Intellectual functionality of speech in children of older preschool age with logopathology

Abstract. Background. The purpose of this study is to identify the current state of intellectual functioning, which affects the speech readiness to study at school, of older preschool children with logopathology. The study included 607 older preschool children (5–6 years old), 250 with normotypical psychophysical development and 357 with speech disorders (dyslalia, stuttering, rhinolalia, dysarthria). Materials and methods. To evaluate the intellectual functioning of older preschool children with logopathology, methods were developed aimed at studying visual-motor coordination, auditory-verbal memory, verbal-spatial representation, verbal-logical thinking, verbal attention. Results. The results of the experimental study give a clear idea that there are significant differences in the formation of intellectual functionality between children with logopathology and those with normotypical psychophysical development. Older preschool children with speech disorders had low ability to copy graphic images, violations of independent control and planning their own activities, problems with the consistent reproduction of words, the volume of memorization, the strength of retention of stimuli, the speed and accuracy of reproduction of speech information, the difficulties understanding spatial relations in the addressed and own speech; verbal and logical skills are formed heterogeneously. Some preschoolers with logopathology can classify objects by features, generalize them, understand the figurative meaning of words and the content of texts. Others experience certain difficulties and make many mistakes; their verbal attention is not sufficiently developed, which prevents children from perceiving educational material. Conclusions. Accordingly, low indicators of visual-motor coordination, auditory-verbal memory, verbal-spatial representation, verbal-logical thinking, verbal attention in older preschool children with speech disorders indicate insufficiently formed intellectual functionality. This will affect their speaking readiness and learning the curriculum at school.

Keywords: intellectual functionality; speech disorder; older preschool children; visual-motor coordination; auditory-verbal memory; verbal-spatial representation; verbal-logical thinking; verbal attention

Introduction

The intellectual functionality of speech readiness provides the basic content of numerous models of the generation and development of speech [1–3]. According to the results of physiological [4–6] and psycholinguistic [7] studies, the speech programming subsystem has a general functional algorithm of action: motive, formation of an idea (speech intention), semantic structuring (syntaxization) of an idea, semantic syntax, surface syntax (transformation of an utterance into a grammatical structure), phonological and motor programming of an utterance. Its coordinated mechanism contributes to the generation of speech. A formulated idea (thought, speech intention) is a process of internal speech. Its structure is not clear enough and formless. The main purpose of the idea is to perform a speech act in the form of dialogic or monologic speech. The stage of transformation is the semantic structuring of a thought or its encoding into an internal word. Next, thought is mediated in the meanings of external words, that is, lexical-semantic organization, grammatical construction (information processing) takes place. The process of speaking is carried out as a result of phonological and motor programming or phonation, acoustic and articulatory action. According to studies, the success of speech implementation depends on the state of cognitive operational support, namely intellectual functionality: operative, declarative (base of verbal-semantic in-

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formation — knowledge about the surrounding world, own experience) and procedural (knowledge about the method of performing actions) memory, properties of attention, thinking operations [4, 7–10].

A damaged interrelationship of intellectual functionality leads to difficulties in perceiving, imagining, comprehending, and reproducing speech information. Underdevelopment or damage to subsystems of planning and regulation of the fictitious language and speech system significantly disrupts the child’s cognitive activity [11–14]. In children with speech disorders against the background of the relative preservation of the semiotic component, there are deviations in the intellectual and regulatory components, which does not guarantee a sufficient level of formation of speech readiness [15, 16].

From a neurophysiological and psycholinguistic point of view, speech is a component of higher mental functions, carries out voluntary mediation of mental processes, unites and organizes them [4, 7, 17]. In particular, sensory perception of the surrounding world creates objective images in the child’s mind. Given that language is a tool for communication, the word acts as the initial image of a representation. It is transformed into a concept, combined into semantic groups, and assimilated in the process of concentration and memorization (Fig. 1).

