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Psychology of Personality: Real and Virtual Context

COGNITIVE CHARACTERISTICS, CREATIVITY AND ACADEMIC ACHIEVEMENTS IN INTELLECTUALLY GIFTED PRIMARY SCHOOLCHILDREN

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Abstract

This article presents the results of comparative study of the dynamic of basic cognitive characteristics and creativity in intellectually gifted children and their peers at the final stage of education in primary school. The emphasis is put on the questions about the peculiarities of the dynamic of cognitive characteristics and creativity in intellectually gifted schoolchildren from their 9th to 10th years. Specifically, the study was focused on whether there is a relationship between the academic achievements of primary schoolchildren and their creativity? Raven's SPM test, tests for basic cognitive processes, verbal and figural creativity test (VFCT), were used, as well as children's academic achievements. In total, 110 primary schoolchildren (29 intellectually gifted and 81 their peers) participated in the study, first when they were 8 and 9 years old, and then again a year later. The results showed a similarity in dynamic of cognitive characteristics in intellectually gifted children (IGG) and their peers (CG), but also significant differences in dynamic of creativity between these groups. IGG group showed more uniform development of creativity compared to CG group: their ability to put forward and develop diverse ideas increase from 9^{th} to 10^{th} year not only in verbal, but in figural domain as well. The results showed the significant positive correlations between creativity and children's academic achievements in Math, Russian language and Science. Verbal and figural productivity and flexibility are important for successfully passing the final achievement tests, while the final school marks are associated with fluid intelligence and cognitive characteristics.

Keywords: Academic achievements, cognitive characteristics, creativity, intellectually gifted, primary schoolchildren.

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1. Introduction

Among the significant problems of modern school education in Russia is the problem of giftedness development. It acquires particular relevance in connection with the transition to an inclusive model of education. The problems of teaching children with advanced intellectual development are well known, but still far from an effective solution (Subotnik et al., 2011; Pfeiffer & Shaughnessy, 2015). Teaching these children in peer-to-peer classes with a wide range of individual differences (from mental retardation to 2 or 3 years ahead of development) raises new questions and research challenges. How is the cognitive development of children with different levels of intellectual giftedness in school settings? Do they lose their advantage in cognitive development during the learning in primary school? How does creativity develop among students with different levels of intellectual giftedness? The issue of creativity development also requires special attention of researchers. This is because the majority of authors think that creativity is an important component for giftedness. Moreover, creativity is also considered as one of the most important competencies of the 21st century (Lubart et al., 2013). It is known that the period of study in elementary school is critical for children with advanced intellectual and creative development (Besançon, & Lubart, 2008). The lack of intellectual challenges can lead to boredom, loss of interest in learning, and ultimately to a relative decrease in the rate of intellectual and creative development of gifted children. The lack of empirical data on the dynamics of basic cognitive indicators and creativity in intellectually gifted children compared to their peers at the final stage of education in primary school necessitates a special study.

The problem of learning ability of intellectually gifted children is also relevant. It is known that basic cognitive processes (speed of information processing, working memory, sense of number), along with intelligence, account for about 60% of the variance of learning ability (Luo et al., 2006; Tikhomirova & Malykh, 2017). Therefore, it is not surprising that most intellectually gifted children have high academic achievements. At the same time, the phenomenon of learning disability is also well known among gifted children (Top 20 principles from psychology for pre K–12 creative, talented, and gifted students' teaching and learning, 2017). One of the reasons for learning disability may be the high level of their creativity. And if the relationship between the intelligence and learning ability is well studied, the link between creativity and academic achievements is much less studied. Moreover, the empirical evidences of this relationship are often contradictory (Rindermann, & Neubauer, 2004). It's largely due to the use of different methods and criteria of academic achievement, as well as gaps in the study of age dynamics and development paths of children with different levels and types of giftedness. In this regard, the study of these questions has not only the theoretical, but also a practical value to increase the effectiveness of the functioning of educational systems.

2. Problem Statement

Considerable evidence suggests that there are the link between the cognitive abilities, fluid intelligence and learning abilities. Many studies were conducted to find and explain the significant effect of some cognitive characteristics and achievements in math, Russian language etc. (Tikhomirova & Malykh, 2017; Tikhomirova et al., 2019). However, the questions about the connections between the academic achievements and creativity in different stages of schooling remain insufficiently studied. As

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noted above the primary school education is a critical period for children with advanced intellectual and creative development. So, the study of the dynamic of basic cognitive characteristics and creativity of children with different levels and types of giftedness has not only the theoretical, but also a practical value to increase the effectiveness of the functioning of educational systems.

