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COGNITIVE FUNCTIONS OF CHILDREN IN GRADES 5-8 – CASE STUDY

EFEKTYWNOŚĆ PRZYSWAJANIA WIEDZY DZIECI KLAS V-VIII – STUDIUM PRZYPADKU

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Abstract

One of the cognitive and practical challenges of the 21st century is unraveling the mystery of the structure and functioning of the most important and the most complicated organ of the human body, which is the brain. Therefore, it is the subject of research by representatives of many fields of science (e.g., medicine, biology, genetics, psychology, and biochemistry). The objective of this study was to evaluate the cognitive functions of school-age children in Poland. The results of research based on tests that diagnose concentration of attention and memory, including short-term and long-term memory, are described. The research was carried out among students from nine primary schools, including a total of 243 children, their parents, and teachers.

Keywords: cognitive functions, concentration of attention, memory, including short-term memory, long-term memory, primary schools students

Streszczenie

Jednym z wyzwań poznawczych i praktycznych XXI wieku jest rozwikłanie tajemnicy budowy i funkcjonowania najważniejszego i najbardziej skomplikowanego narządu ludzkiego ciała, jakim jest mózg. Dlatego też stanowi on przedmiot badań przedstawicieli wielu dziedzin nauki (m.in. medycyny, biologii, genetyki, psychologii i biochemii). Celem niniejszej pracy była ocena funkcji poznawczych dzieci w wieku szkolnym w Polsce. Przedstawiono wyniki badań opartych na testach diagnozujących koncentrację uwagi i pamięć, w tym pamięć krótkotrwałą i długotrwałą. Badania przeprowadzono wśród uczniów dziewięciu szkół podstawowych, w tym łącznie 243 dzieci, ich rodziców i nauczycieli.

Słowa kluczowe: funkcje poznawcze, koncentracja uwagi, pamięć, w tym pamięć krótkotrwała, pamięć długotrwała, uczniowie szkół podstawowych

1. INTRODUCTION

The human brain needs two components to function properly: nutrients (mainly glucose) and oxygen. Deprived of one, it is damaged after just four minutes [1]. Effective human thinking is determined by the oxygen content in the blood in the cerebral arteries. It must be saturated with oxygen by 90%. Even a slight reduction in this level (for example, 5%) causes changes in cell morphology and neuronal functions, resulting in a reduced degree of concentration and

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prevents precise coordination of muscle work [2]. In addition to internal considerations of proper use of oxygen by the brain, external conditions in the body also play an important role. Oxygen is taken in from the air through the respiratory system and transferred from the alveoli to the blood, where it binds to hemoglobin and is carried to various tissues of the body. Human oxygen consumption at rest is nine litres per minute. It is assumed that a change in the oxygen content in air < 2.5 $g \cdot m^3$ is a neutral stimulus, 2.6-5.0 $g \cdot m^3$ – a weak stimulus, 5.1-10.0 $g \cdot m^3$ – a significant stimulus, > 10.0 $g \cdot m^3$ – strong stimulus [3].

The reason for the reduction in the amount of oxygen that reaches the brain is the high concentration of carbon dioxide in the air. When such an unfavourable composition of gases fills a room, it reduces the cognitive function of the people who breathe them. Room ventilation, especially natural ventilation, allows you to shape the level of CO_2 only to a limited extent and in specific situations. When too many people are in a room at the same time, an improperly designed or poorly functioning ventilation system can cause an external air flow too small to dilute indoor air pollutants [4]. In 2018, scientists from the Lodz Institute of Occupational Medicine (Poland) conducted research during the heating season in 12 primary schools located in highly urbanised areas. They checked the concentration of 15 selected volatile organic compounds. They also examined the level of PM 2.5 dust concentration and monitored air quality in terms of comfort: temperature and relative humidity of indoor air and carbon dioxide concentration in rooms. The CO_2 concentration measurements carried out showed that the content of this gas in the air was even higher than 4000 ppm and the average value was 2500 ppm. An increase in its content in the air above 1500 ppm undoubtedly causes a rapid decrease in concentration or a feeling of drowsiness in students.

Indoor air quality is an important element of a healthy school environment. Clean air in classrooms is especially important in schools because growing and developing children are very sensitive to hazardous chemicals. Exposure to poor air quality in classrooms can make it difficult for students to complete tasks and reduce learning effectiveness, as well as lower test scores [5].

Taking into account the above considerations, it can be assumed that facilitating the transport of oxygenated blood to the brain may improve the mood and cognitive functions of students. 'Mood is generally understood as an affective state of moderate intensity and diffuse character, without a clear reference (subjective cause and specific object to which it is directed) and without a clear component of physiological arousal' [6]. It is an important psychological variable because it determines what comes to mind of a person and therefore influences the content of their judgments and behaviours [6].

