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Cognitive predictors of success in learning Russian in native and non-native speakers at high school age

Ludmila A. Verbitskaya[a, b], Sergey Malykh[a] &Tatiana Tikhomirova[c]*

[a]*Russian Academy of Education, 8, Pogodinskaya str., Moscow 119121, Russia*
[b]*Saint Petersburg State University, 7/9, Universitetskaya nab., Saint Petersburg199034, Russia*
[c] *Psychological Institute of Russian Academy of Education, 9, 4, Mokhovaya str., Moscow 125009, Russia*

Abstract

The study focused on the role of the speed of information processing, working memory and non-verbal intelligence in the success in learning Russian assessed with teacher ratings (annual grades) and state exam scores in native and non-native speakers at high school age. Russian-speaking students, who study in different educational environments, differed in non-verbal intelligence, but not the speed of information processing and working memory. Russian-speaking students, who study in Kyrgyzstan, showed better performance at the Russian language exam, than their Kyrgyz-speaking peers. Non-verbal intelligence predicted success in learning Russian across all groups.

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*Keywords:*success in learning Russian; native and non-native speakers;speed of information processing; working memory; intelligence; high school age.

1. Introduction

The problem of the relationship between cognitive development and success in learning the mother tongue is particularly crucial at school age. On the one hand, the mother tongue is a means of processing, storage and transmission of information. On the other hand, language acquisition can be associated with individual differences in cognitive functioning. A number of studies have shown that success in learning is associated with cognitive characteristics such as intelligence (Malykh et al., 2012), working memory (Bull et al., 2010), speed of information

* Corresponding author. Tel.: +7-903-114-28-10.
E-mail address: tikho@mail.ru

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processing (Semmes et al., 2011), and the strength of these associations depends on test tasks (Verbitskaya et al., 2015), age (Rodic et al., 2014) and academic discipline (Tikhomirova et al., 2015).

The majority of studies analyzed the success in learning in terms of mathematical achievement on different socio-cultural samples. The analysis of the success in learning Russian in school students, who are native or non-native speakers, is limited by a socio-cultural context related to a particular language. Partially for this reason there are few studies of cognitive predictors of success in learning Russian. L.A. Verbitskaya and her colleagues (2015) studied the cognitive predictors of the success in learning Russian on a sample of Russian high school students.

The current study aims to analyze the role of cognitive characteristics such as speed of information processing, working memory and non-verbal intelligence in the success in learning Russian measured with annual grades and test scores on standardized state exams in native and non-native speakers at high school age. We investigated the relationship of the measures in high school students from two countries – Russia and Kyrgyzstan – that have similar educational systems, but are different in terms of the quality of education (PISA, 2010).

2. Methods

2.1 Participants

Three samples of final-year students (Grade 11) were enrolled from public secondary schools: 1) 203 Russian students (Mean = 17.7 years, SD = 0.4, 49.5% males), who study in Russian in Russia, 2) 94 Russian students (Mean = 17.6 years, SD = 0.5, 47.2% males), who study in Russian in Kyrgyzstan, and 3) 215 Kyrgyz students, who study in Russian in Kyrgyzstan (Mean = 17.7 years, SD = 0.5, 42.6% males).

2.2 Procedure

Data collection was conducted in educational institutions at the time of lessons strictly following the protocol under the constant supervision of a researcher.

Speed of information processing was measured using a computerized task ‘Choice Reaction Time’(Tosto et al., 2013). In this task numbers 1,2,3,4 appear on the screen one at the time at a random interval between 1 and 3 seconds. The task requires to press the corresponding keys (1, 2, 3, 4 of the key board) as fast as possible. We analyzed the average response time for the correct answers.

Working memory was measured using a computerized ‘Corsi Block-Tapping Task’(Tosto et al., 2013). The participants were presented a set of square blocks lighting up one after another. The test begins with a sequence of 4 blocks; the maximum possible number of elements in a sequence – 9. During the presentation the blocks light up for 1 second at intervals of 1 second. The participants were asked to repeat the presented sequence by clicking the blocks with a computer mouse. The test is automatically discontinued if a participant does not correctly reproduce the sequences at a particular level of difficulty. The program records the number of correct answers.

Non-verbal intelligence was measured using paper-and-pencil test ‘Raven's Progressive Matrices’. It consists of 60 tasks grouped in 5 series. Each correct answer was counted as 1 score. Total scores were calculated.

Success in learning Russian was indicated (1) by annual grades in Russian in both Russian and Kyrgyz samples, (2) by test scores of the Unified State Exam, USE (for Russian schoolchildren) and National testing(for Kyrgyz schoolchildren) which are obligatory school graduation exams.

