin (1999) on the similarity of operations of simultaneous recognition and cognitive mental action, which is formed in the learning process. This conclusion gives us reason to consider successive-simultaneous operational processes as basic and universal for various forms of language learning of preschool children. Their systematic and purposeful development will create not only the necessary prerequisite, but also the basis for the formation of grammatically correct speech in children.

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