Numerous areas of the cerebral cortex and subcortical centres participate in the regulation of mood and psychomotor drive. Brain neurones connect these areas to the corticocortical, Cortico-Striato-Thalamo-Cortical (CSTC) circuits, and other circuitry. The created networks of neurones analyse sets of information about the environment reaching the brain through the senses and endogenous signals coming from inside the body. The next behaviour depends on the result of this analysis. In changing human life conditions, natural short-term changes in mood occur, consistent with the situation. In some cases, mood swings are much greater and appear without external factors that justify them. Then we deal with the so-called exogenous changes [7]. A good mood is one of the nodes of the associative network that constitutes our memory. Its activation activates other positively associated plexuses [8]. Research on memory has revealed two phenomena: its compatibility with mood (in a good mood it is easier to remember and recall positive information than negative information; in a bad mood, the opposite) and its dependence on the state of the body (it is easier to recall events in a state similar to where we were at the moment of remembering them) [6]. Mood also influences behaviour. Good feeling confirms the belief that the desired effects can be achieved [9]. In a positive mood, people become more prosocial and polite, behave in a more relaxed and pleasant way, and are more willing to cooperate and less willing to compete [10]. The literature on the subject does not fully agree on what emotions constitute the group called basic emotions, i.e. universally occurring emotions, which are characterised by a specific facial image, the communication of which probably does not require learning [11]. Cognitive processes enable a person to penetrate the environment, participate in the creation of reality, and understand what has already been explained.

Modern man faces increasingly difficult existential challenges. Absence from technological culture means digital exclusion and a certain disregard for the unadapted [12]. In psychology [13-17], cognitive functions are defined as mental activities that help a person gain orientation in the environment, obtain

information about himself and his body, analyse situations, formulate conclusions, make the right decisions, and act. Elementary and complex thought processes are responsible for receiving, processing, and storing stimuli from the environment. The basic mechanisms of brain function include:

- memory – responsible for storing and reproducing information,
- attention – controlling the scope and quality of information processing and reducing its excess,
- perception – allowing the absorption of information coming directly in the form of impressions, observations, and ideas,
- executive functions – enabling an adequate change of reaction depending on the requirements of the situation, such as information processing, problem solving, planning, and applying the plan in a real situation.

Complex brain systems include:

- thinking – a continuous cognitive process consisting of the processing of information encoded as observations, images or concepts, symbols, phrases, and images and sounds, including learning based on classical and operant conditioning, thanks to which an indirect and generalised knowledge of reality occurs,
- language – enabling understanding and describing the reality around us, which may be subject to modifications throughout life.

This is a relative division because all these reactions occur in the brain almost simultaneously. For complex brain systems to function, the elementary ones must first function. Psychologists [18] explain the functioning of the memory mechanism very accurately. It is a set of processes used to encode, store, and retrieve information. There are three types of coding: semantic (coding words and their meaning), visual (memorising images), and acoustic coding (coding sounds, especially words). Storage is related to the creation of a permanent base for information, i.e. permanent memory. For information to reach the memory store, it must go through three separate phases of memory: sensory (ultra-short-term), short-term (working, data storage in it lasts 15 to 30 seconds), and long-term (permanent) responsible for transferring and storing the information we want to remember [18]. Baddeley and Hitch [19] proposed a model of working memory in which short-term memory takes various forms and has limited capacity. The type of memory (pictorial, verbal) depends on the type of information received. The flow of information is controlled by the central executive system (central executive mechanism), whose task is to transfer information to long-term memory (information processing). According to this model, stimuli from the environment first pass through the sensory register, which stores short-term sensory impressions, such as images, sounds, or tastes. It only takes a fraction of a second or a few seconds, but constantly. The brain cannot retain all or even most of the sensory information. Since most of them have no impact on our lives, we dismiss them as irrelevant. Only if we decide that they are important to us in some way, we transfer them to long-term memory [18]. Due to repetition, information is transferred from short-term to long-term memory, while combining new information with what we already know is called elaborative repetition. Studies have shown that short-term memory capacity is 4 ±1 [20]. Once the information reaches long-term memory, consolidation of memory traces must occur at the synaptic level, which takes several hours, and in the memory system, which can take a week or longer [18]. The most important features of memory are:

- durability – time to store information in memory,
- readiness – speed of extracting and reproducing information from memory,
- fidelity – the accuracy with which we remember information, the degree of accuracy of the reproduced content, determines the number of distortions (errors) made,
- speed – how quickly we can remember the material,
- scope – how much material can be remembered [21, 22].

