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Cognitive predictors of success in learning Russian

Ludmila A. Verbitskaya[a, d], Sergey B. Malykh[a, b, c*], Yury P. Zinchenko[a, c], Tatiana N. Tikhomirova[b, c]

[a] *Russian Academy of Education, Moscow, Russia*
[b] *Psychological Institute of Russian Academy of Education, Moscow, Russia*
[c] *Faculty of Psychology, Lomonosov Moscow State University, Moscow, Russia*
[d] *Saint Petersburg State University, Saint Petersburg, Russia*

* Corresponding author. E-mail: malykhsb@mail.ru

This study examines the role of cognitive characteristics in the success in learning Russian, assessed through teachers' grades and test scores on standardized state exams.

This paper examines the relationship between cognitive characteristics, such as nonverbal intelligence, working memory and speed of information processing, and the results of the Unified State Exam for 11th grade students, the Basic State Exam for 9th grade students and the traditional assessment of Russian language learning.

This study involved students in the 9th and 11th grades from four educational institutions in the Moscow and St. Petersburg regions; 427 students were studying in the 9th grade (50.3% were boys) and 398 students were studying in the 11th grade (44.8% were boys).

This study concluded that expert assessment of Russian language learning is more associated with successful test scores on the Unified State Exam ($r = 0.71$, $p < 0.01$) than with the results of the Basic State Exam ($r = 0.46$, $p < 0.01$).

This study showed that at the lower and upper levels of secondary education, nonverbal intelligence is a significant predictor of success in learning the Russian language according to expert estimates. In addition, we found differences in the relationship between cognitive performance and success in learning the Russian language as assessed by tests. Nonverbal intelligence contributes significantly to individual differences in scores for the Unified State Exam in Russian, while the contribution of cognitive characteristics on the Basic State Exam is not statistically significant.

Keywords: nonverbal intelligence, cognitive characteristics, success in learning Russian, Unified State Exam, State Final Examination, annual assessment

Introduction

The problem of the relationship between language and thought is central for a number of sciences — from linguistics to cognitive neuroscience. This is not surprising because language is not only a means of communication but is also a means

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of processing, storing and transmitting information and, in general, knowledge of the world (Gentner & Goldin-Meadow, 2003; Verbitskaya, 2013; Zinchenko, 2009; Zinchenko & Pervichko, 2013, etc.). Of particular importance is the native language of the student in the course of learning because only by means of language does a child receive new knowledge in all subject areas. Apparently, individual differences in the proficiency level of students in their native language can be associated with academic success in general. However, the process of mastering the mother tongue may be associated with individual differences in cognitive learning.

Understanding the mechanisms of the formation of individual differences in academic success is important not only for the education system. It is also important for each individual student and their families because individual differences in school performance are related to subsequent events in adult life — in higher education, professional choices, mental and physical health and even life expectancy (Power et al., 2013, etc.).

A number of studies have shown that success in learning is associated with cognitive characteristics such as intelligence (Druzhinin, 2007; Malykh et al., 2012; Tikhomirova et al., 2014; Deary et al., 2007), working memory (Bull et al., 2010), speed of information processing (Semmes et al., 2011) and others. Moreover, it was shown on a sample of high school students that intelligence is the "central core" in the relationship between cognition and academic success and that intelligence has the most significant influence on academic success compared with other cognitive characteristics (Rinderman & Neubauer, 2004, p. 574).

In recent years, predictors of academic success, including success in learning how to read, learning a native language and learning mathematics, have attracted the interest of researchers (e.g., Kovas et al., 2011). However, the focus shifted towards the study of cognitive predictors of success in learning mathematics, including the Russian sample (e.g., Tikhomirova et al., 2014; Morosanova et al., 2014; Rudenko, 2013). Unfortunately, most of the scientific studies on the factors that shape individual differences in language learning were conducted abroad (see review article by Krumm et al., 2008), and almost no studies have been conducted on the cognitive predictors of individual differences in successfully mastering the Russian language.

The relationship between success in learning and cognitive performance may be associated with the different types of analyzed indicators of success (e.g., teacher evaluation, scores on state exams, graduation, etc.). Quite often, teachers' assessments are considered a measure of success in learning, reflecting students' understanding of certain elements of the school curriculum. However, the subjectivity of teachers' assessments can result in incorrect comparisons among the educational achievements of students, particularly from educational institutions, with different educational programs (e.g., schools for gifted children, etc.).

Standardized tests on school subjects are also used as indicators of success, which are designed for research purposes, and for the diagnosis of educational achievements at the state level (state exams). These tests include same-type tasks and apply uniform methods for assessing the quality of the work done. In particular, the following final state exams were introduced in Russia: the Unified State Exam (USE) was introduced in 2009, which must be passed at the end of formal education, and the Basic State Examination (BSE) was introduced in 2010 (in terms

of up to 2014 — State Final Examination). These standardized test items were designed to objectively assess the level of knowledge that students learned in different types of educational institutions.