3. Research Questions

This research is focused on answering the question:

3.1. Question 1

What are the peculiarities of the dynamic of cognitive characteristics and creativity of intellectually gifted younger students in comparison with their peers at the final stage of education in primary school (from 9 to 10 years)?

3.2. Question 2

Are there the relationships between the academic achievements in different subjects and verbal and figural creativity of primary school graduates?

4. Purpose of the Study

The purpose of this study was to reveal the features of the dynamics of cognitive characteristics (number sense, working memory, reaction times, fluid intelligence) and creativity in intellectually gifted primary schoolchildren (in the second phase of primary school age) and to explore the connections between creativity and the academic achievements of 10-year-old students.

5. Research Methods

5.1. Participants

The study sample included 110 primary schoolchildren in grades 2-4 in Moscow who participated in an ongoing longitudinal project. All participants were tested twice: the first time was in grades 2-3 and second - in 3-4 respectively). The mean age of the children at time 1 was 8.91 years, at time 2 – 10.0. All measurement waves occurred at the end of the academic year (April-May).

5.2. Methods

Raven's SPM test was used to measure fluid intelligence and to select the group of intellectually gifted schoolchildren. The original version of test comprises 5 sets with 60 tasks in total was used.

Primary schoolchildren demonstrated the result in upper quartile have been included in intellectually gifted group (IGG, n=29; 14 boys, 15 - girls) and other – in control group (CG, n=81; 37 boys, 44 – girls).

Four Tikhomirova's programed tests were used to measure such cognitive characteristics as "Number sense", "Working memory" and "Reaction times" (Tikhomirova et al., 2019). Each participant performed the "blue–yellow dots" test (ANS) and NL test (Non-symbolic and Symbolic Numerosity Representations), "Sequences" (visual working memory) and "Reaction times" (reaction times of choosing

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the right answer) at each time point on a computer. On the following day, they performed the SPM test in paper-and-pencil format.

VFCT test ("Verbal and Figural Creativity Test") has been designed to measure creativity in verbal and figural domain of activity (Shumakova, 2018). VFCT test has two parallel forms A and B, which allowed the use of different forms in wave 1 and 2. Two divergent thinking tasks were used: verbal and figural:

- Guesses. The children were showed the ambiguous figure and asked to make up as many different hypotheses of what it might have be as they could. The time for guessing was unlimited.
- Drawings. After the first part (Guesses) the children were asked to draw as many pictures as they could use these very figures. The children were provided with five sheets of paper. On each, six of the same ambiguous figures were presented. The time for drawing was unlimited. In the end (when the child did not have any more ideas), the child was asked to give a title to each picture.

Different indices of creativity were calculated for these divergent thinking tasks: fluency (number of ideas), flexibility, originality (statistical rarity), elaboration and total scores of Verbal and Figural Creativity.

Academic achievements were measured in two ways: traditional - with the school marks from the final-year school report and relatively new - final verification tests of achievements.

The study used the following methods of mathematical statistics: descriptive statistics, Independent and Paired Samples Tests, correlation analysis.

6. Findings

The following results were received in the study:

6.1. The dynamic of cognitive characteristics and creativity scores in intellectually gifted (IGG) and control group (CG) schoolchildren

At the first stage, descriptive statistics were calculated for the cognitive and creativity indicators in each group. Independent samples Student′s t-tests indicated significant differences between intellectually gifted (IGG) and Control group (CG) schoolchildren in fluid intelligence, different indices of cognitive characteristics as in wave 1 and 2.

Table 01 shows the means of cognitive characteristics scores for different groups in wave 1 and 2. Independent samples t-tests indicated significant differences between groups at wave 1 in scores of fluid intelligence, Non-symbolic Numerosity Representations (ANS test), visual working memory and reaction times of choosing the right answer. Iintellectually gifted schoolchildren (IGG) showed significantly higher scores of fluid intelligence, working memory, number sense (ANS test) and reaction times in compare to Control group (CG). They were also showed the better accuracy in NL test (Symbolic Numerosity Representations) but these differences weren't statistically significant. Intellectually gifted schoolchildren retain their advantage in all the indicators noted above in a year (wave 2) with the exception of the "working memory".

