

PSYCHOLOGY IN RUSSIA: STATE OF THE ART

Volume 13 Issue 2 2020

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EDUCATIONAL PSYCHOLOGY

Cognitive Predictors of Success in Learning Russian Among Native Speakers of High School Age in Different Educational Systems

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Background. The search for cognitive predictors of success in language learning is associated both with basic cognitive characteristics (processing speed and spatial working memory) and with general characteristics (intelligence). However, the ratio between cognitive functioning and success in language learning can change during the period of school education and depends on the socioeconomic level of the society and the effectiveness of the national educational system.

Objective. To analyze the cognitive predictors of Russian language learning samples of Russian-speaking 11th graders from Russia, Kyrgyzstan, and Moldova, three countries with a similar organization of the educational system, but differing in the functional effectiveness of that educational system and in their socioeconomic levels.

Design. The sample comprised 545 Russian-speaking 11th graders (average age = 17.42 + 0.59; 36.1% male) studying Russian throughout their public-school education in Russia, Kyrgyzstan, and Moldova. The statistical methods of one-way analysis of variance, correlation, and multiple regression analysis were used.

Results. Among the indicators of cognitive development we analyzed, the functioning of the national educational system is the one most associated with the development of fluid intelligence of 11th graders, which is directly proportional to the quality of education in the country; to a lesser extent, it is associated with the development of working memory. In Kyrgyzstan (average level of socioeconomic development) and Moldovan (low level of socioeconomic development), only fluid intelligence was associated with the score on the state exam on the Russian language. In Russia, which has a very high level of socioeconomic development, spatial working memory becomes important, along with fluid intelligence.

Conclusion. Differences in the relationship between cognitive functioning and success in Russian-language learning are associated both with the objectives of the state exam (identification of pupils ready to attend university versus testing of what was learned in school), and, in conditions of low educational effectiveness, with a greater cognitive load during the exam.

Keywords: processing speed; spatial working memory; fluid intelligence; success in learning Russian; native speakers; state final examination; teacher's assessment

Introduction

Modern studies of the cognitive mechanisms of academic achievement initially focused on achievements in mathematics, given its importance in modern technological society (e.g., Rodic et al., 2015; Taub, Keith, Floyd, & McGrew, 2008; Tikhomirova & Malykh, 2017). These studies demonstrated that cross-cultural differences in the relationship between indicators of cognitive development and mathematical achievement are also associated with the students' particular native language (Rodic et al., 2015). However, much less research has been devoted to the analysis of success in native language learning; moreover, these studies were mainly related to the English language, with samples of schoolchildren from English-speaking countries (e.g., Alloway & Alloway, 2010; Botting, 2005; Gathercole & Baddeley, 2014).

Studying the success of Russian language learning is limited by the linguistic context, since Russian is used as one of the main languages in an educational system only in a number of countries of the former USSR. There are only a handful of studies of the cognitive foundations of individual differences in the success of learning Russian (Verbitskaya, Malykh, & Tikhomirova, 2017; Verbitskaya, Malykh, Zinchenko, & Tikhomirova, 2017; Verbitskaya, Malykh, Zinchenko, & Tikhomirova, 2015). One of these studies evaluated samples of pupils who were educated in the Russian language throughout their schooling in Russia and Kyrgyzstan – two countries with similar educational systems but different socioeconomic levels (Verbitskaya et al., 2017).

In these national educational systems, a student's knowledge is assessed using the teachers' grades and standardized state exams. Analysis of academic success based on each of these indicators has its advantages and disadvantages. In particular, the teacher's assessment is subjective (even within the same school) and officially varies from 2 to 5, but in reality it varies from 3 to 5, which becomes a limitation in research when conducting statistical analysis of data. At the same time, it is the teacher's assessment that is the indicator of success in learning that can be used throughout the entire period of education – from primary school to high school. On the other hand, the results of state exams are standardized (for example, the Unified State Exam in Russia), but can only be used in studies involving respondents in the final year of their secondary education. According to available data, the relationship between the teacher's assessment of a student's Russian-language learning and the result of the national state exam can vary in cross-cultural terms more than 2.5-fold, and depends, *inter alia*, on the purpose and content of the national state exam (Verbitskaya, Malykh, Zinchenko, & Tikhomirova, 2017).

The search for cognitive predictors of success in language learning is associated with both basic cognitive characteristics (processing speed and spatial working memory) and general characteristics (fluid intelligence) (Tikhomirova & Malykh, 2017; Verbitskaya, Malykh, & Tikhomirova, 2017; Verbitskaya et al., 2015). In particular, intelligence is considered as one of the most significant predictors of individual language learning outcomes at various ages and in different sociocultural samples (e.g., Brouwers, Van de Vijver, & Van Hemert, 2009; Deary, Strand, Smith, & Fernandez, 2007; Taub et al., 2008; Verbitskaya, Malykh, Zinchenko,

& Tikhomirova, 2017; etc.). According to these studies, spatial working memory plays an important role in successful learning at school; however, it has been shown that this cognitive characteristic is associated with a variety of academic and language skills to various extents – from reading technique and vocabulary to grammar (e.g., Cain, Oakhill, & Bryant, 2004; Gathercole & Baddeley, 2014; Verbitskaya et al., 2015). Processing speed is the cognitive indicator for which direct correlations with success in native language learning are obtained, and their absence at certain school ages is being discussed (e.g., Sheppard & Vernon, 2008; Tikhomirova, Voronin, Misozhnikova, & Malykh, 2015; Verbitskaya, Malykh, & Tikhomirova, 2017). It is also reported that the predictive power of each of these cognitive indicators may vary throughout the educational process. Working memory, measured at the beginning of school, is a more powerful predictor of reading and writing skills during the next six years of schooling than is intelligence, for example (Alloway & Alloway, 2010).

A number of studies found that indicators of cognitive functioning, as well as the relationship of these indicators to success in learning, including language, may vary depending on the sociocultural environment (Tikhomirova & Malykh, 2017; Tucker-Drob & Bates, 2016). According to a meta-analysis involving more than 240,000 respondents from 45 countries, such cross-cultural differences are usually associated with the socioeconomic level of the countries ($r=0.16$; $p<0.001$) and the characteristics of the national educational systems ($r=0.25$; $p<0.001$) (Brouwers et al., 2009). It was also reported that given a higher socioeconomic level, there is more intensive development of cognitive functions, especially intelligence (von Stumm & Plomin, 2015).

Numerous studies have shown that the quality of national education is one of the most significant sociocultural factors leading to changes in the relationship between cognitive functioning and learning success (e.g., DeNavas-Walt & Proctor, 2014; Nisbett et al., 2012; Schneeweis, Skirbekk, & Winter-Ebmer, 2014). In particular, it has been shown that cognitive resources play a greater role in the success of school education in a less heterogeneous and more effective educational environment (Tikhomirova & Malykh, 2017; Tucker-Drob & Bates, 2016). A subject-based orientation of the national educational system towards, for example, mathematics, can affect the achievement of students in this discipline (Paik et al., 2011). Specifically, it was shown that various cognitive factors have different effects on the student's development, depending on the educational environment. And, according to a number of studies, fluid intelligence is considered the most "sensitive" to the quality of the national educational system (e.g., Nisbett et al., 2012; Tikhomirova & Malykh, 2017). These results can lead to cross-cultural cognitive predictors of success in learning Russian in native speakers of high school age in different educational systems.