Assuming that the ability to process information is limited, the individual is forced to decide which of them should access the areas of the brain and analyse it there. Attention is such a complex process of selective selection of sensory information or internal activations, thanks to which the available information processing capabilities can be focused on observing or performing a specific task. It also consists of three phases [23]: arousal – activates selected areas of the brain, preparing it to orient itself to receive information that is worth noticing and focussing on, orientation – filtering information, selecting those that require attention (in the case of external stimuli reaching after 100 ms, and in the case of internal ones, after 300 ms), executive control – search. There are at least two attentional networks: automatic reorientation to unexpected events (an external stimulus that the brain considers important enough to analyse it more thoroughly), and conscious

action (creating a map of orientation in space and planning eye and head movements in the appropriate direction). Attention has four basic functions: selectivity – the ability to select one stimulus and ignore others, vigilance – the ability to observe the environment and wait for the appearance of a specific stimulus, searching the perceptual field – the ability to active and systematic examination of the field of perception, the aim of which is to detect appropriate chosen stimulus criterion, switchability – the ability to switch between activities, divisibility – the ability to concentrate on several stimuli [24]. The basic form of cognitive contact between humans and the external world is perception. It involves the active interpretation of sensory data using contextual clues and previously acquired knowledge [25]. The process of perception is the creation of a representation of an object based on data obtained from the sense organs and, in some cases, information contained in memory [29]. Information processing is not only a cognitive feature but also the discovery of emotional content. Psychology also distinguishes three phases of perception: sensory registration – an external stimulus is converted into a nerve impulse, emotional evaluation – valuation, semantic recognition (stimulus categorisation) – comparison of sensory data with categories already existing in memory, searching for a category to which the incoming stimuli would best fit. The learning mechanism itself is immutable. Knowledge acquired by an individual results from his contact with the world, its experience and survival [16]. The basis for understanding various types of relationships through thinking (reason) is sensory perception, which contains "motives" leading to the mental creation of various concepts, categories, patterns, etc. [26]. The processing of information received from the sense organs takes place on two levels: sensory-motor – perception of spatial and temporal wholes, and semantic-operational – perception of objects and signs. An essential role here is played by internal patterns (representations, cognitive schemas) of reality created on the basis of previous experience, which act as specific hypotheses verified as new data arrive. Perception is a process of identification rather than passive recording, going beyond the information provided; therefore, it is possible to accurately identify objects and phenomena despite the gaps in the sensory material, as well as its variability resulting from the conditions in which this process takes place [27]. Perception is not the same as attention because it covers the full cognitive processes of humans, while attention is the ability to focus on selected elements of the environment [28]. According to Gibson [29], research involving its isolation from the natural conditions under which it is used by the body results in the reception of faulty images of its mechanism of action. Executive functions are defined as psychological processes that involve conscious control of thoughts and actions or are responsible for goal-directed behaviour. They constitute the foundation for skills such as refraining from reflex or impulsive reactions, solving problems, planning activities, and initiating them with flexible implementation (even despite the existence of disturbing factors), as well as controlling subsequent phases of goal-orientated activity [30, 31]. Due to the fact that they can be influenced by conscious and unconscious representations of the motivational or affective meaning of a stimulus, they can be distinguished: hot – they participate in solving problems of significant emotional and motivational importance (e.g., strategic games with the prospect of reward) and cold – they participate in solving abstract problems, detached from the context [32, 33]. Executive functions develop gradually and for a relatively long time, even up to the age of 25. The current level of development of the executive functions of the student is the result of the interaction of the pace and dynamics of the developmental changes that result from the maturation of the central nervous system and the stimulation occurring in the sociocultural environment [34-36]. School learning is supposed to be a cognitive activity organised and directed toward a specific goal, which is to acquire knowledge through the processes of memorising and recalling and, at the same time, acquiring the ability to manage them [37].

To identify the impact of student psychological characteristics on their achievements, scientists [38] carried out research that showed that the effectiveness of education is determined by the following psychological characteristics: type of nervous system, level of intelligence, type of motivation, and the coherence of these characteristics. The effectiveness of education also depends on variables such as compliance with elements of the teaching system, teaching strategies, and the living environment of students. The course of the learning process and its effects are influenced by: the general nature of the learner, the nature of the knowledge to be mastered, and the nature of the learning process [39]. In educational psychology, the factors that influence

the course and the effects of learning are divided into three categories: student characteristics, factors that characterise the learning situation, and teacher characteristics [40]. We can therefore summarise that learning depends on who learns, how they learn, and under whose guidance they learn [41]. It is worth mentioning the triad of power of attorney designed by Puślecki [42]. It includes an authorised school, an authorised teacher, and authorised students. All its elements are interdependent, inspire, support, and develop each other. The individual characteristics of a student may be permanent or transformable. The unchangeable feature is gender. Properties that change include intelligence, interests, abilities, and motivations for action [36]. According to Mischel and Shoda [43], people are creatures that interpret situations. They indicate both its value and the importance of perceiving it by an individual. The learning situation is created by everything that happens during it and that is irrelevant to the results. The external conditions in which learning takes place and the methods of conduct used, as a result of which the student acquires new knowledge and skills, are important. The characteristics of the student and the teacher are a variable that depends on internal and external conditions, and these, in turn, are components of the learning situation. It is created by everything that happens during this process and is not indifferent to its effects. Both external conditions and teaching methods are important, under the influence of which the student acquires new knowledge and skills [44]. Facilitating the transport of oxygenated blood to the brain may first contribute to strengthening the basic mechanisms of the brain, which determine the effectiveness of complex cognitive processes.

