

Informatization of society and the intellectual development of children of senior preschool age

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Abstract – The purpose of the study is to examine the degree of formation and the structure of the intellect of children of senior preschool age, the participants of the experiment of two different groups: examination year 2006 and 2014. The hypothesis of the work is the assumption of a decrease in the intellectual development of older preschoolers in the information age compared with children of its beginning. Archival data that contain material for experimental intelligence studies (general and non-verbal on J. Raven matrices and verbal-conceptual in the model of a directed associative experiment) of older preschoolers using a psychophysiological laboratory experiment was studied. The total number of senior preschool groups is 135 people. The best performance of the J. Raven's test is recorded by children of the later group. It was no coincidence that the effectiveness of the verbal conceptual test in non-judgmental conditions by the children tested in 2014. In emotionally charged conditions, assessments of verbal-conceptual intelligence, the differences between groups are not reliable.

The results of performing intelligent tests have close connections with stochastic parameters of the spectrum of fluctuations of cardiointervals, including the fractal index β (beta). For the J. Raven test, truthful differences at a good level of significance for the values of the fractal index β (beta) were found in the background of the ECG recording series. For the associative experiment in all series, no significant differences were obtained for this parameter in children of two groups. The hypothesis of reduced intelligence has not been confirmed, since non-verbal and general intelligence are better developed in children of later group.

Keywords — *intellectual development, older preschoolers, informatization of education and leisure, electrocardiography*

I. INTRODUCTION

Information spread through the Internet was considered and evaluated as a new means of socialization of today's youth [3]. It is believed that the speed of perception and processing of information, which is significantly higher among young consumers of digital services, is an indicator of their success. However, it is known that the speed of reactions contradicts the accuracy of perception of information, including simple sensory stimulus [8]. Focusing on the speed of processing sensory information has the risk of making inaccurate decisions in social interactions and in learning activities.

The experiments of foreign researchers confirm the fact of inhibition of the development of memory and emotional-volitional qualities of children and adolescents with the constant use of gadgets for educational purposes. It is shown [6, 17] that playing the memorized information is less effective

if the subject knows about the possibility of saving it in a file comparing with informing about its possible erasure.

Modern society contributes to the rapid technological progress of personal portable computing devices that make them available for children of preschool age. Low public concern about the negative consequences of involving children in cyberspace leads to a rapid increase in the number of children and adolescents who have become users of cyber services against the background of age-related intellectual underdevelopment.

Foreign studies stated that Internet use became ubiquitous and mobile [7,11]. The usual home control by adults over the time of using the Internet and the content of sites that children visit is no longer enough to correct its negative impact on the psyche and behavior of children and adolescents. It is known that the inclusion of children in the Internet space in Europe occurs starting from the age of 7 to 8 years [7]. Russian society goes through mass informatization the same way the Western Europe did. According to statistics of 2014, 87.5 million Russians (approximately 60% of the population) used the Internet and 10% of this number were adolescents under 15 years old [5]. This work shows that in 2014, 75% of children and adolescents used the Internet without sufficient control from adults.

A child does not fully control his actions in the network. Access to the network and activities in it, especially playing, weaken emotional stress, which may cause cyber dependence [4,12]. Basing on practical observations and experimental results, it was established that the younger generation prefers a visual and oral-speech form of information transfer [1]. Obviously, such distribution of channels for receiving and transmitting information affects the structure of intellectual functions and the general intellectual development of the younger generation, since the verbal-conceptual method of processing and transmitting information requires the necessary maturity of the frontal-temporal cerebral cortex and sufficient development of verbal memory [3,14]. The idea of smaller intellectual resources of modern children and adolescents which requires experimental verification became strong in the public consciousness.

The underdeveloped verbal-conceptual intelligence reduces the adaptive abilities of children to master school programs and leads to an increase in personal and situational anxiety, most noticeably at the beginning of school: first-graders (27%), poorly noticed by teachers [16]. In connection with these circumstances, it is necessary theoretically and practically to study the degree of formation and the structure of the intellect of children of senior preschool age who are getting prepared for school, which is the main goal of our research.

The hypothesis of the work is the assumption of a decrease in the intellectual development of older preschoolers in the information age compared with children of its beginning. For the practical solution of this task, an archive of psychophysiological examination of children of senior preschool age was used in 2006 and 2014, when 75% of preschool children with different degrees of success used mobile phones and had access to the Internet.