The effective functioning of the national educational system is derived from various predictors related to both economic indicators (government spending on education; gross enrollment ratio of people older than 15 years of primary, secondary, and higher education; average duration of education in the population; satisfaction of the population with the quality of education; proportion of the population with secondary education or higher; proportion of primary school teachers with teacher training), and to educational achievements (reading literacy, math, science,

and computer literacy). These socioeconomic and educational indicators are taken into account when deriving the Human Development Index (HDI), yielding scores from which the categories (groups) of countries are formed.

In the present study, the analysis of cognitive predictors of success in learning Russian is was performed on samples of Russian-speaking 11th graders from Russia, Kyrgyzstan, and Moldova, three countries with a similar organization of the educational system, but differing in the functional effectiveness of that educational system and in their socioeconomic level.

According to the 2016 international rating of the United Nations Development Programme, based on the achievements of a country in three areas of development – health, education, and living conditions – Russia is included in the group with a very high level of human development (49th place), Moldova in the group of countries with a high level (112th place), and Kyrgyzstan in the group with a medium level (122th place). It should be emphasized that in Moldova the present study was conducted in schools in Tiraspol, in the unrecognized Transnistrian Moldavian Republic, characterized by a very low socioeconomic level and, as a consequence, low effectiveness of the national educational system.

Consideration of differences in the socioeconomic situation of these countries, including the effectiveness of the educational system, makes it possible to assess the impact of public education on the correlation ratio between the cognitive development of the students and their success in learning Russian as a native language.

Methods

Participants

The sample comprised 545 Russian-speaking students in 11th grade (average age = 17.42 + 0.59; 36.1% male) studying the Russian language for the duration of their public-school education in Russia, Kyrgyzstan, and Moldova.

The sample in Russia includes 231 students (average age 17.7 years, standard deviation 0.39; 41.6% male), the Kyrgyz sample consists of 165 students (average age 17.6 years, standard deviation 0.55; 33.3% male), and the Moldovan sample includes 149 students (average age 17.3 years, standard deviation 0.55; 30.9% male).

Public schools from Russia, Kyrgyzstan, and Moldova were selected for participation in the study according to the following criteria:

1. State status (departmental affiliation, number of teachers per student, etc.);
2. Qualifications and structure of the teaching staff (ratio of teachers with higher education to the total number of teachers, age group with the largest number of teachers, etc.);
3. Similar educational programs in the Russian language;
4. Quality of students' education (ratio of the average grade for the final state exam on the Russian language to the grade for the region).

Eleventh graders from one Russian school (Moscow Region), one Kyrgyz school (Bishkek), and two Moldovan schools (Tiraspol), equalized with respect to ranking position in the region, took part in the study.

Procedure

Assessment of Cognitive Development

For assessment of *processing speed*, the computerized “Choice Reaction Time” test was used (Tikhomirova & Malykh, 2017; Tosto et al., 2013). In this test, the numbers 1, 2, 3, 4 appear 40 times in random order at intervals of 1 to 3 seconds. Participants are asked to press the key corresponding to the number that appears on the screen as quickly and accurately as possible. The response time is limited to 8 seconds. The number of correct answers and the average value of the reaction time are recorded. Statistical analysis uses a measure of reaction time only for the correct answers.

For assessment of *spatial working memory*, the computerized “Corsi Block” test was used (Tikhomirova & Malykh, 2017; Tosto et al., 2013). The screen shows a sequence of “igniting” cubes one after another. The test begins with a sequence of four cubes; the maximum possible number of elements in the sequence is nine. During presentation, the cubes “ignite” for 1 second with an interval of 1 second. Participants are asked to reproduce the entire sequence of “igniting” the cubes by clicking on the desired cubes with a computer mouse. The task was automatically interrupted if the student incorrectly performed all the sequences of the same level. Statistical analysis uses an indicator of the number of correct answers.

For *fluid intelligence* assessment, the “paper-pencil” version of the “Standard Progressive Matrices” test was used. Tasks are grouped into five series, each of which consists of 12 tasks. Participants are asked to choose the missing element of the matrix task from six or eight proposed options. Statistical analysis uses an indicator of the total number of correct decisions.

Success in Learning Russian

As indicators of success in learning, we used (a) the average score of semi-annual assessments in the Russian language on samples of Russian, Kyrgyz, and Moldavian students and (b) test scores on state exams: the Unified State Exam (Russian students), National Testing (Kyrgyz students), and the Unified State Exam (Moldovan students).

The semi-annual assessment is made by the teacher of the Russian language when assessing students’ the Russian language and varies from 2 (unsatisfactory) to 5 (excellent).

The Unified State Exam in Russia is a set of tasks in a standardized form, the successful completion of which establishes that the student meets the federal state educational standard of Russia in academic subjects. The exam on the Russian language is compulsory for all graduates of Russian schools and is taken upon completion of the last, 11th, year of schooling.

National Testing in Kyrgyzstan is a set of tasks in a standardized form aimed at identifying the high school students most ready for further study at a university. In the present study, the score for the main test is used for statistical analysis; it is taken at the end of the last, 11th, year of schooling.

The Unified State Exam in Moldova, in Tiraspol, as well as in Russia, is the main form of state certification of school graduates and constitutes a set of standardized tests aimed at determining whether the results of the basic educational programs

completed by students meet the state educational standard. The Unified State Exam in one's native language (optionally Russian, Moldavian, or Ukrainian) is compulsory for all graduates of Tiraspol schools and is taken upon completion of the last year of study at general academic schools.

Informed consent of participants' parents and representatives of the school administration was obtained. Data was collected in the computer science office of a general educational institution, strictly according to the developed protocol and under the supervision of a researcher. Data analysis was carried out on the anonymized personal data.

Statistical Approach

In the first step of statistical analysis, differences in the indicators of cognitive development were assessed using the method of univariate analysis of variance. It is assumed that the differences between Russian-speaking high school students who study throughout their schooling in Russia, Kyrgyzstan, or Moldova can be explained, first of all, by differences in the effectiveness of the national educational systems.

In the second step, we investigated the indicators of cognitive development (processing speed, working memory, and fluid intelligence) and of success in learning Russian (both annual grade and state exam score) in each group of participants by correlation analysis. Spearman correlation coefficients were calculated.

In the third step, significant cognitive predictors of success in Russian language learning (grade and state exam score) in each group of participants were determined by multiple regression analysis.

Results

The indicators of processing speed, spatial working memory, and fluid intelligence were analyzed as cognitive predictors, and the results of the state exam on the Russian language and the teacher's assessment were analyzed as indicators of the success of learning Russian.

Table 1 presents the average values and standard deviations (in parentheses) for the indicators of cognitive development and success in teaching the Russian language for native speakers from Russia, Kyrgyzstan, and Moldova. For processing speed, Table 1 gives the average response time in seconds to the correct answers for all tasks of the "Choice Reaction Time" test. For spatial working memory and fluid intelligence, the total numbers of correct answers for the "Corsi Block" and "Standard Progressive Matrices" tests, respectively, are presented. The minimum and maximum possible values for spatial working memory are from 0 to 12; for fluid intelligence from 0 to 60.

Table 1 shows that the best values for all the indicators of cognitive development are found in the sample of students in Russia: large values for spatial working memory and fluid intelligence, lower values for processing speed. The average processing speed is the same for students from Kyrgyzstan and Moldova. In terms of spatial working memory, Moldovan students are ahead of their Kyrgyz peers (5.30 versus 4.73), and inferior to them in fluid intelligence (47.02 versus 48.67).