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Table 01. Estimated means and standard deviations of cognitive characteristics scores in intellectually gifted (IGG) and Control group (CG) schoolchildren in wave 1 and 2

Measures		**IGG (N=29) M /SD**	**CG (N=81) M /SD**	**t**	**p**
Fluid intelligence (SPM)	Wave 1	49,15/4,13	41,18/4,45	8,190	,000**
	Wave 2	48,69/5,40	42,92/5,84	4,636	,000**
Symbolic Numerosity (NL test)	Wave 1	54,04/31,68	69,24/40,18	-1,756	,082
	Wave 2	48,19/22/11	57,86/23,70	-1,892	,062
Non-symbolic (ANS test)	Wave 1	109,62/10,10	102,27/12,44	2,728	,007**
	Wave 2	109,39/10,61	103,00/13,61	2,271	,025*
Working memory	Wave 1	4,23/1,92	3,41/1,53	2,232	,028*
	Wave 2	4,57/1,55	4,25/1,84	0,827	,410
Reaction time (RT)	Wave 1	0,92/0,22	1,04/0,16	-2,909	,005**
	Wave 2	0,85/0,14	0,98/0,16	-3,870	,000**

Note: M = mean; SD= standard deviation. *p<0.05; **p<0.01

An analysis of the dynamic of cognitive characteristics in control group (CG) of primary schoolchildren from 9 to 10 year showed the significant increase in all indicators (fluid intelligence, NL test, visual working memory and reaction times) except of ANS test (differences are statistically significant with $p < 0.01$, Paired Samples t-test). At the same time, in intellectually gifted schoolchildren (IGG) found the statistically significant increase only in reaction times indicator ($p < 0.05$), although they retained their advantage in all cognitive indicators in compared to the control group (CG).

A comparative analysis of the results obtained using the test "Verbal and Figural Creativity" (VFCT) didn't reveal statistically significant differences between the IGG and CG groups in terms of verbal and figurative creativity in either wave 1 or wave 2. The exception is the revealed difference in pictures' elaboration between groups 1 and 2 per wave 1. Children from the control group (CG) showed more pictures' elaboration than their intellectually gifted peers of 9 years (wave 1). Moreover, children from the CG found higher indicators of both verbal and figurative creativity than their intellectually gifted peers of 9 years old (IGG), although these differences were not statistically significant. In order to understand the reason for the lack of differences in creativity between IGG and CG groups, we conducted a frequency analysis of children with high creativity (the top quartile in terms of verbal or figurative creativity) in each group using the Fisher criterion (φ*). It was found that both in IGG and CG groups, the percentage of highly creative children does not significantly differ, although in control group they were slightly more than among the intellectually gifted schoolchildren. In fact, the data obtained are close to the results obtained in the well-known study by Wallach and Kogan, performed on older children (11-12 years), which indicate the coexistence of different combinations in terms of intelligence and creativity in different groups of children (Wallach & Kogan,1965). It is important to emphasize that in our study, as in the study of Wallach and Kogan, testing of creativity was carried out without time limitation. Children completed tasks as much as they wanted.

It is important to analyse the dynamic of creativity indicators (fluency, flexibility, originality and elaboration) in intellectually gifted (IGG) and Control group (CG) schoolchildren between 9 and 10 years of age in each groups separately. Tables 02-03 show the means of verbal and figural creativity scores for different groups in wave 1 and 2. An analysis of the dynamic of verbal and figurative creativity in IGG

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and CG groups shows that the main line for the development of creativity between the ages of 9 and 10 is the development of verbal creativity. According to the data in Table 02, it can be seen that both IGG and CG group shows a statistically significant increase in verbal fluency, flexibility, elaboration and a total score of verbal creativity. Children of 10 years of age can put forward much more diverse ideas and develop them verbally than they did a year ago (at 9 years old). Only originality does not show positive dynamic in this period. Our data are consistent with those obtained in other studies (Arkhireeva, 2013).

Table 02. Estimated means and standard deviations of verbal creativity indicators in intellectually gifted (IGG) and Control group (CG) schoolchildren in wave 1 and 2

	Variables		**IGG (N=29) M /SD**	**p**	**CG (N=81) M /SD**	**p**
Verbal subtest	Fluency	Wave 1	11,42/6,72	,000**	12,96/6,57	,002**
		Wave 2	17,38/8,21		16,49/8,56	
	Flexibility	Wave 1	7,21/2,81	,000**	8,18/3,34	,000**
		Wave 2	11,33/5,09		10,45/4,22	
	Originality	Wave 1	19,04/16,08	,106	24,16/19,25	,425
		Wave 2	25,67/16,27		26,41/18,82	
	Elaboration	Wave 1	5,25/3,55	,025*	6,41/5,34	,033*
		Wave 2	8,42/6,14		8,07/5,40	
	Verbal Cr	Wave 1	42,92/25,70	,004**	51,71/31,01	,039*
		Wave 2	62,79/30,88		61,42/31,76	