The purpose of the article was to assess the cognitive functions of children studying in schools, which will allow us in the future to take steps to improve conditions in schools.

2. METHODS AND METODOLOGY

A total of 243 students from grades 5, 6, and 7 attended schools in the swietokrzyskie voivodeship (Fig. 1) were subjected to the study. These students came from 18 classes in 9 different schools with different locations. The survey included students from schools with up to 10-15 children in classes and schools with 30 children in classes. The surveys were completed by students, their parents, and teachers. The results of tests diagnosing students' cognitive functions (concentration of attention, memory, including short- and long-term memory) are presented in percentage form to better illustrate the distribution. The analysis presents distributions considering the age of the students (the class in which the surveyed students currently attend).

Fig. 1. Map swietokrzyskie voivodeship [45]

The analysis included:
- a test measuring students' memorisation and attention,
- interview with the student – interview questionnaire "My emotions and feelings",
- hidden, participant observation – observation sheet completed by parents and teachers,
- measurement of blood saturation using pulse oximeters.

As part of the test measuring students' memorisation and attention, an original sheet of 66 questions was developed, including the following:
- attention test – 5 questions,
- memory level test – 6 questions,
- quantitative tests of the student's mood level – 13 questions (including those regarding mood: 8 questions, regarding physical well-being: 4 questions, general: 1 question),
- observation of students in terms of memory and attention – 22 questions (including 11 questions determining memory, and 11 questions determining attention),
- observation of students in terms of memory and attention – 20 questions (including 10 questions determining memory and 10 questions determining attention).

The maximum number of points for the entire test was 213.5 points. Tasks assessing concentration of attention allowed one to obtain a maximum of 95 points. Long-term memory tasks allowed to obtain a maximum of 36 points. However, tasks that assess

short-term memory allowed a maximum of 82.5 points to be obtained. The methodology used to test the cognitive abilities of children is original, created for the needs of the project, and was created according to the methodology to test the cognitive functions and the guidelines conditioned by theoretical foundations.

3. RESULTS

The results of tests diagnosing students' cognitive functions (concentration of attention, memory, including short-term and long-term memory) are presented as percentages to better illustrate the distributions.

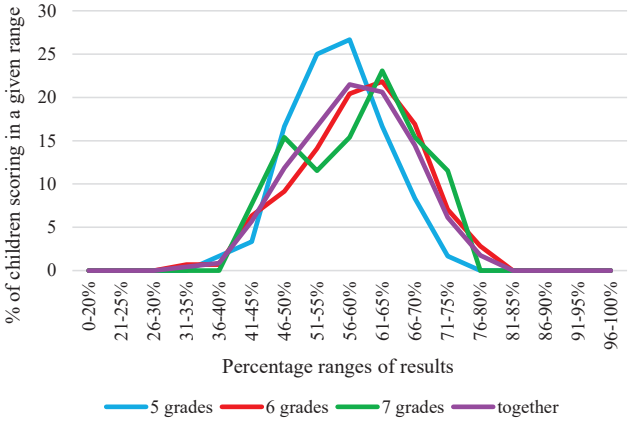

Fig. 2. Distribution of the results of the diagnostic tests for cognitive functions

Analysing the data obtained (Fig. 2), it can be concluded that the distribution of results of 5th grade students is slightly shifted to the left (toward lower results). Statistical analysis of the data obtained (Table 1) can conclude that the average result of the students in the fifth grade is significantly different from the average result of the students in the sixth grade ($Z = 2.81$). This is the only significant difference between the means of individual age groups (grades 5 and 7 $Z = 1.2$, grades 6 and 7 $Z = 0.42$).

Table 1. Summary of the results of the cognitive tests for each age group

Grade	Mean [pts.]	Standard deviation	Median [pts.]	Modal [pts.]	Minimum [pts.]	Maximum [pts.]
5	56.23	7.12	56	54	38	72
6	59.58	9.03	60	63	33	79
7	58.77	8.99	60	63	41	73
Σ	58.61	8.68	59	56	33	79

The test results obtained were compared with the blood saturation levels tested in the students. A low correlation can be found between the test results and the saturation level of the students ($r = 0.11$), which is not statistically significant at the adopted level of $\alpha = 0.05$.