Table 1

Descriptive statistics of indicators of cognitive functioning and success in learning Russian

	Russian speakers from Russia	Russian speakers from Kyrgyzstan	Russian speakers from Moldova
Processing speed	0.71 (0.2)	0.74 (0.2)	0.74 (0.2)
Spatial working memory	5.43 (2.0)	4.73 (2.3)	5.30 (1.9)
Fluid intelligence	52.17 (4.9)	48.67 (6.1)	47.02 (6.8)
Grade	4.04 (0.6)	3.76 (0.6)	4.15 (0.7)
State Exam	72.1 (12.0)	173.3 (26.7)	38.3 (9.9)

The success in Russian language learning in this study is represented by two indicators: the average score of semi-annual assessments and the score on the state exam. The minimum and maximum possible values are: for the teacher's grade, from 2 to 5; for the Unified State Exam in Russia, from 0 to 100; for National Testing in Kyrgyzstan, from 0 to 231; for the Unified State Exam in Moldova, from 15 to 57.

Although the grading system is identical in the three countries, a cross-cultural comparison of academic success on the basis of grades is impossible due to the high degree of subjectivity of school grades and their dependence on the educational achievements of a particular school group (class, school, etc.). At the same time, within the population samples, teacher assessment is acceptable to consider as one of the indicators of academic achievement in the Russian language, along with the results of the state exam.

Differences in Cognitive Development

Using univariate analysis of variance, we estimated differences in processing speed, working memory, and fluid intelligence among the three groups of high school students.

Table 2 summarizes the results of analysis of variance for cognitive indicators. As a categorical factor, the students belonged to the group "Russian speakers from Russia", "Russian speakers from Kyrgyzstan", or "Russian speakers from Moldova".

According to the values of the Levene's variance equality criterion ($p > 0.05$), all distributions of the cognitive variables for the compared groups have the same variances.

Table 2

Results of analysis of variance for indicators of cognitive development

	SS	F	<i>p</i> -value	η^2
Processing speed	0.08	0.89	0.41	0.01
Spatial working memory	48.52	5.13	0.01	0.02
Fluid intelligence	2201.3	31.05	0.00	0.12

Table 2 shows that the effect of belonging to the group “Russian speakers from Russia”, “Russian speakers from Kyrgyzstan”, or “Russian speakers from Moldova” is statistically significant for fluid intelligence and spatial working memory. At the same time, the effect size for the spatial working memory indicator turned out to be insignificant (2%, respectively, at $p < 0.05$). The results of multiple comparisons with the Bonferroni correction revealed differences in spatial working memory only between the students from Russia and those from Kyrgyzstan, in favor of the former (5.43 versus 4.73).

The effect size for fluid intelligence reaches a value of 12% ($p < 0.001$). Multiple comparisons with the Bonferroni correction demonstrated differences between the students from Russia and their peers from Moldova and Kyrgyzstan. Moreover, the best results in the “Standard Progressive Matrices” test are shown by the students in Russia (the average value of the fluid intelligence is 52.17 versus 47.02 and 48.67, respectively). The students from Moldova and Kyrgyzstan differ only at the level of $p = 0.046$, with a slight advantage for Kyrgyz students. The average values of fluid intelligence are presented in Table 1.

Processing speed does not differ among the students studying in Russia, Moldova, or Kyrgyzstan ($p = 0.41$).

Relationships Between Cognitive Development and Success in Learning Russian

Correlation analysis was used to estimate the relationships between cognitive development indicators – processing speed, spatial working memory, and fluid intelligence – and success in learning Russian as measured by the state exams and grades in Russian-language class. Table 3 shows the Spearman correlation coefficients between indicators of cognitive development and success in learning Russian.

Table 3
Results of the correlation analysis of the relationship between indicators of cognitive development and success in learning Russian

	Processing speed	Working memory	Fluid intelligence
State exam	-0.08	0.22**	0.25**
	0.02	0.09	0.33**
	-0.02	0.09	0.19*
Grade	-0.01	0.09	0.30**
	-0.02	0.09	0.15*
	-0.04	0.06	0.03

Note. Upper row – “Russian speakers from Russia”, middle row – “Russian speakers from Kyrgyzstan”, bottom row – “Russian speakers from Moldova”. * $p < 0.05$; ** $p < 0.01$.

Table 3 shows that in the group from Russia, one of the indicators of the success in learning Russian – the state exam score – is moderately correlated with fluid intelligence and spatial working memory. The correlation coefficients between state

exam score and fluid intelligence ($r=0.25$ at $p<0.01$) reach large values. The teacher's assessment correlates only with fluid intelligence ($r=0.30$; $p<0.01$). It should be noted that in the students studying in Russia, none of the success indicators in learning the Russian correlated with processing speed ($p>0.05$).

In the group of students studying in Kyrgyzstan, both measures of the success in learning Russian – state exam score and grade – are moderately correlated with fluid intelligence. Moreover, the score on the state exam is more closely related to fluid intelligence than the annual grade (0.33 ; $p<0.01$ vs. 0.15 ; $p<0.05$). In the sample from Kyrgyzstan, as in the students from Russia, none of the success indicators is statistically significantly related to processing speed ($p>0.05$).

In the group of students in Moldova, among all the indicators of cognitive development and success in learning Russian, only one weak but statistically significant association was found, that between the state exam score and fluid intelligence ($r=0.19$; $p<0.05$).

The relationships between the grade and the state exam score showed that these two indicators are more closely related in the students from Russia ($r=0.68$; $p<0.01$) than in those from Moldova ($r=0.20$; $p<0.05$). In the students from Kyrgyzstan, the correlation coefficient between the state exam score and fluid intelligence is 0.33 ($p<0.01$).

The moderate correlation among cognitive development indicators – processing speed, spatial working memory, and fluid intelligence – were observed in all three students samples ($|0.19|>r>|0.32|$ with $p<0.05$).

The Role of Cognitive Characteristics in Success in Learning Russian

In order to investigate the role of the indicators of cognitive development – the processing speed, spatial working memory, and fluid intelligence – in the success in learning Russian, a multiple regression analysis was performed for the three groups of students. The scores on the state exam and the teacher's assessments were used as dependent variables.

Table 4 summarizes the results of a regression analysis for the state exam score. Regression coefficients are given only for statistically significant predictors of the success of the state exam in the three analyzed groups.

Table 4

Results of the regression analysis of the state exam scores in the analyzed groups of students

Group of Russian-speaking students	adjusted R ²	Significant predictors	β	B (standard error B)	t	p
From Russia	0.08	Fluid intelligence	0.20	0.44 (0.18)	2.30	0.02
From Kyrgyzstan	0.12	Fluid intelligence	0.36	1.56 (0.36)	4.34	0.00
From Moldova	n/s	n/s	n/s	n/s	n/s	n/s

Note. n/s – non-significant

Table 4 shows that a regression analysis revealed differences in the percentage of the explained variance of scores on the state exam in the students from Russia (adjusted $R^2 = 0.08$; $F = 3.00$; $p = 0.02$) and Kyrgyzstan (adjusted $R^2 = 0.12$; $F = 6.87$; $p = 0.000$). It is also noteworthy that there is a lack of significant results of the multiple regression analysis on the sample of students from Moldova ($p > 0.05$).

In the students studying in both Russia and Kyrgyzstan, fluid intelligence is the only cognitive predictor of the state exam result. In particular, in the group of students in Russia, the standardized regression coefficient reaches 0.20 ($p < 0.05$); in the group of students in Kyrgyzstan it reaches 0.36 ($p = 0.000$).