II. RESEARCH METHODOLOGY

Groups of children

The study was performed with archival data containing experimental material for the study of senior preschoolers using a psychophysiological laboratory experiment. The total number of groups of senior preschoolers - 135: 100 children were examined in 2006, 35 children examined in 2014. The average age in both groups was identical (6.5 ± 0.6 years old in the first group, 6.6 ± 1.1 years old in the second group). There were 52 girls and 48 boys in 1st group, and 17 girls and 18 boys in the second group. Thus, the approximate equality of number of boys and girls was respected. Both groups are pupils of the same kindergarten, that participated in classes for the development of fluent speech and the formation of an active lexicon for 2 years. All children who participated in the experiment had informed written consent from parents for a test examination, its results were communicated in written form to each parent.

Experiment technology

In a separate experiment, the assessment of general and non-verbal intelligence was carried out using the J. Raven matrix test. The verbal-conceptual component of the intellectual system was evaluated using the author's method of a directed associative experiment, that looked like a word game for a child. The experimenter named a word from a pre-compiled list of words (verbs, nouns, adjectives and adverbs) in response to which the child had to answer with an antonym during 5-6 seconds. Three series of experiments with three different lists of words and different emotional backgrounds were used. The first series is a model of non-evaluative activity (AE background), second and third series were held in a situation of emotional evaluation of the experimental results. In a non-evaluative situation, the preschooler played a speech game without having information about the results of his activities during the experiment. The following two series differed not only in other lists of stimulus words, but also in the introduction of emotional feedback. In the second series, positive feedback was introduced in the form of a reward for correct verbal reactions (AE+) (candy for 5 correct answers) and in the last series the presence of negative feedback (AE-), a fine (taking back the candy) for 5 incorrect answers. Consequently, in the second and third series of experiments, an emotional situation of reinforcement or punishment was created which could influence the results of the speech game of children. During the speech game, all verbal reactions of the child were recorded in the protocol, the antonyms were considered correct which coincided with the stimulus word in the same-word form.

A significant complication of the verbal activity of older preschoolers was the registration of background electrocardiogram (ECG) and ECG that was recorded during all verbal series. Four separate ECG series, 5 minutes long each, took 20 minutes, during which the child could not move spontaneously. The activity proceeded, thus, in conditions of

partial immobilization. The ECG was processed according to the method of nonlinear stochastic cardiointervalometry (NSC) [15,18] which, in addition to the classical dynamic indicators of the heart rate, provided information on the frequency-spectral composition of the cardio-interval fluctuations of each experimental series. A sufficient number of studies carried out with the help of the NSC, including with the participation of preschoolers, showed that the magnitude and sign of the fractal index β (beta) is conjugated with intellectual development to the maximum extent. The calculation and analysis of this indicator is described in detail in the work [9, p. 209-211]. Statistical processing of results and their interpretation was performed using SPSS-15 for Windows 7.

III. RESULTS OF THE STUDY.

Despite the objective difficulties of performing an experiment to assess the development of verbal-conceptual intelligence, older preschoolers did not refuse to participate in the experiments, as competitive motivation gradually formed, the children shared their successes, which were evaluated by the number of sweets won. A single case of refusal to participate in the experiment out of 135 participants was recorded.

Descriptive statistics

Table 1 shows the results of qualitative analysis and descriptive statistics with arithmetic mean values and errors of average percent of total and non-verbal intelligence and the verbal-conceptual component of the intellectual system (based on the results of an associative experiment) of groups of children from 2006 and 2014. In many measurements the variances of the distributions of characters were not equal; therefore, non-parametric criteria were used to assess the reliability of differences. Table 1 shows the significance levels of the Mann-Whitney test for those cases where the differences in the results of performing intellectual tests were reliable or close to non-random.

TABLE 1. AVERAGE GROUP VALUES WITH THE STANDARD DEVIATION OF INTELLECTUAL TESTS

Year of experiment	J. Raven	AE background	AE+	AE-
2006	63±14	83±24	92±21	100±25
2014	71±10**	94±28*	99±22	102±25

** - according to the Mann-Whitney test, differences are significant at $P = 0.0048$

* - according to the Mann-Whitney test, the differences are close to non-random at $P = 0.054$

Basing on the materials of Table 1, it is obvious that reliably better Raven test performance is recorded by children of the later group. It was close to no coincidence that the effectiveness of the verbal conceptual test in non-judgmental conditions by the children tested in 2014. In emotionally charged conditions, the differences in the effectiveness of the associative directional experiment do not have significant differences.