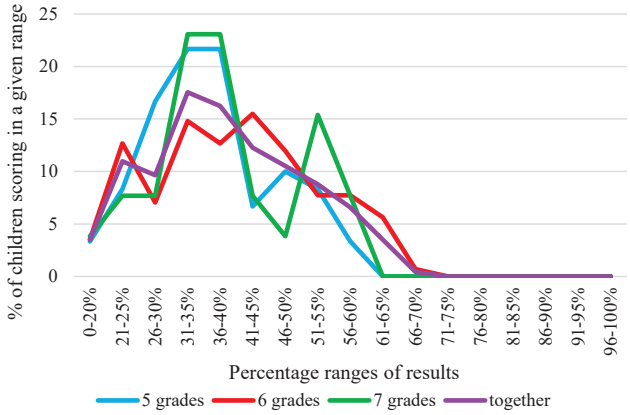

Fig. 3. Distribution of the results of diagnostic tests for concentration of attention

Analysing the data obtained in the results of tests diagnosing concentration of attention (Fig. 3), it can be concluded that the distribution of results of students of grades 5 and 7 is slightly shifted to the left (towards lower results). Statistical analysis of the data obtained (Table 2), it can be concluded that the average result of the students in the fifth grade is significantly different from the average result of the students in the sixth grade ($Z = 2.23$). This is the only significant difference between the means of individual age groups (grades 5 and 7 $Z = 0.91$, grades 6 and 7 $Z = 0.66$).

Table 2. Summary of the statistical results for each age group – an attempt to concentrate attention

Grade	Mean [pts.]	Standard deviation	Median [pts.]	Modal [pts.]	Minimum [pts.]	Maximum [pts.]
5	36.68	9.71	37	38	17	59
6	40.33	12.43	40	44	15	66
7	38.80	10.49	38	33	20	57
Σ	39.20	11.66	38	38	15	66

The test results obtained were compared with the blood saturation levels tested in the students. There is a slight correlation between the test results and the saturation level of the students ($r = 0.03$), which is not statistically significant at the adopted level of $\alpha = 0.05$.

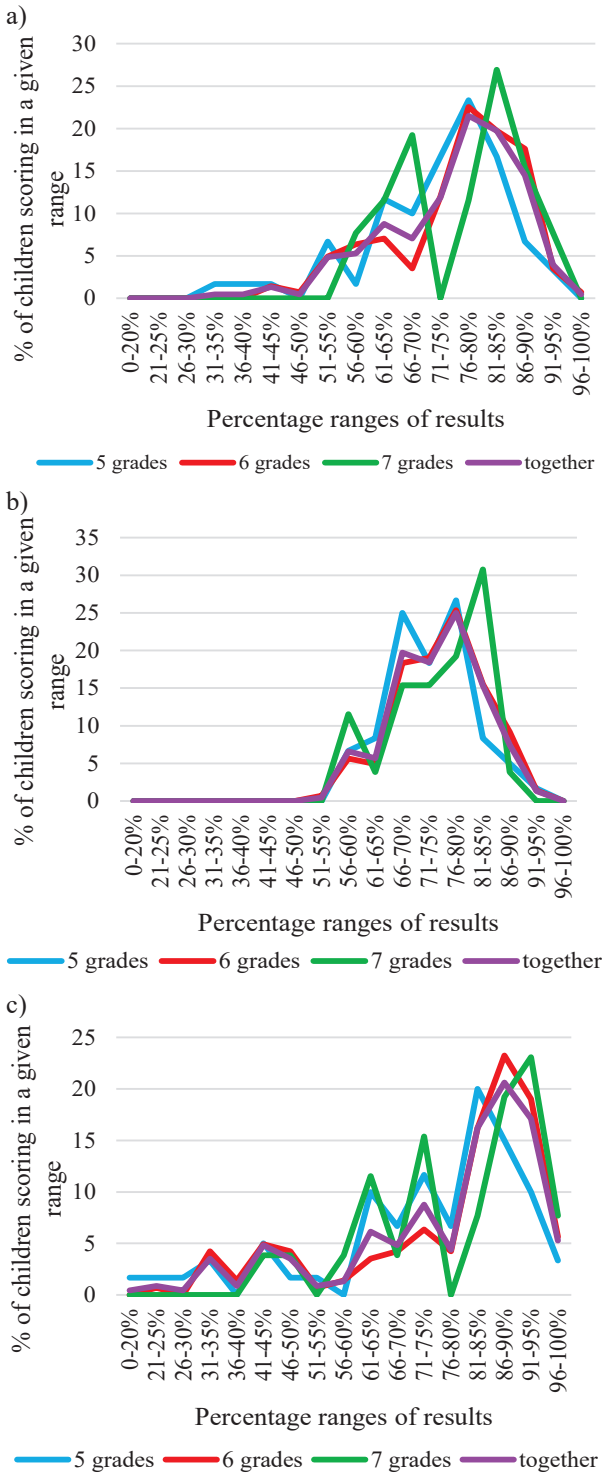

Fig. 4. Distribution of the results of diagnostic tests for the level of memory (a) total memory; (b) short-term memory; (c) long-term memory