For the assessment of success in learning Russian based on teacher assessment, different results of multiple regression analysis were obtained for the students studying in Russia, Kyrgyzstan, and Moldova. Only in the students from Russia was the variance significant, with 8% of the variance of the scores explained by fluid intelligence (model characteristics: adjusted $R^2 = 0.08$; $F = 4.94$; $p = 0.003$), whereas in the students from Kyrgyzstan and Moldova, the results of multiple regression were statistically insignificant ($p > 0.05$).

Discussion

In the present study, we investigated the cognitive predictors of the success in learning Russian as a native language in various educational environments. The study involved Russian-speaking 11th graders studying throughout their entire period of schooling in Russia, Kyrgyzstan, or Moldova – countries with a similar organization of the educational system, but with different levels of effectiveness in its functioning.

With the analysis of variance, differences in the indicators of cognitive development – information-processing speed, spatial working memory, and fluid intelligence – were studied in the three groups. The greatest cross-cultural differences were obtained for fluid intelligence, with the best values for the students in Russia. The results of multiple comparisons with the Bonferroni correction showed the differences between those in Russia and their peers in both Moldova and Kyrgyzstan. The students from Moldova and Kyrgyzstan differ from each other only at the level of $p = 0.046$, with a slight advantage for students from Kyrgyzstan. These results are consistent with data reported in the literature (e.g., Nisbett et al., 2012), in that they indicate a more significant effect of the quality of the educational process on fluid intelligence, measured by the “Standard Progressive Matrices” test, in comparison with the other indicators of cognitive development. It was also reported that cross-cultural differences in fluid intelligence reach their maximum at primary school age, which is explained by large differences in the availability and quality of preschool education, and at the full level of general education, when children are selected to continue their schooling (Tikhomirova & Malykh, 2017).

The smallest, but statistically significant, cross-cultural differences were found for spatial working memory. Multiple comparisons showed differences in working memory only between the students from Russia and Kyrgyzstan, in favor of the former. This result contradicts the data on the absence of significant differences in spatial working memory in a sample of Russian and Kyrgyz high school students (Grades 10–11; $p = 0.07$; Tikhomirova & Malykh, 2017), which can be explained by

the slightly different age characteristics of the sample in the present study (only students in Grade 11). At the same time, in a number of studies of Russian schoolchildren, cross-cultural differences are reported for indicators of visual-spatial working memory (e.g., Tikhomirova, Malykh, Tosto, & Kovas, 2014).

Thus, the fluid intelligence of 11th graders, which is directly proportional to the quality of education in the country, is most closely related to the effectiveness of the national educational system; to a lesser extent, it is related to the development of spatial working memory. Processing speed does not differ among the 11th graders in national educational systems with different levels of effectiveness: those of Russia, Kyrgyzstan, and Moldova.

Correlation analysis revealed that the specific relationship between the cognitive indicators and the state exam score has a cross-cultural character. In particular, in Kyrgyzstan (average level of socioeconomic development) and Moldovan Tiraspol (low level of socioeconomic development), only fluid intelligence is correlated with the result of the state exam on the Russian language. In Russia, with a very high level of development, spatial working memory becomes important, along with fluid intelligence.

The specific goals of the state exams in Russia, Moldova, and Kyrgyzstan, and, as a consequence, their content, could explain these cross-cultural differences. Thus, the National Testing of high school students in Kyrgyzstan is aimed, first of all, at identifying the most capable students, regardless of the quality of their education in a particular school. The Unified State Exam in Russia is aimed at checking the level of knowledge acquired during the educational process, which can actualize the role of working memory. However, the result of the state exam on the Russian language in Moldova (Tiraspol, in the unrecognized Transnistrian Moldavian Republic), designed according to the model of the Russian exam, is not correlated with spatial working memory ($p > 0.01$), which may be due to the low effectiveness of the educational system in this region.

The content of state exams can apparently explain the relationships between the teacher's assessment and the score on the state exam on the Russian language in the groups studied. These two indicators of success in learning Russian are closely related in the group of students from Russia, moderately related in the students from Kyrgyzstan, and weakly related in the students from Moldova.

Regression analysis revealed differences between the percentage of the explained variance of scores on the state exam on the Russian language in the students from Russia (adjusted $R^2 = 0.08$; $F = 3.00$; $p = 0.02$) and from Kyrgyzstan (adjusted $R^2 = 0.12$; $F = 6.87$; $p = 0.000$). These differences may be related both to the content of the state exam in Russia (assessment of the level of knowledge acquired at school) and Kyrgyzstan (identification of graduates capable of university study), as well as to a greater cognitive load for the exam in conditions of low learning effectiveness. Moreover, regardless of the national socioeconomic level, fluid intelligence is a universal statistically significant predictor of students' success in the state exam on the Russian language ($0.20 < \beta < 0.36$; $p = 0.000$). The central role of intelligence for academic success has been emphasized in a number of studies performed on samples of schoolchildren from different European countries and the USA (e.g., Rinderman & Neubauer, 2004).

The lack of significant results of multiple regression analysis on the group of 11th graders studying in Moldova may be due to the specificity of the state exam and the degree to which it matches the content of Russian-language education in the city of Tiraspol.

With respect to teacher assessment, different results of multiple regression analysis were obtained for the groups in Russia, Kyrgyzstan, and Moldova. In the students from Russia, 8% of the variance in improvement as measured by the teacher's assessment was explained by fluid intelligence (model characteristics: adjusted $R^2 = 0.08$; $F = 4.94$; $p = 0.003$). In Kyrgyzstan and Moldova, the results of multiple regression were statistically insignificant ($p > 0.05$). This result indicates the possible use of a variety of cognitive and other (e.g., emotional and motivational) resources when performing various tasks, to determine success in learning.

It should be emphasized that in the analyzed samples, a small percentage of the variance of the indicators of success in language learning was explained by cognitive characteristics – from 8% to 13%. This result is consistent with evidence that greater heterogeneity and less effective educational environments result in lower contribution of the cognitive performance in the educational achievement (Tucker-Drob & Bates, 2016).

Conclusion

Among the indicators of cognitive development we analyzed, the fluid intelligence of 11th graders, which is directly proportional to the quality of education in the country, is most closely associated with the effectiveness of the national educational system; to a lesser extent, it is also associated with spatial working memory. Processing speed did not differ among the 11th graders in the three national educational systems with their different levels of functional effectiveness.

The present study showed the cross-cultural specificity of relationships of fluid intelligence, spatial working memory, processing speed, and in success in learning Russian based on the state exam grade. In more favorable educational conditions for successful completion of the state exam, working memory also plays an important role, along with fluid intelligence.

Further research may be directed to understanding the cognitive mechanisms of learning Russian as second language in national educational systems with different levels of functional effectiveness.

Limitations

The lack of statistically significant results from a regression analysis on a sample of students from Moldova confirms the need to include an additional number of Russian-speaking 11th graders studying in Russian from other regions of Moldova.

Acknowledgements

The research was supported by the Russian Foundation for Basic Research (Project No. 17-29-09147).

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Original manuscript received September 13, 2019

Revised manuscript accepted January 16, 2020

First published online June 15, 2020

To cite this article: Verbitskaya, L.A., Zinchenko, Y.P., Malykh, S.B., Gaidamashko, I.V., Kalmyk, O.A., Tikhomirova, T.N. (2020). Cognitive Predictors of Success in Learning Russian Among Native Speakers of High School Age in Different Educational Systems. *Psychology in Russia: State of the Art*, 13(2), 2–15. DOI: 10.11621/pir.2020.0201

Cognitive Processes and Personality Traits in Virtual Reality Educational and Training

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Background. Virtual reality (VR) is designed to provide a person's contact with informational reality. VR technology is an effective tool for solving a whole class of economic problems, when it is cheaper and safer to carry out preliminary tests in virtual technology than in reality. In psychology, sociology, and pedagogy, virtual reality technologies provide the ability to model complex social objects (not just stimuli, irritants).