The aim of this study is to examine the role of cognitive characteristics, such as nonverbal intelligence, working memory and speed of information processing, in the successful learning of the Russian language (in terms of both school grades and state exams).

Method

The study involved students in the 9th grade (mean age = 15.77, SD = 0.47) and 11th grade (mean age = 17.77, SD = 0.42) from four secondary public schools in the Moscow and St. Petersburg regions. Of the 427 students who were studying in the 9th grade, 50.3% were boys, and of the 398 students who were studying in the 11th grade, 44.8% were boys.

Cognitive characteristics

To assess working memory and the speed of information processing, the Internet version of the test battery "Cognitive characteristics" was used (https://www.inlab-twins.ru). The test battery was adapted, and it contained a number of tasks aimed at measuring the level of cognitive performance (Tikhomirova, Malykh, Tosto, Kovas, 2014). For this paper, we used the following tests:

- "Corsi block", in which a participant had to repeat the sequence of "lighting" blocks, and which determined the volume of working memory. The empirical analysis included the number of correct answers on the test.
- "Reaction time", in which a participant had to press a key corresponding to a number on the screen and which captured the speed of information processing. We analyzed the average response time for the correct answers.
- To assess nonverbal intelligence we used the "Standard Progressive Matrices" test (Raven, 1999).

Success in learning

Russian teachers' evaluation of academic quarters (on a sample of 9th grade students) or of semesters (on a sample of 11th grade students) was used as an expert evaluation of the success of the training assessment. We analyzed the arithmetic average of teachers' ratings on the Russian language learning for a more subtle differentiation of expert ratings.

The rate of success in learning was defined by the results of the Unified State Exam (for 11th grade students) and the Basic State Exam (for 9th grade students) for Russian language learning. The USE was assessed in primary points, which were later converted into test points in accordance with the conversion scale. We used test scores. Test items in the BSE were evaluated in primary points that were then correlated into a five-point scale. This paper analyzes the primary points for the BSE.

Analysis of the results was carried out on the basis of anonymous personal data with prior written consent from the parents of the participants.

Results

The study analyzed the test indicators of success in learning Russian — the results of the Unified State Exam and the Basic State Examination — as well as expert assessments — grades given by teachers of the Russian language. The empirical analysis also included the cognitive characteristics of the students — speed of information processing, working memory and nonverbal intelligence.

Table 1 presents descriptive statistics for analyzed measures of cognitive development and success in learning Russian for students in the 9th and 11th grades.

Table 1. Means and standard deviations

	9th grade	**11th grade**
USE_11	–	70.21 (12.22)
BSE_9	32.77 (7.29)	–
Grade_Russian	3.61 (0.58)	4.02 (0.65)
Working memory	5.12 (1.95)	4.29 (2.04)
Speed of information processing	0.73 (0.22)	0.73 (0.23)
Nonverbal intelligence	48.71 (6.38)	52.37 (4.74)

Table 1 presents the mean of test scores for the Unified State Examination (USE) and the Basic State Exam (BSE), which were calculated in accordance with the established rules of converting the primary points. "Grade_Russian" shows the average value of the arithmetic mean for quarter (for 9th grade students) or semester (for 11th grade students) marks for the study of the Russian language. For working memory and nonverbal intelligence, the average number of correct answers is shown. For the speed of information processing, the average response time for correct responses in seconds is shown.

Minimum and maximum values are as follows: for USE_11 — from 0 to 100; for BSE_9 — from 0 to 42. "Grade_Russian" ranges from 2 to 5, "Working memory" from 0 to 12 and "Nonverbal intelligence" from 0 to 60.

According to Table 1, a sample of 11th grade students showed higher performance on the Russian language, working memory and nonverbal intelligence evaluations. However, the estimates differed significantly for the Russian language ($\eta^2 = 0.09$, $p < 0.001$) and nonverbal intelligence ($\eta^2 = 0.09$, $p < 0.001$) evaluations. The speed of information processing did not differ between students of the 9th and 11th grades.

In further analysis, we analyzed the relationship among test scores and expert estimates of success in learning Russian and cognitive characteristics (speed of information processing, working memory and nonverbal intelligence).

ANOVA showed no effect of educational institutions on test scores and expert estimates of academic success ($p > 0.05$), allowing us to conduct a further comprehensive analysis of the data.

It should be noted that the teachers' grades for Russian language learning correlated with test scores for the BSE ($r = 0.46$, $p < 0.01$).

Table 2 presents the results of the correlation analysis of the relationship between the Basic State Examination and estimates for Russian language learning with cognitive development in 9th grade students.