Analysing the data obtained, it can be concluded that the distribution of general memory results (Fig. 4a) of fifth-grade students is slightly shifted to the left (toward lower results). Analysis of short-term memory data (Fig. 4b) showed that the distribution of results of seventh-grade students is slightly shifted to the right (toward higher results). However, in the case of long-term memory, the distribution of students' results is similar for all classes. Performing a statistical analysis (Table 3-5) of the data obtained, it can be concluded that the average overall memory score of students in grades 5 does not differ significantly from the average score of students in grades 6 (Z = 1.86) and 7 (Z = 1.44) and that there is no significant difference between the average result of grades 6 and 7 (Z = 0.2). The average short-term memory score of fifth grade students does not differ significantly from the average score of sixth grade students (Z = 1.87) and seventh grade students (Z = 0.76), and there is no significant difference between the average score of sixth and seventh grade of students (Z = 0.47). The average long-term memory score of students in fifth grade does not differ significantly from the average score of students in sixth grade (Z = 1.44) and seventh grade (Z = 1.54), and there is no significant difference between the average score of sixth and seventh grades (Z = 0.46).

Table 3. Summary of statistical results for each age group: level of memory

Grade	Mean [pts.]	Standard deviation	Median [pts.]	Modal [pts.]	Minimum [pts.]	Maximum [pts.]
5	72.96	11.15	76	76	39	94
6	76.21	11.36	79	84	41	96
7	76.69	10.71	80	82	57	91
Σ	75.41	11.33	78	84	39	96

The general results of the memory tests were compared with the blood saturation level of the students. A low correlation can be found between the test results and the saturation level of the students (r = 0.13), which is not statistically significant at the adopted level of α = 0.05.

Table 4. Summary of statistical results for each age group: short-term memory level

Grade	Mean [pts.]	Standard deviation	Median [pts.]	Modal [pts.]	Minimum [pts.]	Maximum [pts.]
5	72.96	7.66	73.5	68.77	57	91
6	75.28	8.22	76	78	53	94
7	74.43	9.29	76	83.84	56	88
Σ	74.58	8.27	75	72	53	94

The results obtained from the short-term memory tests were compared with the blood saturation level tested in the students. A low correlation can be found between the test results and the level of blood saturation of the students (r = 0.14), which is not significant at the adopted level of α = 0.05.

Table 5. Summary of statistical results for each age group: long-term memory level

Grade	Mean [pts.]	Standard deviation	Median [pts.]	Modal [pts.]	Minimum [pts.]	Maximum [pts.]
5	72.96	19.38	78	83	19	97
6	77.15	18.56	83	89	22	97
7	78.95	15.08	83	89.92	44	97
∑	76.25	18.54	83	89	19	97

The results obtained from the long-term memory tests were compared with the blood saturation level tested in the students. A low correlation can be found between the test results and the level of blood saturation of the students (r = 0.09), which is not significant at the adopted level of α = 0.05.

In the next step of the analysis, parents and teachers completed questionnaires that assess the cognitive functions of the students.

A statistical analysis of the results of questionnaires addressed to parents and teachers was performed, the purpose of which was to determine the level of attention and memory of the individual students subjected to the study. A summary of Pearson's correlation coefficients between teachers' and parents' ratings is presented in Table 6.

Table 6. Correlation between teacher and parent ratings

		Together	5 grade	6 grade	7 grade
Memory	Correlation coefficient *r*	0.46	0.6	0.42	0.5
	Correlation strength	Moderate	High	Moderate	Moderate
	T	7.46	4.92	4.61	2.51
	Significance of correlation	Important	Important	Important	Important
Concentration of attention	Correlation coefficient *r*	0.4	0.51	0.41	0.26
	Correlation strength	Moderate	High	Moderate	Short
	T	6.57	3.89	4.5	1.16
	Significance of correlation	Important	Important	Important	Important

Analysing the data obtained, high and moderate correlations can be found between the assessments of cognitive functions made by parents and teachers. In fact, all covariates turned out to be statistically significant at the assumed level of α = 0.05. Only a low and insignificant covariation appeared in the assessment of concentration of attention in seventh grade students.

The results of the described questionnaires were compared with the results of the tests performed on students (Tables 7 and 8).

Table 7. Correlation between parent ratings and student results

		Together	5 grade	6 grade	7 grade
Memory	Correlation coefficient *r*	-0.25	-0.08	-0.33	-0.32
	Correlation strength	Short	Short	Moderate	Moderate
	T	3.3	0.53	3.48	1.48
	Significance of correlation	Important	Unimportant	Important	Unimportant
Concentration of attention	Correlation coefficient *r*	-0.19	-0.05	-0.23	-0.52
	Correlation strength	Short	Short	Short	Moderate
	T	2.48	0.33	2.3	2.67
	Significance of correlation	Important	Unimportant	Important	Important

Table 8. Correlation between teacher ratings and student results

		Together	5 grade	6 grade	7 grade
Memory	Correlation coefficient *r*	-0.28	-0.12	-0.32	-0.3
	Correlation strength	Short	Short	Moderate	Moderate
	T	3.74	0.8	3.37	1.38
	Significance of correlation	Important	Unimportant	Important	Unimportant
Concentration of attention	Correlation coefficient *r*	-0.27	-0.25	-0.21	-0.53
	Correlation strength	Short	Short	Short	Moderate
	T	3.6	1.77	2.19	2.72
	Significance of correlation	Important	Unimportant	Important	Important

The next step was to analyse the results of the cognitive functions divided according to the normal curve (according to the means and standard deviations of the sample) – 243 results (Fig. 5). And evaluations of cognitive functions and concentrate on by parents and teachers (Figs. 6 and 7).