Objective. In our study we explored the influence which virtual reality has on cognitive processes and personality characteristics. The study analyzes the influence of educational VR programs on cognitive processes and a number of personal characteristics.

Results. Laboratory experiments show that short-term work in the educational VR (created as a study of complex topics in Biology and Geometry) positively affects cognition and thinking. VR-programs improve traditional parameters of figurative short-term memory, observation and generalization. Students in the control group had significantly lower values. In fact, the technologies designed in the VR do not affect the basic personal structures, rather they only influence the functional personality characteristics.

Conclusion. Short-term work in the educational VR positively affects the development of knowledge, thinking, memory, observation and attention span, as well as increasing field independence. The work of a person with training and educational programs in the virtual reality does not cause any alteration of the basic personal traits. Our result justifies the use of VR for educational purposes and professional training.

Keywords:
Virtual reality (VR); changes of cognitive processes; personality; thinking

Introduction

Currently, whenever the efficiency of science and technology plays a role in the balanced development of a country (Huan, 2017), virtual reality technology is being used extensively. VR technology is effective for the resolution of current tasks in social research from the perspective of the postnonclassical approach (Zinchenko et al., 2015). The influence of virtual reality (VR) on cognitive processes and personality traits has become a reality for modern psychological and pedagogical science, and social work. The research we present here is generally aimed at elucidating and describing the basic changes which occur in cognitive processes (primarily thinking and memory) under the influence of virtual reality.

Virtual reality is defined as high-tech products characterized by three-dimensional images of objects, animations, and interactivity functions, which are immersive by their nature. The authors share K. Murray's philosophical interpretation of virtual reality, which looks similar to the world of ideas described by Plato. K. Murray defined those ideas as a combination of pure entities, *i.e.*, extremely generalized, invariant properties of objects (Murray, 2000). The real, visible human world is the shadow of the world of ideas. Virtual objects have slightly different properties than natural things. For example, a VR-house cannot be ruined, burnt, or flooded unless the researcher programmed in these properties.

The present research interprets the essence of the virtual reality in a traditional cybernetic sense, which in turn determines its following basic characteristics: 1) creation of digital three-dimensional images imitating real objects; 2) animation opportunities; 3) network real-time data processing; and 4) the presence effect (the co-experience illusion a person might have in the artificial digital reality while interacting with objects or subjects) (Lombard & Ditton, 1997).

On the whole, virtual reality can be treated as a technology of man-machine interaction, which enables the users to immerse themselves in the 3-D interactive information environment. Virtual reality technologies are actively used in the study of visual illusions (Menshikova, 2013a, Menshikova, 2013b); parameters of the vestibular apparatus (Menshikova et al., 2017); research on the presence effect (Velichkovsky et al., 2016); and social research, including investigation of ethnic attitudes (Menshikova et al., 2018). Such research is carried out at the Faculty of Psychology of Moscow State University, including using the virtual reality room (CAVE). Virtual reality technologies are widely used in psychotherapy, counseling, and psycho-correction in Europe and the United States.

In 2008 the International Association of Cyber Therapy and Rehabilitation (founded in Brussels, Belgium), published the *Cyber Therapy & Rehabilitation* journal (Voiskynsky, 2010, p. 203). The research they published proved virtual therapy to be efficient in helping people get over or reduce fear, anxiety, and phobias (Hodges et al., 2001; Riva, 2005; Rothbaum et al., 1990; Seliskya et al., 2004; Selivanov, 2015; 2016; Slater et al., 2016), especially with the use of an avatar (an avatar is defined as a VR object controlled by a person who identifies him or herself with it) (Meyerbroecker et al., 2008; Riva, 2008). Combined cognitive-motor rehabilitation in virtual reality also leads to more successful elimination of cognitive and motor deficits after a stroke (Faria et al., 2018).

The following two psycho-therapeutic training programs were designed for adults under the authors' guidance: "Getting over nyctophobia" (fear of darkness), and "Getting over claustrophobia" (fear of confined spaces). Each program has a frame-by-frame scenario that can be edited according to the reliability of each particular case's ecological and educational requirements. All the elements are put together on the "Unity" platform; the final variant has a male avatar (Fig. 3).



Figure 3. A screenshot from the program "Getting over nyctophobia". The subject under an avatar is placed in the room with a 5% shadow.

In the creation of VR-programs we used dynamic and static lighting, a particle system, dynamic cameras of various formats, and high-resolution textures. At first, most of the experiments were carried out with the help of ordinary 3D monitors, or with the VR Z800 3DVisor headset (eMagin), which displays with a resolution of 800×600 pixels; a field of view of 60×40 degrees was used for all cases.

As in most experimental series, a laboratory experiment (with a simple experimental plan for three independent variables) was used.

Study Designs

The Impact of Educational VR Experience on the Retention of Auditory Material

Subjects. The study included high school students in 10th grade (public high schools № 26 and 29, Smolensk, Russia), ages 16–18 (105 people); 46 were male, and 59 were female. They were divided into two groups: an experimental group of 50 students, and a control group of 55 students. The groups were equal in age and sex ratio.

Before viewing the educational VR program, the subjects were tested in Geometry and the following parameters were measured: the volume of short-term figurative, symbolic memory; the stability and shifting of attention; the ability to make generalizations; and field dependence/independence (cognitive style). After viewing the program, they were tested again with another test of a similar difficulty and their parameters were measured again. This stage also included diagnosing their thinking dynamics (changes in operations or intellectual actions) and processes (such as analysis, synthesis, and generalization). The dynamics of their cognitive activity were defined with the help of micro-semantic analysis of their reports.

The experiment included a control group, which worked with a teacher on the same Geometry as in the VR program. The control group subjects were tested in the same way as the experimental group.

The Impact of Educational VR Experience on Cognitive Processes

Subjects. The experimental group included 25 adults, intellectually advanced (studying or having a university degree), ages 20–50, of which 12 were males and 13 females. The control group was comprised of 23 adults, 10 males and 13 females, all of whom specialized in subjects other than biology.

The test subjects were administered the classical psychological test on memorizing 12 images, 12 numbers, and numerical sequences before and after the viewing of the educational program in Biology “Protein synthesis.”

Other cognitive processes were also analyzed during the study: changes in cognitive functions were studied with the help of the modified digital Shulte Table (switching of attention); the Bourdon-Anfimov proof test (the measurement of attention stability and concentration); exception of concepts and identification of the similarity to a concept (the ability to make generalizations and classifications; the test on finding general (common) concepts, including 20 sets of five words for finding the similarity to a concept; exclusion of concepts (17 sets of 5 words to exclude the odd one), etc.

Individual differences in cognition included the cognitive style characteristics of field dependence/independence (Witkin, et al., 1977; Witkin, et al., 1974) (EFT (Embedded Figures Test, H. Witkin).

VR in Phobias Treatment

Subjects. The study included young adults ages 21–55 (37 people), either in the university or with a university degree, who requested assistance at the Social and Psychological Center (Smolensk, Russia). The majority of them suffered from certain fears and phobias, or had suffered from phobias in the past, which they had overcome (19 people). The group consisted of 30 men (81%) and 7 women (19%), since the training programs were created with male avatars.

Each subject took a Spielberg-Khanin test several days before and after their VR experience to overcome a certain phobia. Their personal and reactive anxiety were then evaluated. The indices of self-evaluation of reactive and personal anxiety were treated as dependent variables, whereas parameters of the subjects’ work with the VR-training programs were considered to be instructive independent variables.