It is worth noting that, regardless of the year of the tests and the practice of communicating with gadgets, children are taught in an associative experiment, since in the third series of an associative experiment test results are improved in both groups of subjects. The group tested in 2006 improved the results in the third stressful situation reliably at a high level of significance ($P = .000$ $t_{st} = 8.93$ by the Student's criterion for paired groups) in comparison with the background series. The children surveyed in 2014 also improved their results for the

last series, but at a noticeably lower level of significance ($P = 0.45$ at $t_{st} = 2.19$ for pairing groups).

As shown in previous studies, the fractal index β (beta) is related to the results of performing intellectual tests. This indicator reflects the degree of dynamic consistency and orderliness of the activity of neuronal systems that control both cognitive processes and their provision (adaptive stochastic homeostasis) [9, 10]. Regarding this, an assessment of the reliability of differences in the fractal index β (beta) was made in those experimental series that have efficiency of performing intelligent tests was significantly higher in the group of children tested in 2014 compared with the group of earlier testing.

For the J. Raven test, truthful differences at a good level of significance for the values ($P=0.03$ according to the criterion of Mann-Whitney) of the fractal index β (beta) were found in the background ECG recording series. For an associative experiment in a non-evaluative situation, the differences in the values of the fractal index β were far from the accepted significance levels ($P = 0.55$ according to the Mann-Whitney criterion).

Multi-factor statistics

Due to the fact that significant differences between the groups of 2006 and 2014 were found for a small number of parameters, factor analysis was performed using the method of principal components in order to establish the closeness and

Parameters	2006, 3-factor solution			2014, 2-factor solution	
	1 GF	2 GF	3 GF	1 GF	2 GF
AE background	-0.418	-0.541	0.729		0.540
RR-intervals		0.861	0.475	0.855	
Centralization index	0.833			-0.753	
Frac. Index β	0.842			-0.470	0.754

strength of the links between the results of intelligent tests and the accompanying parameters of the NSC. The signs of factor analysis by the method of principal components include those signs that do not have strong correlations with each other. Such signs were the effectiveness of the performing of Raven test, cardiointerval values and two spectral characteristics (centralization index and fractal index β , beta).

3-factor structure shown in Table 2 was adopted for both groups. In the 2006 group of children, the main factors had the following factor loads: 1 GF - 1.68, 2 GF - 1.01, 3 GF - 0.95, Kaiser-Meyer-Olkin criterion is 0.53. These three factors included 89.5% of the accumulated dispersion of the sample, which indicates a relatively successful variant of the analysis.

For a group of children of 2014, a factorial decision was made, describing 90.6% of the accumulated dispersion. The first GF has a factor load equal to 2.61, 2 GF - 1.05, 3 GF - 0.95. In both cases, the factor solution turned out to be adequate without rotation of the axes.

TABLE 2. FACTOR MATRIXES FOR J. RAVEN TEST AND ECG PARAMETERS IN GROUPS OF CHILDREN OF 2006 AND 2014

The first thing you have to pay attention to is the different factor structure of the materials of two time-separated experiments. In the group of 2006 children, the parameter of the effectiveness of the performance of J. Raven test has no connection with the fractal index β (beta) in any of the factors. In the second and third factors, the results of J. Raven's test are located together with the values of the cardiointervals, in one case the connections are positive, in the other negative. Secondly, for senior preschool children who participated in

the experiment in 2014, the execution of J. Raven matrices falls into 2 GFs along with the values of cardiointervals and the fractal index β with large factor weights. In this case, the material of 2014 confirms previously published materials indicating that the efficiency of solving visual-spatial problems can be predicted by the value of the fractal index β (beta) and the resting ECG pulse rate [2]. The lower the pulse, the higher the likelihood that the child will be good at solving visual-spatial tasks. The presence of negative correlations of the efficiency of performing the J. Raven test with the fractal index β (beta) is probably explained by the heterogeneity of the sample according to the sign and the value of the fractal index of the spectrum of cardiointerval fluctuations.

An attempt was made to compare the factor structures of ECG signs recorded during the implementation of verbal activities of AE in a series with a non-evaluative situation (AE background), which the children of 2014 performed better at a non-random value ($P = 0.054$). (Table 3). The set of attributes that was used in the construction of factor matrices in verbal testing was similar to the set of attributes in a series of studies of non-verbal and general intelligence.

In the group of 2006, a 3-factor model without axle rotation was adopted, in which 1 GF had a factor load equal to 1.57, 2 GF - 1.12, 3 GF - 0.90, with a total accumulated dispersion equal to 88.7%. At the same time, the Kaiser-Meier-Olkin coefficient (KMO) was equal to 0.58, which made it possible to consider the possibility of factor analysis by the method of principal components.