Accordingly, in children of older preschool age, the cognitive component of speech readiness involves the development of visual-motor coordination, auditory-speech memory, verbal-spatial representation, and verbal-logical thinking. In particular, visual-motor coordination ensures the coordinated activity of movements that are performed under the control of the visual analyser [18–21]. With the help of vision, the child gets to know the surrounding informational and subjective world, exercises control over his actions, improves skills and abilities during subject activities. Visual-motor coordination includes the development of visual perception, fine motor skills and visual-spatial orientation. The formation of these components determines the child’s readiness for school.

Auditory-verbal memory is responsible for perception (with the help of an auditory analyser), storage (encoding process, memorization of information) and reproduction (transmission of encoded information through the speech central and peripheral departments) of verbal information. This type of memory develops after the formation of motor, emotional and image memory. Auditory-verbal memory maintains a close relationship with the functions of the dominant left hemisphere, where Broca’s and Wernicke’s areas are located, which are associated with the functioning of the second signalling system [17]. This type of memory is essential during the perception and assimilation of verbalized knowledge, performs active mental processing of informative materials [5, 8–10]. Individual features of auditory-verbal memory include volume (amount of memorized information), speed (memorization time), accuracy (relevance of the reproduced material), strength (duration of storage of learned information), reproduction (speed of recalling the necessary information). All components of auditory-verbal memory are important for children’s educational activities in educational institutions.

Verbal-spatial representation provides an understanding of spatial representations and concepts that surround the subject of research (impressive speech), ability to use prepositions and spatial speech constructions during communication (expressive speech). Spatial orientation is formed simultaneously with general motor activity, auditory, visual, and kinesthetic analyser system. The process of awareness of spatial relationships, their verbal meaning is attributed to a complex mechanism of thought-speech activity. This type of thinking is a kind of mental action and is oriented towards the performance of practical-spatial tasks according to existing images and imagery (perception of time, location, estimation of the distance to an object, the position of one’s own body, etc.) [16]. One thing is certain: during manipulative actions with objects, the child begins to realize their position in space: on the top shelf, under the chair, next to the cup, to the left of the toy, to the right of the doll, between the books, etc. The formation of spatial thinking in a preschooler ensures adequate orientation in social and everyday conditions, the ability to operate with imagery during play and educational activities [2].

Verbal-logical thinking organizes a thought-speech process during which information about the established connections and relations between cognitive objects is transformed into internal speech, undergoes sign-speech coding, is grammatically constructed, and implemented in the form of concepts, statements, and conclusions. In the scientific works [22], it is noted that mental activity in children is formed in stages. First of all, there is an analytical perception of surrounding objects. Subsequently, thinking actions are accompanied by speech without relying on the subject component. The next stage is solving thinking tasks mentally — using internal speech. And the final point is automation, generalization of mental operational actions, their implementation in practical, game, educational activities.

Verbal attention provides conscious perception and concentration on speech information. According to the generally accepted concept [3, 22, 23], attention is a special form of mental activity, provides conditions for the functioning of cognitive processes, it is characterized by the orientation and concentration of the individual’s consciousness on significant subjects, objects, or experiences. Attention does not have its own content, but is
determined by specific properties: distribution, volume, stability, selectivity, switching, concentration. The formation of verbal attention in older preschool children ensures the ability to focus on speech material: listen to instructions, understand messages, perform actions as instructed, and not react to extraneous stimuli when performing tasks.

Underdevelopment of the cognitive component leads to disorientation, maladaptation, social stigmatization, as well as persistent difficulties in learning the school curriculum. As a result, the problem of integrating children with logopathology into the educational environment of an educational institution arises.

The purpose of this study is to identify the current state of intellectual functioning, which affects the speech readiness to study at school, in older preschool children with logopathology.

To achieve the set goal, the following tasks are expected to be performed: to consider the impact of intellectual functionality on the speech readiness of older preschool children to study at school; outline the types of methods for comprehensive diagnosis of intellectual functionality of speech readiness; to reveal the state of formation of intellectual functionality of older preschool children with normotypical psychophysical development and speech pathology.

Materials and methods

Design. To study the intellectual functionality of speech readiness in older preschool children with logopathology, we focus on the state of development of their visual-motor coordination, auditory-verbal memory, verbal-spatial representation, verbal-logical thinking, and verbal attention. The results of the study of children with logopathology are compared with the indicators of their peers with normotypical psychophysical development.