The experiment included a control group treated in a conventional way.

Ethical Statement

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki of 1975, revised in 2013. All participants were over 18 years old and gave their written consent to take part in the experiments with VR-headsets.

Statistical Analysis

Mann-Whitney and Kramer-Welch tests were used to find the differences between the experimental and control groups.

Statistical processing of the results was performed in STATISTICA 6.0, SPSS11v11.0.1 and included correlation analysis.

Results

The Impact of Educational VR Experience on the Retention of Auditory Material

The dependent variable was the actualization level of the students’ knowledge in Mathematics (e.g., in solving mathematical problems); independent variables were the parameters of VR. At the beginning of the experiment, both groups were tested in Mathematics (10 problems test). Then one group of students was offered the opportunity to work with a VR educational program (in a computer lab), while the other group of students studied the topic with a teacher, without the use of any virtual program. After the class, both groups took Mathematics tests with two tasks, the content of which was related to the studied topic. The chosen topic was the application of the “Three perpendiculars theorem” of solid geometry. The results are summarized in Fig. 4.

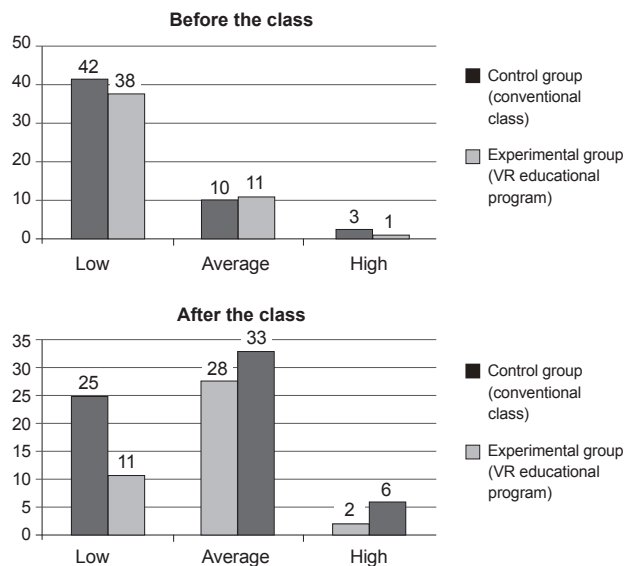


Figure 4. Test results in Mathematics (Geometry). Note. The histogram illustrates the results of the mathematics tests taken before and after the class with and without VR educational program

The application of the “Three perpendiculars theorem” VR-educational program in Geometry had the following results. According to P.A. Pobokin’s data in a study carried out under our guidance, the parameters of the students’ performance

increased on average to 1.5 times the original score. The calculated empirical value of Student's t-criterion ($t = 11.747$) appeared to be larger than the critical Student's t-criterion ($t = 2.05$), which indicates the reliability of the improvement in the number of correct answers after the use of virtual mathematical program ($p = 0.05$). According to the homogeneity criterion χ^2 , three levels of knowledge development were distinguished: 1) $L = 3$; 2) $L - 1 = 2$; and therefore 3) $\times 2cr(2; 0.05) = 5.99$. Since $x_{2emp} = 7.63 > \times 2cr(2; 0.05) = 5.99$, the reliability of differences in the test results between pupils using the virtual program and those having the teacher explain the topic, is 95% (significance level $p \leq 0.05$).

The initial test results of both the experimental and control groups were the same (Student's T-test and Chi-square test, $p \leq 0.05$). The final test results of the students after the use of the virtual program, and the test results of the students after the teacher explained the topic, were different, as measured by the Student's T-test ($Temp = 11.74 > Tcrit = 2.05$); the Mann-Whitney test ($Wemp = 3.025 > Wcrit = 1.96$); and the Kramer-Welch tests ($Wemp = 3.22 > Wcrit = 1.96$), $p \leq 0.05$). The average test score in the control group was 4.8, whereas the average results of those students who had worked with the VR program was 5.72. The application of the VR educational program in Geometry thus increased the parameters of the students' performance on average to 1.5 times the original score (from 3.78 to 5.72), while the control group's learning experience went up to 1.2 times (from 3.96 to 4.8). The size of the effect for the control sample is $d_{cont.} = 0.60$; for the experimental, $-d_{exp.} = 1.29$ (Cohen's d, J. Cohen index).

Since all three statistical criteria (Mann-Whitney, Kramer-Welch, and chi uniformity) rejected the main hypothesis (H_0) at a significance level of $p \leq 0.05$, and d (Cohen's d) is ex-large, it can be argued that empirical differences do exist. Therefore, the effect of changes in the results is caused by the use of a virtual program. The study subjects expanded the search zone of correct answers, and increased their semantic links.

It should also be noted that, after the application of the VR educational program, the number of students giving 6-8 correct answers out of 10 rose dramatically. There were also a small number of students who gave nine correct answers out of 10. Similar data were previously obtained with the use of VR programs in education (Pobokin, 2014; 2015 a, b).

The Impact of Educational VR Experience on Cognitive Processes

The test subjects in this experiment took a classical psychological test on the memorizing of images, numbers, and numerical sequences before the learning experience. After viewing the educational VR-program in Biology "Protein synthesis" (duration 11–20 min), the test subjects took the tests again. The adults in the control sample read a biology textbook for a secondary school on the topic "Protein Synthesis" for 20 minutes and were tested both before and after reading the material.

The VR educational programs had a considerable positive influence on the volume of short-term figurative memory (the difference of average indices was 1.96 in the experimental group, and 0.5 in the control group; the symbolic memory (memorizing numbers), and short-memory volume were less influenced (the

differences of average indices were 0.08 and 0.28. In the control group they were 0.04 and 0.09).

Other cognitive processes were also analyzed during the study: changes in cognitive functions were diagnosed with the help of the modified digital Shulte Table (switching of attention); the Bourdon-Anfimov proof test (the measurement of attention stability and concentration); the exception of concepts and identification of the similarities between concepts (study of generalizations), etc.

The VR educational program had a considerable influence on the powers of observation (in the differences detection test, the difference in average indices was 1.4, as compared to 0.8 in the control group); attention stability and concentration (test Bourdon-Anfimov); and the ability to make generalizations and classifications (finding general (common) concepts, exclusion of concepts). The difference of average indices before and after the viewing of the VR program was 1.8; in the control group it was 1.1. The effect size for the control sample is $d_{\text{cont.}} = 0.30$; for the experimental, $d_{\text{exp.}} = 0.9$ (Cohen's d , J . Cohen index). Significant changes in all indicators have occurred after using the virtual program (the Wilcoxon criterion: $W_{\text{emp}} = 26$, with $W_{\text{crit}} = 37$, $W_{\text{emp}} < W_{\text{crit}}$, $p \leq 0.01$).

The decrease of parameters was only observed during the general switching of attention (modified digital Shulte Table): the average time of task solving increased from 136.4 sec. up to 158.2 sec., remaining at the average level of switching. Individual differences of cognition included the characteristics of cognitive style. VR programs caused a significant increase in field independence; the average time needed for solving tasks decreased from 42.3 sec. to 18.7 sec.; in control group it went from 48.1 sec. to 40.02 sec.

Therefore, similar results were received after the application of the VR educational programs in both Geometry and Biology. Changes in the scores on Geometry (Biology) tests in the control sample, which used conventional education methods, were in the range of 10-15%. The results show that the VR educational programs improved students' performance (for the students with a low performance the increases were 40-50%; for high performers it was several times more than 100%).