Note: M = mean; SD= standard deviation. *p<0.05; **p<0.01

Table 03. Estimated means and standard deviations of figural creativity indicators in intellectually gifted (IGG) and Control group (CG) schoolchildren in wave 1 and 2

	Variables		**IGG (N=29) M /SD**	**p**	**CG (N=81) M /SD**	**p**
Figural subtest	Fluency	Wave 1	9,88/5,31	,003**	11,82/6,81	,267
		Wave 2	14,67/6,38		13,00/7,50	
	Flexibility	Wave 1	7,29/3,33	,001**	7,78/3,66	,090
		Wave 2	10,21/3,16		8,74/4,22	
	Originality	Wave 1	23,88/19,17	,365	26,05/18,79	,843
		Wave 2	27,42/12,85		26,59/19,66	
	Elaboration	Wave 1	22,21/13,04	,085	30,28/18,04	,030*
		Wave 2	28,21/12,67		25,09/13,77	
	Figural Cr	Wave 1	63,25/38,03	,049*	75,95/41,59	,676
		Wave 2	80,50/27,00		73,43/40,81	

Note: M = mean; SD= standard deviation. *p<0.05; **p<0.01

A comparative analysis of the dynamic of indicators of figural creativity in IGG and CG groups reveals significant differences. The data in table 03 show that in IGG group there is a significant increase in indicators of figural fluency, flexibility, as well as elaboration (at the level of the tendency), which is also described in the total score of figural creativity. On the contrary, in CG group, was not found the significant positive dynamic in any of the indicators of figural creativity, while the elaboration of the pictures was significantly reduced. As in the case of performing the verbal subtest, we did not find significant positive dynamic in the figural originality in both IGG and CG groups. Thus, we found the

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differences in developmental trajectories of creativity between IGG and CG groups in the final phase of primary school age. In IGG group, in comparison with CG group, a more harmonious (uniform) development of creativity is observed: the ability to put forward and develop diverse ideas is increase both in verbal and figural domain.

6.2. The relationship the creativity and children's academic achievements

To explore the connections between cognitive characteristics, creativity and the academic achievements of 10th year students, a Pearson correlation analysis was performed. The school marks from the final-year school report and the results of final verification tests of achievements were considered as indicators of the academic successes of schoolchildren. Tables 04 and 05 show the results of the correlation analysis (Pearson Correlation).

Table 04. Correlations (r) between the cognitive characteristics and creativity in 10-year-old students (wave 2, n=114, Pearson Correlations)

Variables	NL-test	ANS test	Working memory	Reaction time	Intelligence (SPM)
Verbal Fluency	,067	-,013	-,030	,026	-,085
Verbal Flexibility	,077	-,047	,050	,008	-,081
Verbal Elaboration	-,043	,130	,092	-,138	,116
Verbal Creativity	,064	-,033	-,011	,002	-,102
Figural Fluency	-,064	-,098	-,046	,112	-,066
Figural Flexibility	-,039	-,146	-,100	,106	-,019
Figural Elaboration	-,073	-,073	,001	,158	-,094
Figural Creativity	-,055	-,128	-,043	,143	-,140

Table 05. Correlations (r) between the cognitive characteristics, creativity and academic achievements in 10-year-old students (wave 2, n=114, Pearson Correlations)

Variables	Math-test	Math-marks	Russian language - test	Russian language - marks	Science-test	Science-marks
NL-test	-,163	-,269**	-,049	-,288**	-,141	-,146
ANS test	,058	,277**	,220	,261**	,152	,157
Working memory	,119	,233*	,171	,214*	,113	,091
Reaction time	-,313**	-,397**	-,419**	-,405**	-,318**	-,343**
Intelligence (SPM)	,174	,292**	,236	,296**	,101	,242*
Verbal Fluency	,379**	,194*	,284*	,152	,250	,254**
Verbal Flexibility	,328*	,158	,193	,148	,230	,206*
Verbal Elaboration	-,016	,139	,213	,160	,188	,129
Verbal Creativity	,324*	,185	,266*	,183	,284*	,234*
Figural Fluency	,298*	,088	,167	,038	,193	-,069
Figural Flexibility	,396**	,077	,199	,054	,238	-,057
Figural Elaboration	,050	,033	-,167	-,048	,042	-,118
Figural Creativity	,238	,029	,001	-,014	,180	-,123