Participants. The study included 607 older preschool children (5–6 years old), 250 with normotypical psychophysical development and 357 with logopathology (dyslalia (n = 212), stuttering (n = 40), rhinolalia (n = 28), dysarthria (n = 77)).

Instruments. The state of formation of intellectual functionality is investigated using methods aimed at studying in older preschool children with logopathology and normotypical development: visual-motor coordination [18] during redrawing of four images; auditory-verbal memory [24] during the tasks “Remember the words” (consistency, volume, strength), “Find numbers by ear” (speed), “Recreate the story” (accuracy); verbal-spatial representation [16] during the tasks “Understanding spatial prepositions in speech”, “Understanding spatial concepts” (impressive speech), “Using spatial prepositions in one’s own speech” (expressive speech); verbal-logical thinking [25] during the tasks “Find an extra word”, “Name in one word” (classification of words according to typical features of objects), “Understanding the figurative meaning of words”, “Understanding the meaning of the story” (ability to analyse and draw conclusions); verbal attention [3] — assessment of concentration, stability, distribution, volume, switching, selectivity of speech signals during activities. Tasks for studying the sequence, volume, strength of auditory memory are evaluated by the number of reproductions of given words. All the rest are evaluated according to a three-point system: 3 points — correct execution; 2 — from one to two errors; 1 — from three to four errors; 0 — more than five errors. The total number of points that a child can receive is presented in Table 1.

Experimental research includes variational-statistical (quantitative) and qualitative analysis of study materials [26], which allows understanding the structure of the studied phenomenon, its variability, dependence, relationships, and principles of functioning.

An important component of the psychological and pedagogical experiment is also the collection and processing of research materials. The implementation of this stage is ensured by the formed system of evaluation criteria (based on point measurement). Quantitative and statistical analysis provides grounds for identifying the levels of development of the phenomenon under study, namely low, medium, and high. Qualitative analysis considers a holistic approach focused on the inductive description of the studied unit. Variational-statistical and qualitative analyses during the examination of the cognitive component of the speech readiness of older preschool children with logopathology to study at school provide grounds for making a psychological-pedagogical characterization and generalized conclusions regarding the planning of educational and developmental work.

Differences in research results (while performing experimental tasks) between children with logopathology and those with normotypical development are confirmed by the Student’s parametric t test.

Results

The study of visual-motor coordination found a high level of copying in 54.4 % (n = 136) preschoolers with normotypical development and 34.7 % (n = 124) with logopathology. The results of this group of children indicated a high level of self-control and planning of their own activi-

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ties. Their images were similar to the sample: the overall size of the image and its details, required tilt, position in space (relative to other images) were taken into account; the lines of the drawings are clear; the number of structural details is preserved; task is completed independently. The average level was more frequent in preschoolers with logopathology (40.3%; n = 144) than with normotypical development (34.4%; n = 86). All drawings are visually similar to the sample, but their position in space and sizes did not match; the children needed stimulating help from an adult. A low level was observed in 25% preschoolers with speech disorder (n = 89) and only in 11.2% (n = 28) with normotypical psychophysical development. The depicted drawings did not correspond to the given sample, which indicated insufficiently formed graphic skills.

The research indicators show differences in the development of visual-motor coordination between the two groups of children. Preschoolers with logopathology have a lower ability to copy graphic images than their peers with normotypical development, the independence of control and planning of their own activities is impaired. The main indicators are as follows: non-sequential image of figures on the sheet; the task caused fatigue and reduced the quality of copying; distortion of drawings: incorrect reproduction of dimensions (as a rule, their increase), mutual location, change in the number of elements, size, shape, inconsistency in spatial location. The most errors are observed in children with dysarthria (46.8%; n = 36) in whom operational actions of the fingers suffer, namely holding a pencil. Preschoolers cannot adjust the pressure of the pencil, draw sloppily, do not adhere to the outline of the image, etc.