The Impact of Training VR Experience in Treatment of Phobias

Participants were introduced to a VR experience of a dark or confined place depending on their phobia. The interconnection between the virtual images and personality was analyzed with the help of MMPI both before and after the work in the VR. The subjects' anxiety levels (reactive and personal anxiety) were measured by the Spielberg-Khanin test (the State-Trait Anxiety Inventory) several days before and after the VR training program to overcome a certain phobia.

There were no significant alterations in the basic personal traits evaluated with the short MMPI version. The secondary diagnostics results of the personal characteristics also showed that no significant changes occurred. Thus the VR training programs did not have a significant influence on the basic personality traits (the Wilcoxon criterion: $W_{\text{emp}} = 4$, with $W_{\text{crit}} = 1$, $W_{\text{emp}} > W_{\text{crit}}$, $p \leq 0.01$).

The alteration of the anxiety level was based on average values. During the primary diagnostics, the subjects had the average of reactive anxiety of 54.3 and personal anxiety of 56. During the secondary diagnostics, the reactive anxiety was 36 and personal anxiety was 52. Consequently, significant changes occurred (the

Wilcoxon criterion $W_{emp} = 11$, with $W_{crit} = 27$, $W_{emp} < W_{crit}$, $p \leq 0.01$) for the experimental sample, while no significant changes were observed in the control sample (the Wilcoxon criterion: $W_{emp} = 17$, with $W_{crit} = 3$, $W_{emp} > W_{crit}$, $p \leq 0.01$). The effect size for the control sample is $d_{cont.} = 0.2$; for experimental, $d_{exp.} = 0.98$ (Cohen's d , J. Cohen index).

The VR activity performed under an avatar and targeted at overcoming fears dramatically decreased the subjects' reactive anxiety, while there was practically no alteration of personal anxiety. Reactive anxiety is considered to be a situational, functional, and personal characteristic, which reflects general overstrain, worrying, and nervousness. Personal anxiety is connected with more stable characteristics, which make a person perceive a wider circle of situations as threatening, which results in turn in the manifestation of anxiety. It is probable that the short-term immersion into the VR environment primarily affected the degree of reactive anxiety, lowering its indices from high to moderate values. However, not all the subjects had such low indices; the average value decreased by 1.5 (for more, see Selivanov, V.V. (Ed.), 2016).

Our results correlate with the data gathered in the United States and Israel on the decrease of different kinds of anxiety after a short-term application of virtual programs, which helped to overcome the fear of public speaking (Harris et al., 2002; Wallach et al., 2006).

Discussion

There is little question but that VR educational programs have some influence on a person. At the same time this situation is rather problematic since the possibility of their further application depends directly on the degree of influence the VR exerts on cognitive processes and personality properties. Nowadays there are some publications which support the use of VR technologies for educational purposes, without proper discussion of their effect.

VR training programs are treated with some suspicion because they are often associated with some special world which *withdraws* the person from the present reality, causes virtual dependence, etc. Among the negative effects which accompany VR are the presence effect (McLellan, 1996; Lombard, & Ditton., 1997); the Proteus effect (Yee et al., 2009); virtual ego-dissolution (Metzinger, 2018); the immersion effect, etc. These effects result from constant surfing the virtual worlds, where a user can spend more than 20 hours per week using avatars. Modern Internet and computer games content already contains elements of VR, in particular, an immersive environment with avatars (including games like Call of Duty, World of Warcraft, League of Legends, etc.). The problem of minimizing the high-risk internet behaviors, which in adolescence are associated with styles of parental control like supervision (condoning) (Álvarez-García et al., 2018), is posed. The present study has been devoted to VR educational functions when they are used for a short period of time without any avatars in the educational programs (the avatar was used in the training program).

Why does education organized with the adequate use of VR turn out to be such effective educational environment? Probably, as the research shows, it is because

the VR performs three main functions: it can be a method, means and technology of education (Selivanov, & Selivanova, 2014). Apart from this, VR has three basic mechanisms which stimulate the development of cognitive processes.

The first mechanism is connected with a percept (super-image) created in the virtual environment: its holographic, distinct character constructs personal mental images in perception and memory, as well as a figurative plan for thinking (necessary for symbolic modeling).

The second mechanism is based on the VR animation opportunities (performing a wide range of actions with virtual objects). It thus stimulates the intensive development of a perception plan, memory, and thinking (it is combined with the structural plan). Some studies emphasize the importance of hand gestures for virtual education (in modern VR-education content where the hand is a VR-controller) (Johnson-Glenberg, 2018).

The third mechanism is based on the presence effect in VR, which encourages the development of specific cognitive motivation of a person, and creates the motivational plan of perception, memory, and thinking. These basic mechanisms are key elements of training programs.

Conclusion

Short-term work in educational VR positively affects the development of knowledge, thinking, and other cognitive processes. VR educational programs stimulate personal, procedural, and operational mechanisms of thinking, which result in the higher student performance. VR-programs improve traditional parameters of figurative short-term memory, observation, stability and attention span, and generalization and classification; they also increase field independence (cognitive style). The educational virtual environment causes a decrease in traditional switching of attention parameters.

However, the use of the VR educational programs may also cause some negative effects, such as a “super-figurative,” visual presentation of educational information that can reduce the development of abstract concepts and symbolic thinking.

The work with training and educational programs in VR does not affect a person’s basic personality characteristics (the indices on the main MMPI scales). At the same time the application of VR training programs designed to trigger personal alterations have a great influence on the modification of the functional personal properties, such as reactive anxiety.

Limitations

The present investigations are aimed at identifying the most common laws of influence of short-term programs in VR on cognitive processes and personal characteristics. Young, mentally healthy people involved in learning participated in the experiments. In the future, it may be possible to obtain slightly different data by expanding the sample and increasing the time spent in VR.

Author Contributions. Conceptualization, Methodology, Writing – Original Draft Preparation, Experiments, Funding Acquisition, V.S.; Writing – Review &

Editing, Data Curation, Supervision, L.S., N.B.; Didactic Correction of Scenarios of VR-programs, L.S.; Conducting experiments, L.S., N.B.; Ecological Verification of Program Scenarios, N.B.

Acknowledgements

The present research is an assignment of the RF Ministry of Science and Higher Education for 2020-2023.

The authors thank software developer V.P. Titov for the creation of the educational and training software products in VR; the associate professor P.A. Pobokin for the scenarios of VR programs in Geometry; and the teacher P.V. Sorochinsky for the scenarios of VR-programs in Biology.

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Original manuscript received April 23, 2019
Revised manuscript accepted January 20, 2020
First published online June 15, 2020

To cite this article: Selivanov, V.V., Selivanova, L.N., Babieva, N.S. Cognitive Processes and Personality Traits in Virtual Reality Educational and Training. *Psychology in Russia: State of the Art*, 13(2), 16–28. DOI: 10.11621/pir.2020.0202

How Do Primary Schoolchildren Use Concept Definitions in Recognition Tasks? Orientation Towards Given Knowledge in Two Different Educational Systems

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Introduction The need to develop students' ability to learn independently has been a widely discussed issue in the theory and practice of education over the past 50 years (in research on learning to learn, self-regulated learning, metacognitive learning, etc.). If we understand instruction as a system of activities by the student and teacher, associated primarily with the transmission of cultural experience, then studying the psychological mechanism for accepting and using the proffered knowledge as an orientation for future actions is highly relevant.