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

3. Results and discussion

3.1. Descriptive statistics

Table1 shows means and standard deviations (in brackets) for all analyzed variables in native (Russian students from Russia and Kyrgyzstan) and non-native speakers (Kyrgyz students from Kyrgyzstan). The speed of information processing reflects the mean reaction time for correct answers on the test ‘Choice Reaction Time’. Working memory

and non-verbal intelligence are represented by mean number of correct answers for 'Corsi Block – Tapping Task' and 'Raven's Progressive Matrices' respectively. For the success in learning Russian two measures are presented: 1) annual grades in Russian, and 2) scores for a standardized test: Unified State Exam (USE) in Russia or National Testing in Kyrgyzstan. The minimum and the maximum possible scores are as follows: the 'Corsi Block Tapping Task' – from 0 to 12; the 'Raven's Progressive Matrices' – from 0 to 60; the grades in Russian – from 2 (unsatisfactory) to 5 (excellent); USE – from 0 to 100; the National Testing – from 0 to 231.

Table 1. Means and standard deviations

	Russian from Russia	Russian from Kyrgyzstan	Kyrgyz from Kyrgyzstan
Speed of information processing	0.73 (0.2)	0.76 (0.2)	0.79 (0.2)
Working memory	5.20 (2.0)	4.92 (2.2)	4.70 (2.3)
Non-verbal intelligence	50.1 (6.1)	46.6 (6.2)	45.5 (6.9)
Grades in Russian	3.74 (0.6)	3.72 (0.6)	3.63 (0.6)
Unified State Exam	70.2 (12.2)	–	–
National Testing	–	174.38 (30.0)	162.91 (29.9)

According to Table 1, Russian students studying in Russia have the highest values for the working memory and non-verbal intelligence and the lowest scores for the speed of information processing, while Kyrgyz students from Kyrgyzstan showed a reverse pattern. Mean annual grades and the National testing scores are higher in Russian-speaking high school students from Kyrgyzstan, compared to their Kyrgyz peers.

3.2 ANOVA

We ran a one-way ANOVA to test the differences in the speed of information processing, working memory and non-verbal intelligence between the three groups: 1) native speakers from Russia (Russian students from Russia), 2) native speakers from Kyrgyzstan (Russian students from Kyrgyzstan) and 3) non-native speakers from Kyrgyzstan (Kyrgyz students from Kyrgyzstan) (see Table 2).

Table 2. Assessment of the group effect on the analyzed cognitive measures.

Cognitive measure	SS	F	p-value	η2
Speed of information processing	0.87	6.70	0.000	0.02
Working memory	71.88	5.19	0.001	0.01
Non-verbal intelligence	4226.8	33.32	0.000	0.10

Levene's test showed $p > 0.05$ suggesting the equality of variances. The group effect was significant for all cognitive measures, but the effect size was non-significant – 2% for the speed of information processing and 1% for working memory, $p < 0.05$. The greatest effect size was obtained for non-verbal intelligence – 10%, $p < 0.001$.

The Bonferroni correction showed significant differences in the speed of information processing and working memory only between native speakers from Russia and non-native speakers (Kyrgyz) from Kyrgyzstan. For non-verbal intelligence, differences were found not only between the groups of native speakers from Russia and non-native speakers from Kyrgyzstan, but also between Russian-speaking students from Russia and Kyrgyzstan. This results confirm the previously reported hypothesis about the effect of education on the performance on 'Raven's Progressive Matrices' (e.g., Nisbett et al., 2012). Native and non-native speakers from Kyrgyzstan only differed in non-verbal intelligence ($p < 0.001$).

Another one-way ANOVA was used to test the differences in the success in learning Russian in high school students from Kyrgyzstan, who were native and non-native speakers of Russian (see Table 3).

Table 3.Assessment of the group effect on the analyzed measures of success in Russian.

Measure of success in Russian	SS	F	p-value	η2
Annual Grade	1.17	3.94	0.07	0.01
National Testing	7058.18	7.90	0.01	0.03

Levene's test showed that all variances were equal ($p > 0.05$). High school students from Kyrgyzstan, who are native or non-native speakers of Russian, did not differ in annual grades ($p > 0.05$), whereas these groups showed significant differences in the results of the National testing with a non-significant effect size of 3% ($p < 0.01$).

3.3. Correlation analysis

Table 4 presents the Spearman correlations between the cognitive measures and success in learning Russian.

Table 4. Correlations between the analyzed variables on Russian and Kyrgyz samples.