TABLE 3. FACTOR MATRIXES FOR AE BACKGROUND SERIES AND ECG PARAMETERS IN GROUPS OF CHILDREN OF 2006 AND 2014

The 2014 survey material received a 2-factor solution with a KMO=0.47, which makes it possible to consider the matrix as satisfactory. 1 GF had a load equal to 1.67, 2 GF - 1.03, total dispersion 67.5%. Factor matrixes significantly differ not only in the number of factors, but also in their composition. Indicators of AE background in a group of preschool children of 2006 were included in all factors with significant factor weights. In 1 GF, the test performance efficiency is negatively related to the spectral parameters of the spectrum of fluctuations of cardiointervals. In the 2nd and 3rd GF, the effectiveness of the verbal test is mated only with the values of cardiointervals and with different signs. The matrix is complex, in which, however, the features of similarity with the previous materials obtained on a different sample of children [2, 9]. The factor matrix of experiments in 2014 has only two main factors and a different composition. 1 GF includes all

Parameters	2006, 3-factor solution			2004, 3-factor solution		
	1 GF	2 GF	3 GF	1 GF	2 GF	3 GF
J. Raven		-0.842	0.474		-0.415	0.825
RR-intervals	-0.432	-0.554	0.704	-0.408	0.719	0.519
Centralization index	0.872			0.900		
Frac. Index β	0.821			0.714	0.601	

signs, except for the results of the AE, which entered the 2nd GF and associated only with the values of the fractal index β (beta). Thus, the structure of the factor matrix of children of a later period completely repeats modern materials.

IV. DISCUSSION OF RESULTS

As a basic assumption, the work tested a statement about a decrease in the intellectual development of senior preschool children of the era of information compared to its beginning, which often appear in popular TV programs and discussions of the pedagogical community. It is worth noting that these judgments relate primarily to adolescents enrolled in school and colleges. There is a clear lack of experimentally obtained facts regarding the dynamics of the intellectual development of children of preschool and primary school age in the period of the formation of the information-digital society. In this regard, there is an obvious interest in the results of the examination of children in the age range from 6 to 10 years [11-14], which is considered as sensitive to the influence of the social environment on the formation of intellectual functions, including its informational components in the form of new technological making. Our materials, which were obtained in different years on the populations of senior preschool children of the same pre-school educational institution, allow us to compare changes in intellectual functions as the digital society develops. In addition, according to the ECG characteristics, we can assess their provision with neuronal brain populations that control the dynamics of the cardio system, which is sensitive to any changes in the functional state and human activity.

Compliance with the indicated experimental conditions and the results of the statistical analysis of the empirical material makes it possible to refute the work hypothesis with a large degree of confidence without confirming the decline in the intellectual functions of children in the era of information and Internet as compared to the pre-Internet period. New facts were obtained indicating a significant increase in non-verbal and general intelligence in preschool children in the 2014 group compared with the group of 2006 testees. Improving of performance of J. Raven test, according to literary information, can be associated with the visual-imaginative language of the Internet communication system [3, 13]. It turned out that the results of multifactor analysis confirm the relationship of the effectiveness of Raven test with a fractal index and cardiointerval values of the background ECG for children of a late examination (who were brought up in conditions of intensive informatization not only of education, but also of children's leisure time). These statistical relationships allow a greater degree of maturity of the parieto-occipital parts of the brain in preschool children of 2014 responsible for visual perception and memory.

Dynamics of verbal-conceptual intelligence is more ambiguous and contradictory. Perhaps, the reason for the ambiguity of verbal-conceptual development is determined by the incomplete process of the formation of verbal memory in preschoolers and junior students, the intensification of which is associated with schooling [13,14]. This material does not contradict the existing ideas about the maturation of the frontal-temporal and parietal fields of the cerebral cortex in later ontogenesis [19] compared to the parietal-occipital areas. The observed variations in the implementation of the directional associative experiment in both groups may be due to the individual features of early ontogenesis and the family developmental environment, which was not studied in our work.

V. CONCLUSION

1. Reduction of non-verbal and general intelligence in older preschoolers, as measured in the psychometric test, in children of the information-digital society (2014 sample)

compared with children in 2006 was not confirmed in the experiment;

2. for the period from 2006 to 2014, the verbal-conceptual intelligence had not undergone noticeable changes, remaining within the boundaries of age variation;

3. the factor structure of the relationship between the performance of intellectual tests performed by children in 2014 is close to the factor structure of intelligence connections with the stochastic parameters of the fluctuation spectrum of cardiointervals of modern preschoolers;

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