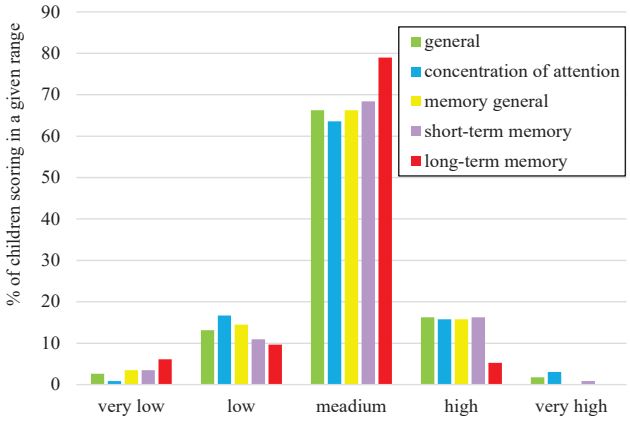

Fig. 5. Distribution of the results of the cognitive functions tests

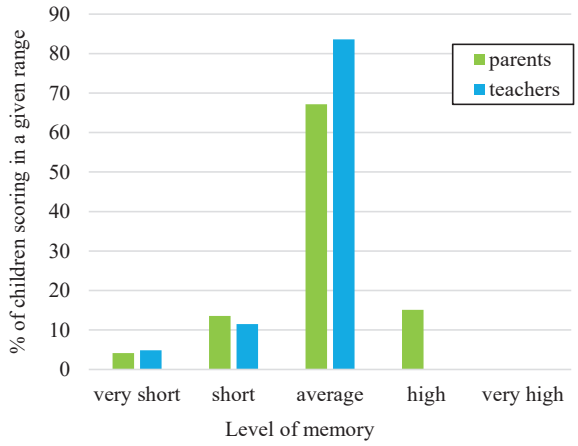

Fig. 6. Student memory level as assessed by parents and teachers

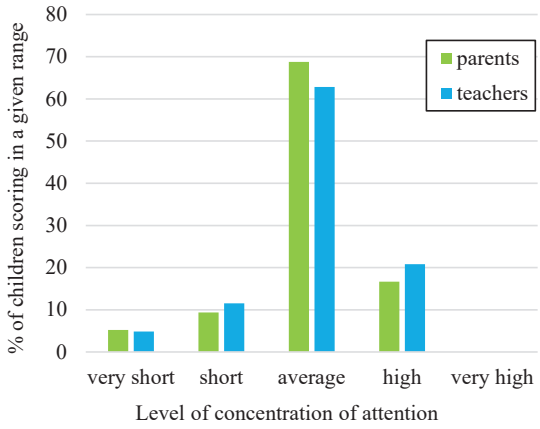

Fig. 7. Level of concentration of attention of students as assessed by parents and teachers

Based on the data obtained (Tables 6-8, Figs. 5-7), it can be concluded that both parents and teachers quite accurately assess the level of memory and concentration of students (moderate and high levels of correlation between test results and parents' and teachers' ratings). No significant correlation was observed between the results and the assessment of parents and teachers only in the fifth grade and in the seventh grade (in terms of memory).

Then, analyses of student well-being and mood were performed (Fig. 8).

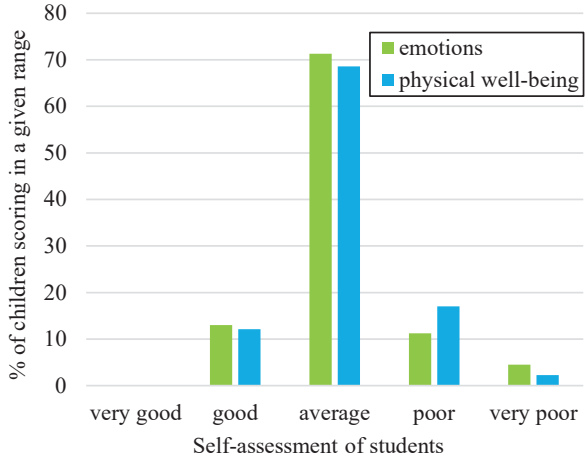

Fig. 8. Assessment of students' well-being

For this purpose, the students completed surveys to determine their mood, physical well-being, and general emotional state (Fig. 8).