	Speed of information processing	Working memory	Non-verbal intelligence
State Exam	-0.11	0.20**	0.28**
	-0.11	0.10	0.38**
	-0.10	0.11	0.36**
Grade	-0.01	0.18**	0.30**
	0.09	0.11	0.21**
	0.02	0.05	0.30**

Upper row – Russian from Russia, middle row – Russian from Kyrgyzstan, bottom row – Kyrgyz from Kyrgyzstan
*** p<0.01*

In Russian students from Russia both USE scores and annual grades were moderately related to working memory and non-verbal intelligence. The correlations between success in learning Russian and non-verbal intelligence were higher (up to 0.30, $p < 0.01$). In native and non-native speakers of Russian from Kyrgyzstan success in learning Russian was only associated with non-verbal intelligence. Similar results were obtained in our previous studies of success in mathematics (Tikhomirova et al., 2014). A possible explanation for these differences might be due to the content of the exams in Russia and Kyrgyzstan. The National testing is primarily aimed at the identification of bright children, whereas USE aims to test the level of knowledge, which can involve the working memory. Indeed, USE shows stronger association with annual grades ($r = 0.71$, $p < 0.001$), than the National testing (in Russian students: $r = 0.25$, $p < 0.01$, in Kyrgyz: $r = 0.29$, $p < 0.001$).

3.4 Regression analyses

To investigate the role of cognitive variables multiple regression analyses were performed separately in three groups of participants. Dependent variables – exam results and annual grades – were introduced sequentially. The analyzed measures of the cognitive development of the high school students were used as independent variables.

Table 5. Results of the regression analysis of the exams success rates in the analyzed samples

Sample	Significant predictors	β	B (standard error B)	t	p-value
Russian from Russia	Non-verbal intelligence	0.20	0.40 (0.18)	2.20	0.03
Russian from Kyrgyzstan	Non-verbal intelligence	0.30	1.45 (0.58)	2.49	0.02
Kyrgyz from Kyrgyzstan	Non-verbal intelligence	0.30	1.32 (0.32)	4.18	0.00

In Russian high school students from Russia the only significant cognitive predictor of USE scores was non-verbal intelligence ($\beta = 0.20$, $p < 0.05$). The characteristics of the regression model were as follows: $R2 = 0.08$, adjusted $R2 = 0.07$, $F = 3.42$, $p < 0.05$. Similar results were obtained for Russian ($\beta = 0.30$, $p < 0.02$) and Kyrgyz ($\beta = 0.30$, $p < 0.001$) students from Kyrgyzstan. The characteristics of the regression model were as follows: for native speakers: $R2 = 0.11$, adjusted $R2 = 0.07$, $F = 3.01$, $p < 0.05$; for non-native speakers: $R2 = 0.12$, adjusted $R2 = 0.11$, $F = 8.05$, $p < 0.001$. Thus, the results were similar among native speakers of Russian regardless of the country. The results showing

that intelligence was a predictor of successful exam performance are consistent with previous studies on different disciplines (e.g., Taub et al., 2008) including Russian (Verbitskaya et al., 2015).

According to Table 5, non-verbal intelligence was the only predictor of annual grades in Russian ($0.19 < \beta < 0.32$), with the smallest percent of variance of annual grades explained in Russian students from Kyrgyzstan (adjusted $R2 = 0.05$, $F = 3.41$, $p < 0.05$) followed by Russian students from Russia (adjusted $R2 = 0.09$, $F= 4.74$, $p < 0.001$) and Kyrgyz students from Kyrgyzstan (adjusted $R2 = 0.09$, $F = 6.90$, $p < 0.001$). Thus, native speakers of Russian studying in Kyrgyzstan might need less cognitive resources than those studying in Russia.

Table 6. Results of the regression analysis of the annual grades in the analyzed samples.

Sample	Significant predictors	β	B (standard error B)	t	*p*-value
Russian from Russia	Non-verbal intelligence	0.32	0.04 (0.01)	3.34	0.00
Russian from Kyrgyzstan	Non-verbal intelligence	0.19	0.02 (0.01)	2.22	0.03
Kyrgyz from Kyrgyzstan	Non-verbal intelligence	0.33	0.03 (0.01)	4.40	0.00

4. Conclusions

In the current study we analyzed the relationships of success in learning Russian with cognitive measures in native and non-native speakers studying in different educational environments. The correlation analysis showed similar patterns for both indicators of success in learning Russian. The structure of the relationships between cognitive development and success in Russian differed among the native speakers studying in different educational environments: success in Russian was associated with both non-verbal intelligence and working memory in students from Russia, but only with non-verbal intelligence in all students from Kyrgyzstan. Native speakers from Russia and Kyrgyzstan differed in non-verbal intelligence with Russian students having higher scores (effect size 10%) – this might confirm the hypothesis that Raven scores are affected by the quality of education.

Our results confirmed that the level of nonverbal intelligence is a significant predictor of success in learning Russian not only in Russian high school students, who study in Russia (Verbitskaya et al., 2015), but also in Russian and Kyrgyz high school students, who study in Kyrgyzstan. A possible limitation of the study could be the fact that we should have included a group of Kyrgyz students studying in Russia, but these students must have been studying in Russia for 11 years, so this group is rare and hard to find. Further research might be focused on the success in Russian in native and non-native speakers in other cultures.

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