The study of auditory-verbal memory involved investigating the abilities of older preschool children with logopathology to remember speech stimuli and reproduce them correctly. High indicators were observed in 51.2% (n = 128) of children with normotypical psychophysical development and 32.5% (n = 116) with logopathology. Preschoolers performed all tasks independently, played most words with orientation to visual stimuli (volume); clearly, consistently reproduced the stimuli proposed for memorization (accuracy); kept information in memory for a long time (durability); carried out alternate presentation of the material (sequence); performed tasks quickly (speed). The average level was more frequent in preschoolers with logopathology (41.5%; n = 148) than in children with normotypical development (38.4%; n = 96). This group often had problems reproducing material presented verbally without visual reinforcement (volume); replacing words with others that have a similar meaning (accuracy); after a break, all words are reproduced (strength); order is not maintained, grouping of numbers on one’s own choice occurs (sequence); more time is needed to recall the material (speed); children required a stimulating help of the teacher. A low level was found in 26.1% children with logopathology (n = 93) and only in 10.4% (n = 26) with normotypical psychophysical development. Children memorized a few words (volume); stimuli were not correctly reproduced by them (accuracy); the material was not remembered (strength); the sequence is broken; stimuli for a certain experimental time are not reproduced (speed); the need for constant help from an adult is needed.

The state of formation of impressive (understanding of verbal constructions) and expressive (use of verbal constructions in speech) verbal-spatial representation is most characteristic of older preschoolers with normotypical psychophysical development (66.4%; n = 166) than with speech disorders (33.1%; n = 118). Children from this group showed good orientation in the surrounding space; they understood spatial prepositions (before, behind, for, over, under, on, near, between, near, in) in addressed speech; correctly answered the teacher’s questions; correctly found the spatial location of the object in the picture; understood the meaning of the spatial relations “right” — “left”, “above” or “above” — “below”; determined the position of the subject in relation to another subject; used spatial prepositions in their own speech (in, on, under, between, near, before, over, through, behind); performed tasks independently.

The presence of an average level is observed in a significant percentage of children with speech disorders (47.3%; n = 169) and is less frequent in normotypical development (27.2%; n = 68). In such children, the understanding of the spatial belonging of objects depends on the state of their concentration; they made errors during the verbal designation of the spatial location of some objects in relation to others; there is a constant need for stimulating help from an adult. A low level was found more often in preschoolers with logopathology (19.6%; n = 70) than in those with normotypical development (6.4%; n = 16). Children did not sufficiently understand the content of spatial relations in addressed speech, had problems determining the position of an object in relation to another objects, confused spatial prepositions in their own speech, needed constant help from an adult, namely the repetition of logical-grammatical constructions, which confirmed their low level of auditory-speech memory.

The indicators of the research materials showed that 62.4% (n = 156) of older preschoolers with normotypical psychophysical development and 36.4% (n = 130) with logopathology had a high level of verbal and logical thinking, most of the latter were children with dyslalia (54.7%; n = 116). They independently performed tasks, had a tendency to systematization, accuracy, criticality, consistency, correctly classified subjects — grouped them according to aggregate characteristics, were able to generalize — to combine subjects, objects, phenomena, abstract concepts according to certain characteristics, had a well-developed semantic analysis and understanding of the subtext of metaphors and figurative meanings, were able to analyse life situations and draw appropriate conclusions.

The average level is characteristic of 50.4% (n = 180) of examinees with logopathology and only 37.6% (n = 94) without speech disorders. Such children did not concentrate enough on subject classification tasks regarding their generalization, analysis, and conclusions, performed exercises with minor errors. There was often a need for stimulating help from an adult. A low level is observed only in 13.2% (n = 47) preschool children with speech disorders, it was more common in children with dysarthria (27.3% (n = 21)). This category of preschoolers needed constant help from an adult. During the execution of the tasks, a slow transition was made from one type of question to another, most of them were done incorrectly, with significant difficulties when per-
forming tasks related to the classification and generalization of subjects by features; children were unable to explain the meaning of metaphors and figurative meanings, had problems with analysis and formulation of conclusions to the text.