Note. * $p < 0.05$; ** $p < 0.01$;

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The Pearson correlation analysis of the cognitive characteristics, creativity and academic achievements of students completing primary school has revealed three important facts. The first was the lack of significant relationships between non-verbal intelligence and the studied cognitive characteristics on the one hand and indicators of verbal and figurative creativity, on the other (Table 04). This result agrees well with the fact that we have found before (that there are no significant differences in creativity indicators between IGG and CG groups). The second fact was the significant correlations between fluid intelligence, cognitive performance, and student academic achievement. This fact, in itself, is well known. However, in our case, we examined two indicators of student achievement, one of which is traditional for Russia and well-studied, and the second is recently introduced and studied insufficiently: 1 - school marks from the final-year school report and 2 - results of the final verification tests of achievements in Math, Russian language and Science. It was found that there are positive significant correlations between fluid intelligence and cognitive characteristics and only one indicator of academic achievement – traditional. At the same time there are not found any significant correlations between the same cognitive characteristics and another indicator of academic achievements - final verification tests of achievements (Table 05). Students with higher score in Raven's SPM test showed significant higher school marks from the final-year school report in Math, Russian language and Science ($r=.29$, $p\leq0.01$; $r=30$, $p\leq0.01$; $r=.24$, $p\leq0,05$). Also, schoolchildren of 10 years with better accuracy (NL test) and precision (ANS test), higher visual working memory and reaction times showed the higher school marks from the final-year school report. An exception is the reaction time indicator. The significant negative correlations between the reaction time and academic achievements in Math, Russian language and Science were found for two selected indicators. The shorter the time for choosing the right answer was showed by schoolchildren the better the achievements in Math, Russian language and Science were as in the school marks from the final-year school report and final verification tests of achievements.

Finally, the third fact is a significant connection between creativity and academic achievement at the age of 10 years. It was found a weak but significant positive correlation between verbal creativity and the success in final verification tests in Math, Russian language and Science ($r=.32$, $r=.27$, $r=.28$). Moderate and weak, but significant positive correlation was found between verbal fluency and flexibility on the one hand, and the success of the final tests of achievements in Math and Russian language on the other, between figural fluency and flexibility on the one hand, and the success in completing the final tests in Math with another.

Thus, the data we obtained suggest that the different indicators of the academic achievements of elementary school graduates are of a different nature. Creativity, the ability to put forward a wide variety of verbal ideas or many diverse figural ideas are of great importance in success in final verification tests (for Math and Russian language), whereas fluid intelligence and cognitive characteristics are of great importance in success of the school marks from the final-year school report. Reaction time is the only among other cognitive characteristics that affects the academic achievements of elementary school graduates, measured both in the traditional way and with the help of screening tests.

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7. Conclusion

As shown in the study, the dynamic of cognitive characteristics of both intellectually gifted schoolchildren and their peers has the same pattern during the final stage of their education in primary school (from 9th to 10th year of age). Intellectually gifted children achieve superior results on fluid intelligence assessments and such cognitive characteristics as Number Sense (ANS test) and reaction time both at 9 years old and a year later. They also show an advantage in visual working memory, although at the age of 9 the differences between the groups are statistically significant, and at the age of 10 they appear as a tendency. At the same time, the results showed that creativity levels in both the verbal and figural domain did not differ between two groups. The percentage of schoolchildren with high creativity in the group of intellectually gifted is almost the same as among their peers, both at 9 and 10 years old. This suggests that different groups of gifted children are distinguished by the end of primary school: those with high intelligence, but moderate creativity and those with high creativity (verbal and/or figural), but moderate fluid intelligence. The results obtained in the study also showed the relationships between creativity of primary schoolchildren and their academic achievements in Math, Russian language and Science. However, creativity plays an important role in academic achievements of primary schoolchildren only when a new form of assessment of academic success is applied, namely the results of the final achievement tests in Math, Russian language and Science. Verbal and figural productivity and flexibility, as well as reaction time are important for successful performance on final achievement tests, while the school marks from the final-year school report are more associated with fluid intelligence and such cognitive characteristics as Number sense, working memory and reaction time. The problem of the contribution of creativity, manifested in different domains, to the academic achievements of children in different subjects and at different ages requires a more detailed study.

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