Table 2. Relationships of test and expert estimates of academic success with cognitive characteristics in 9th grade students

	Speed of information processing	Working memory	Nonverbal intelligence
BSE	0.12	–0.11	0.09
Grade_Russian	–0.10	0.17**	0.30**

**$p<0.01$

As shown in Table 2, BSE scores did not correlate with any of the analyzed cognitive characteristics ($p > 0.05$). However, the expert estimate was associated with working memory ($r = 0.17$, $p < 0.01$) and nonverbal intelligence ($r = 0.30$, $p < 0.01$).

In high school students (11th grade), it was shown that the test scores (USE) highly correlated with the teachers' estimates of Russian language learning ($r = 0.71$, $p < 0.01$).

Table 3 presents the results of the correlation analysis of the relationship of the Unified State Exam and estimates for the Russian language learning with indicators of cognitive development in a sample of 11th grade students.

Table 3. Relationships of test and expert estimates of academic success with cognitive characteristics in 11th grade students

	Speed of information processing	Working memory	Nonverbal intelligence
USE	–0.12	0.20**	0.28**
Grade_Russian	–0.03	0.16*	0.31**

According to Table 3, in a sample of 11th grade students, the test scores correlated with working memory ($r = 0.20$, $p < 0.01$) and nonverbal intelligence ($r = 0.28$, $p < 0.01$). Similar patterns were found for the expert estimates. The speed of information processing did not correlate with test scores or with expert estimates of Russian language learning ($p > 0.05$).

The correlation analysis showed that in 9th and 11th grade students, the expert estimates of success in learning Russian show similar patterns in the relationship with cognitive performance. Grades for Russian language learning in both age samples correlated with the level of development of working memory and nonverbal intelligence, but did not correlate with the speed of information processing.

Test indicators of success in Russian language learning — the USE and BSE — differ in their relationship with cognitive performance. The USE is interrelated with

working memory and nonverbal intelligence. The BSE is not associated with any of the analyzed measures of cognitive development.

To investigate the role of cognitive variables — speed of information processing, working memory and nonverbal intelligence — multiple regression analyses were performed on samples of 9th and 11th grade students. Dependent variables — test success rates and expert estimates — were introduced sequentially. The independent variables were measures of the cognitive development of the students.

Table 4 shows the results of the regression analysis for the test scores for Russian language learning on a sample of 11th grade students.

Table 4. Results of the regression analysis of the USE the Russian language in students of 11th grade

	β	**B (standard error B)**	**t**	*P*
Working memory	0.12	0.74 (0.12)	1.28	0.20
Speed of information processing	–0.05	–2.72 (4.93)	–0.55	0.58
Nonverbal intelligence	0.24	0.62 (0.25)	2.54	0.01

In 11th grade students, among all the analyzed cognitive characteristics, the only significant predictor of high test scores was nonverbal intelligence ($\beta = 0.24$, $p < 0.01$). The characteristics of the regression model were as follows: $R^2 = 0.10$, adjusted $R^2 = 0.07$, $F = 3.09$, $p < 0.01$.

Regression analysis was conducted on the BSE scores on a sample of 9th grade students. It is worth emphasizing that the results of the regression analysis on the BSE were statistically not significant: no significant predictors were found among the cognitive variables.

Further analysis included multiple regression analysis on the expert estimates of success in learning Russian. Table 5 shows the results of the regression analysis on the assessment of Russian language learning on a sample of 11th grade students.

Table 5. Results of the regression analysis on "Grade_Russian" in 11th grade students

	β	**B (standard error B)**	**t**	*p*
Working memory	0.06	0.02 (0.03)	0.66	0.51
Speed of information processing	0.02	0.04 (0.26)	0.16	0.88
Nonverbal intelligence	0.32	0.04 (0.01)	3.34	0.00

According to Table 5, the expert estimates — grades on the Russian language assessments — for a sample of 11th grade students predicted nonverbal intelligence ($\beta = 0.32$, $p < 0.001$). The characteristics of the model were as follows: $R^2 = 0.12$, adjusted $R^2 = 0.09$, $F = 4.74$, $p < 0.001$.

Table 6 shows the results of the regression analysis on the expert estimates of success in learning Russian on a sample of 9th grade students.

Table 6. Results of the regression analysis on "Grade_Russian" in 9th grade students

	β	B (standard error B)	t	*p*
Working memory	0.13	0.04 (0.02)	1.80	0.07
Speed of information processing	-0.03	-0.07 (0.19)	-0.36	0.72
Nonverbal intelligence	0.24	0.02 (0.01)	3.47	0.00

Similar results on the expert estimates were obtained for the sample of 9th grade students. The only cognitive predictor of grades for Russian language learning was nonverbal intelligence. The characteristics of the model were as follows: $R^2 = 0.10$, adjusted $R^2 = 0.09$, $F = 7.37$, $p < 0.001$.