Table 9 lists the correlations between individual groups of samples that examine various cognitive functions and mood, well-being, and general emotional state.

Table 9. Correlation between samples examining various cognitive functions and mood, well-being, and general emotional state

	Cognitive function test result	Concentration of attention test result	Memory test result	Short-memory test result	Long-memory test result
Mood	r=-0.01	r=-0.01	r=-0.02	r=-0.002	r=-0.02
Physical well-being	r=0.02	r=0.03	r=0.03	r=0.05	r=0.01
General emotional state	r=-0.08	r=-0.09	r=-0.02	r=-0.08	r=0.01

All described correlations are low. It can be concluded that there is no covariation between mental and physical well-being and general emotional state and the results of cognitive function tests.

4. DISCUSSION

Research on memory has revealed two phenomena: its compatibility with mood (in a good mood it is easier to remember and recall positive information than negative information; in a bad mood, the opposite) and its dependence on the state of the body (it is easier to recall events in a state similar to where we were at the moment of remembering them) [6]. The analysis presented in this article does not confirm this conclusion, as there was no covariation between well-being and the results of cognitive tests. However, the age of the subjects should be taken into account. In the case of this study, these were children under 14 years of age. However, most of the studies conducted so far in this area included adults [45] or elderly people over 60 years of age, most often with medical conditions [47] and preschool children [31]. Therefore, it seems very important to conduct such research on a group of children and minors, especially today, when they are exposed to numerous sources of negative influence.

Some studies in this area show mainly the consistency of negative mood. This result can be explained by the concept of evolution [47]. Information remembered in a negative mood is more important than information remembered in a positive mood because it determines the adaptation to the environment to a greater extent. For adaptive reasons, it is more beneficial to remember information that is associated with a negative mood than that that is associated with a positive mood.

In the next stage, it seems reasonable to expand the research to additional aspects, such as issues of socioeconomic status as indicated by the latest research [48, 49], contact with nature [50] or issues of development in childhood [51] because they can influence the development of cognitive functions.

The literature contains analyses of the impact of various factors on cognitive functions, such as physical fitness [52], playing computer games [53, 54], or cognitive function training [55, 56]. However, there are no analyses that present the level of cognitive functions of school-age children. Our study fills this research gap by showing the level of cognitive functions of children at various levels of education, from fifth grade to seventh grade in primary school.

5. CONCLUSIONS

Analysing the data obtained in the field of cognitive function and memory level testing, it can be concluded that the distribution of results of fifth-grade students is slightly shifted to the left (towards lower results). The average result obtained for the cognitive functions of fifth grade students differs significantly only from the average result of sixth grade students. Statistical analysis of the data obtained allows us to conclude that the average result of the fifth grade students does not differ significantly from the average result of the sixth grade students ($Z = 1.86$) and the seventh ($Z = 1.44$). Analysing the results obtained of concentration of attention, it can be concluded that the distribution of the results of students of grades 5 and 7 is slightly shifted to the left (towards lower results), but the average result of students of grades 5 differs significantly only from the average result of students of grades 6 ($Z = 2.23$). The results obtained for short-term memory show that the distribution of the results for seventh-grade students is slightly shifted to the right (toward higher results). The average result of students in grades 5 does not differ significantly from the average result of students in grades 6 ($Z = 1.87$) and 7 ($Z = 0.76$), and there is no significant difference between the average result in grades 6 and 7 ($Z = 0.47$). In the case of long-term memory, it can be concluded that the distribution of students' results is similar. By performing a statistical analysis of the data obtained, it can be concluded that the average result of students in grades 5 does not differ significantly from the average result of students in grades 6 ($Z = 1.44$) and 7 ($Z = 1.54$), and there is no significant difference between the average result of students in grades 6 and 7 ($Z = 0.46$).

In addition to tests that determine the level of cognitive functions, students completed surveys to determine their mood, physical well-being, and general emotional state. All the correlations described are slight. It can be concluded that there is no covariation between mental and physical well-being and general emotional state and the results of cognitive function tests.

Analysing the data obtained, high and moderate correlations between the cognitive function assessments made by parents and teachers can be found. In fact, all covariates turned out to be statistically significant at the assumed level of $\alpha = 0.05$. Only a low and insignificant covariance appeared in the assessment of attention concentration in seventh grade students. Based on the data obtained, it can be concluded that both parents and teachers quite accurately assess the level of memory and concentration of students (moderate and high levels of correlation between test results and parents' assessments and teachers). Parents' and teachers' ratings for grades 5 did not correlate significantly with test results, and for grades 7 only with memory test results.

The test results obtained were compared with the blood saturation levels tested in the students. In all the groups of questions analysed, there is a low correlation between the test results and the blood saturation level of the students, which is not significant at the adopted level of $\alpha = 0.05$.

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Declaration of Interest Statement
The authors certify that they have no with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non- financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Data will be made available on request.

Authors' contributions
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