A high level of verbal attention was mostly observed in children with normotypical psychophysical development (55.2\%; n = 138) and slightly less frequent in those with logopathology (33.1\%; n = 118). Preschoolers listened carefully to the interlocutor and independently performed speech tasks (concentration of attention), were able to focus on verbal tasks for a long time (stability of attention), performed several verbal actions at the same time (listening to instructions and performing tasks; distribution of attention), worked on various verbal exercises during the entire lesson (attention span), switched from one verbal action to another (switching attention), focused on verbal tasks (selectivity of attention).

The average level was more common in preschoolers with logopathology (42.9\%; n = 153) than in those with normotypical development (36\%; n = 90). Children in this group often had problems concentrating on speech tasks, which led to errors. But with the stimulating help of the teacher, most of the tasks were performed correctly. A low level was found in 24.1\% (n = 86) children with logopathology and only in 8.8\% (n = 22) with normotypical development. They quickly tire, lose interest in completing tasks, needed constant help from an adult.

The analysis of intellectual functioning shows that high level (from 44 to 65 points) was observed in 80.8\% (n = 202) of children with normotypical psychophysical development and 42\% (n = 130) with logopathology (Fig. 2). Children of this category have sufficiently formed visual-motor coordination, auditory-verbal memory, verbal-spatial representation, verbal-logical thinking, and verbal attention. They took an active part in the research, had a positive attitude towards completing the tasks, explained their choices in an accessible way, performed the exercises correctly (sometimes there were isolated mistakes that the preschoolers corrected on their own). Experimental tasks were performed without the help of a teacher.

The average level (from 22 to 43 points) was more common in children with logopathology (45.9\%; n = 164) and less frequent in peers without speech disorders (19.2\%; n = 48). In this group, we observe excessive fussiness, inattention during tasks, which often led to mistakes. To ensure better results, this group of children needs stimulating, motivational and emotional support from adults.

A low level (from 0 to 21 points) was found only in children with logopathology (12\%), mostly with dysarthria (27.3\%; n = 21), less often in other categories. The outlined group of preschoolers was passive, not interested in performing experimental tasks. Some children wanted to play and had no desire to cooperate with the teacher. The study of intellectual functionality revealed that they had poorly developed visual-motor coordination, auditory-speech memory problems, violations of verbal-spatial representation, verbal-logical thinking, and verbal attention. Preschoolers made many mistakes when solving tasks even with the help of an adult, did not explain their choice, avoided difficulties, and could refuse to do the exercises (Fig. 3).

Statistical analysis of the generalized results of the study on intellectual functioning showed that most older preschool children with logopathology (M ± SD = 42.27 ± 14.27; SEM = 0.97) compared to those with normotypical psychophysical development (M ± SD = 53.67 ± 10.54; SEM = 0.94) had no sufficiently formed visual-motor coordination, auditory-verbal memory, verbal-spatial representation, verbal-logical thinking and verbal attention. Experimental data of children with speech disorders (t(lim)) is 7.7883. The detected standard error of difference is 0.375. Taking into account the degree of freedom (y = 340), the tabular (t(lim)) value within p = 0.05 corresponds to 1.967. Since the empirical results are more tabular (t(lim) 7.7883 > t(lim) 1.967), the H1 hypothesis at the significance level of 5\% (p = 0.05) becomes reliable and gives grounds for asserting that there are significant differences between the groups of the examined children with logopathology and those with normotypical psychophysical development.

**Discussion**

Referring to the research of scientists, we can claim that the lack of intellectual functionality delays the development of the semiotic component of speech, namely the phonetic, lexical, and grammatical levels [1, 3, 4, 13]. In particular, the lack
of visual-motor coordination in children with logopathology indicates their lagging behind the age norm [19, 20], which in the future will lead to difficulties in mastering written speech and reading. Low indicators of auditory-speech memory (sequence of reproducing words, volume of memorization, strength of retention of stimuli, speed and accuracy of reproducing speech information, inability to remember verbal material) provoke difficulties in learning the school curriculum in future junior high school students [8, 12, 14, 15, 27].

Irregularity of verbal-spatial representation causes difficulties in understanding verbal constructions and using them in speech, which affects the level of intellectual development and the child’s general readiness for schooling. Problems of verbal and logical thinking reduce the working capacity of preschoolers and, accordingly, affect the quality of task performance. The inability to concentrate attention on educational activities leads to impaired perception of speech information, its memorization, representation, reflection, and verbal reproduction.