In the multiple regression analysis, similarities in expert estimates were revealed between the samples of 9th and 11th grade students: 9% of the variance of the grades for Russian language learning was predicted by nonverbal intelligence. However, differences were revealed between the samples for the test scores: the USE results could be predicted from nonverbal intelligence (7% of the variance), and the contribution to the results of the BSE were statistically not significant.

Discussion

In general, it was shown that the expert estimates and the test indicators of success in learning the Russian language are interconnected to different extents at the lower and upper levels of secondary education. Thus, grades for Russian language learning are to a much greater extent associated with the USE results in the 11th grade than with the BSE results in the 9th grade. This fact may be associated with both the superior validity of the USE and with the selection of students who wish to continue their studies at the upper level of secondary education.

The study found no association between the level of cognitive development and the BSE scores in Russian language learning. This may reflect the specificity of success in learning Russian in contrast, for example, with success in mathematics. In a study on the Russian sample, the BSE scores in mathematics significantly correlated with spatial memory ($r = 0.20$, $p<0.05$) and were not related to nonverbal intelligence (in Russian: Morosanova et al., 2014). It is possible that non-cognitive characteristics are more important for success in learning the Russian language at the lower and upper levels of secondary education. The studies highlight the role of learning activity as a component of achievement motivation for success in learning the mother tongue, mathematics and reading (Anderman, Midgley, Wigfield, & Eccles, 2001).

On the contrary, the test scores for the USE on Russian language learning are associated with working memory and nonverbal intelligence. This fact is consistent with the results of previous studies, which emphasize that these cognitive variables especially contribute to individual differences in academic success across different fields (e.g., Rinderman & Neubauer, 2004).

As a result of our study, we found no relation of all the analyzed measures of success in learning the Russian language with the speed of information processing.

Similar results were obtained in our previous studies of success in mathematics (In Russian: Tikhomirova et al., 2014).

Interestingly, the contribution of cognitive characteristics to expert estimates of Russian language learning is equivalent in the two samples — 9th and 11th grade students. For example, 9% of the variance of the expert estimates can be explained by nonverbal intelligence. A slightly smaller percentage of variance of the USE scores (7%) is also explained by a single cognitive predictor — nonverbal intelligence. These data correspond to studies that found a moderate to strong association between intelligence and a whole range of indicators of success in learning (Sternberg et al., 2001). However, the relationship tends to be stronger if intelligence is seen not as a test indicator, but as a latent variable allocated by means of factorization of measures from a battery of tests. Moreover, it was shown that intelligence is a cognitive measure of a higher order and plays a mediating role in the relationship of elementary cognitive characteristics and academic success (Rinderman & Neubauer, 2004). Thus, our results confirmed that the level of nonverbal intelligence is a significant predictor of success in learning the Russian language.

It seems necessary to emphasize not only the relationship of intelligence and success in learning but also their differences within educational activities. Indeed, in our study the level of nonverbal intelligence explains no more than 10% of the variance of success in learning Russian. Apparently, some of the remaining variance relates to measurement errors; however, there are other factors in addition to intelligence affecting academic success. These factors may include personality traits, level of motivation and effort, support from parents, interaction with the teacher and the quality of a school as a whole (for discussion of these factors see, for example, in Petrides, Chamorro-Premuzic, Frederickson, & Furnham, 2005).

In our study we found no contribution by working memory on individual differences in either expert estimates or test indicators of success in learning the Russian language. This result may be related to the characteristics of the stimuli in the working memory test used in our study. Working memory was measured with the "Corsi block" test based on nonverbal stimulus material. At the same time, the contribution of working memory on success in learning the Russian language was obtained in a study using verbal stimuli to determine the level of working memory (Krumm et al., 2008).

Conclusion

This study shows that at the lower and upper levels of secondary education, nonverbal intelligence may be a significant predictor of success in learning Russian as assessed by experts. At the same time, we found differences in the relationship of cognitive performance with success in learning the Russian language in terms of test scores. Nonverbal intelligence contributed significantly to individual differences in the results of the Unified State Exam in Russian, while the contribution of cognitive characteristics to the results of the Basic State Exam was not statistically significant.

The study also showed that in high school students the teachers' estimates of Russian language learning more highly correlated with test scores on the USE (of 11th grade students) than with test scores on the BSE (of 9th grade students).

Limitations

We used a cross-sectional design. Therefore, the test scores of Russian language learning — the USE and the BSE — were analyzed on two independent samples. However, to evaluate the stability of test success rates, it is necessary to conduct a longitudinal study. A future direction for research may be associated with the study of cognitive predictors of success in learning Russian on a sample of bilingual students in Russian schools.

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