The psychological component of speech readiness and its elements (cognitive (intellectual functionality), motivational, and emotional) provide the basic content of numerous models of speech production and development [3]. The results of scientific research prove that the subsystem of speech programming has algorithm of action: motive, opinion, semantic structuring of an opinion, semantic syntax, surface syntax, phonological and motor programming of an utterance. Its coordinated mechanism contributes precisely to the generation of speech.

The speech motive (speech need) indicates the child’s desire to communicate with people close to him. There is an activation of speech processes that ensure the awareness of verbal information, and affect the stability of motives, opportunities for self-expression, and satisfaction from communication [1]. Communicative orientation largely depends on the positive and emotional communication of the child in a close environment. A comfortable atmosphere significantly affects the productivity and purposefulness of speech production; accordingly, unfavorable conditions can block speech activity [13, 15].

The study of operational support specifies the state of formation of the psychological component of speech readiness in children with speech pathology through cognitive (intellectual functionality: visual-motor coordination, auditory-speech memory, verbal-spatial representation, verbal-logical thinking; neuromotor functionality: manual, oral, articulatory praxis), motivational (motivational orientation, learning motivation, speech motivation), emotional (verbal-emotional adaptability) subsystems.

Conclusions

Analysis of the research results and statistical confirmation provide an opportunity for the following conclusions. Most older preschool children with logopathology have an insufficiently formed state of intellectual functionality of the cognitive-psychological component of speech readiness. Visual-motor coordination in preschoolers with logopathology develops slowly, so it lags behind the indicators of normotypical development. In children, mainly with dysarthria, there is a low ability to copy graphic images and a violation of independent control and planning own activities. The auditory-verbal memory of preschoolers with logopathology is not formed according to their age, so there are problems in the consistent reproduction of words, the volume of memorization, the strength of retention of stimuli, the speed and accuracy of reproduction of speech information. Verbal-spatial representation in some groups of preschoolers with speech disorders (especially with dysarthria) is at the stage of development. They have difficulties in understanding spatial relations in a spoken language, determining the position of an object in relation to another objects, confuse spatial prepositions in own speech. Verbal-logical thinking is formed differently in all children, in particular, most preschoolers with dysarthria (less so with stuttering and rhinolalia) are able to classify objects by their features, generalize them, understand the figurative meaning of words and the content of texts. Other children, especially with dysarthria, experience certain difficulties and make many mistakes. Verbal attention constantly needs motivational and emotional reinforcement. Its properties in most older preschool children with logopathology are not sufficiently focused and long-lasting, which prevents them from carefully perceiving speech information (concentration), concentrating on it for a long time (persistence), additionally performing other verbal tasks (distribution), practicing a greater number of speech exercises during the lesson (volume), switching to other actions without difficulty (switching), focusing on a specific verbal task without paying attention to extraneous stimuli (selectivity). Volitional self-regulation is a weak point in the general development of children with logopathology, it was determined by such features as avoidance of difficulties by children; not making efforts to perform difficult tasks; ignoring, not analysing own mistakes; the need for stimulating help, constant support, encouragement and approval from the teacher.

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References


Мета дослідження: виявити сучасну інтелектуальну функціональність; порушення умінь словесно-логічного мислення, вербальної уваги. Завдання: класифікувати предмети за ознаками, узагальнювати їх, розуміти розмір і форму, шукати парадокси з розуміння просторових відношень у зверненому і незворотному порядку.

Результати. Актуальність. Мета дослідження: вивчити сучасний стан інтелектуальної діяльності, що впливає на мовленнєву готовність до навчання в школі, у дітей старшого дошкільного віку з логопатологією. Обстежено 607 дітей старшого дошкільного віку (5–6 років): 250 з нормотиповим психофізичним розвитком, 357 з логопатологією (дислалія, заїкання, ринолалія, дизартрія).

Для оцінки інтелектуальної діяльності дітей старшого дошкільного віку з логопатологією свідчать про недостатньо сформовану інтелектуальну функціональність. Це вплине на їхню мовленнєву готовність і вивчення шкільної програми.