Objective. We surmised that the ability to use given knowledge in the school instruction process (which we call "orientation towards given knowledge" [OGK]) would differ between fourth-graders studying in traditional educational systems (TE) and those in Developmental Education (DE), since these systems differ significantly in the principles of the selection learning material and organization of learning activity. We also sought to clarify the correlation between OGK and such important educational outcomes as the ability to identify the most important thing in a text, logical skills, memorization skills, and academic achievement.

Design. To diagnose OGK, we gave fourth-graders (N = 115) the definition of a concept, an instruction to recognize and identify objects as either being described or not described by that concept, and 10 recognition problems in the form of short texts. We assessed the level of OGK by counting the number of problems for which the answer was justified by the given definition. In addition, we measured the ability to identify the main point in the text, logical skills, and random memorization skills.

Results. Almost a quarter of all the fourth-graders (25.7%) failed to use the given definition at all; however, the DE students demonstrated a higher level of OGK ($U = 2038$, $p < .01$) significantly more often. OGK among general sample also correlated with the ability to identify the most important thing in a text ($R = 0.31$, $p < .001$), logical skills ($R = +0.35$, $p < .001$), and memorization skills ($R = +0.195$, $p < .05$ for short-term memory and $R = +0.301$, $p < .01$ for long-term memory).

Conclusions. Possible reasons for the cognitive performance of the fourth-graders are discussed. We argue that orientation towards given knowledge can be considered an essential condition for effective learning, and therefore serious attention should be paid to its development.

Keywords:

Activity approach, Developmental Education, action, recognition action, orientation towards given knowledge

Introduction

The problem of students not applying the knowledge they have gained to solving problems is one of the key ones in pedagogical psychology and educational practice (Barnett & Ceci, 2002; Vosniadou, 2013; Zukerman & Ermakova, 2004).

In Bloom's widely known taxonomy of learning tasks (1956), which was revised by L. Anderson and D. Krathwohl (Anderson & Krathwohl, 2001), the authors describe six educational goals that the teacher should achieve: to remember, to understand, to apply, to analyze, to evaluate, and to create. The student must first remember and understand, and only after that learn to apply this "knowledge" to solving problems. The teacher's task in the first two grades is to ensure the "acquisition of knowledge" as such, whereas how it can be used, how the limits of its applicability can be analyzed and evaluated, serves only in an explanation of the role that the acquisition of knowledge should play in the next stages of the learning process.

In the Activity Approach to the learning process developed in Russian psychology and based on L.S. Vygotsky's ideas (Vygotsky, 1978; Leontiev, 2005; Gal'perin, 1989; Talyzina, 1975) a fundamentally different approach has been proposed to how given knowledge mediates problem solving. The main ideas of this approach were implemented in real educational practice, known as Developmental Education system, which emerged in the Soviet Union more than 60 years ago (Davydov, 1996, 1995; Zukerman & Venger, 2010). How does this system work?

The Activity Approach to Applying Given Knowledge to Problem Solving

In Russian, the word "knowledge" (*znanie*) has two different meanings. There is knowledge considered as information that must be acquired through sociocultural experience, and knowledge that is the result of individual experience of an activity. We will use this term in the first sense: knowledge as a social and cultural experience that has to be learned. This distinction is described by L. Radford (2013), who suggested a clear difference between knowledge and knowing: Knowledge is a "historically and culturally codified fluid form of thinking and doing," which exists independently of the individual mind. But real knowledge ("knowing") is only real if it is the result of one's own activity (Radford, 2013, p. 16).

The Russian philosopher E.V. Ilyenkov (1991), addressing the differences between given knowledge and knowledge "possessed by the subject," writes: "[T]here is a serious reason to think that the very problem they are trying to solve in this way arises only because the 'knowledge' is given to a person in an inadequate form, or, to put it more crudely, is not real knowledge, but merely a surrogate..." (Ilyenkov, 1991, p. 381).

But what can be considered an adequate form of given knowledge in this case? According to the Activity Approach, developed in Russian psychology in the general framework of cultural-historical consideration of the psychological mechanisms of acquisition of knowledge, we should begin with an analysis of actions rather than of knowledge. It is important to choose actions in which the proffered knowledge can assume the role of a cultural mediator (in L.S. Vygotsky's terminology; see, e.g., Vygotsky, 1978) – i.e., the way of performing these *actions* will *necessarily* include the given knowledge as a component. What is *action* and how does it

relate to knowledge obtained from a textbook, from the words of the teacher, and other sources?

Action [Russian: *deistvie*], according to P.Ya. Gal'perin (1989), is the leading component of the educational process: "For students, the learning process is a continuous sequence of actions: listening and understanding (the teacher's instructions and explanations), reading and writing, counting, adding and subtracting, performing grammatical, mathematic, and historical analyses, etc.); these are all different actions: intellectual, perceptual, verbal, and physical" (Gal'perin, 1989, p. 65). There is no precise English translation of the Russian term *deistvie*; it can be most closely translated as a purposeful action that leads to the solution to the particular problem.

Another component of the educational process are concepts that must be acquired through action or as part of different actions (Gal'perin, 1989). Gal'perin distinguishes between the content of concepts (mathematical, linguistic, etc.) and their psychological role in an action.

He states that from the psychological standpoint, we can speak of three components of any action: orienting (developing a goal, a plan for implementation, and tools for checking the results), executing, and controlling (Gal'perin, 1966). The main component of the orienting part is the **orientation basis of action (OBA)**, which is what the subject actually focuses on when performing the action. OBA also includes an understanding of the goal (object) of an action, the sequence in which it is implemented, as well as the characteristics of the material (if it is physical action), the tools used, and much more (Gal'perin, 1989). Moreover, the actual OBA may contain significant discrepancies from the cultural norm associated with "given knowledge", making it possible to solve problems in this subject area without errors.

The task of any student is to achieve an OBA that will allow an independent solution of the specific problems presented. Cultural content is conveyed in school by educational texts, including presentations by the teacher, which contain definitions of the necessary concepts and other educational information "provided for the acquisition of knowledge". Most students do not have much success in extracting from these sources the points of orientation that are objectively necessary to grasp a concept (understanding the way its content can orient their own actions).

Gal'perin did not consider it promising to study how concepts are formed spontaneously. In his view, the genesis of mental processes (actions and concepts) should be that of systematic and stage-by-stage formation of mental actions and concepts (Gal'perin, 1966), by means of which, through creating conditions for actions of the necessary quality, we simultaneously clarify those conditions. One of the most important is the teacher's ability to choose a learning method that forms the first, second, or third type of orienting basis of action. In fact, only the second and third types of instruction promote the formation of knowledge as an orientation of action. What are these types?

The **first type of OBA** is mainly characterized by students' use of trial and error to orient their own actions. In the search for points of orientation, students may use completely different aspects of the learning situation (the teacher's explanation as coming from a "knowledgeable" person; demonstration of a model for solving spe-

cific problems; description rather than definition of objects that are grouped into a concept; demonstration of a set of objects for independent comparison and identification of “essential” attributes, etc.). The student’s gradually developing OBA usually contains some attributes that are insignificant for the particular concept, unsuitable for solving this class of problems, operations, etc. For example, if the teacher suggests to students only the *definition* of “perpendicular lines”, and then gives them problems that require the *recognition* of perpendicular lines (actions of recognition), the students will have to independently find a way to perform such actions. N.F. Talyzina (Talyzina, 1975) distinguished three operations in the action of recognition: (a) identification of attributes (if a definition is given, the attributes have to be “extracted” from it); (b) identification of their presence (or absence) in each object presented; (c) a conclusion about whether an object belongs or does not belong to this class of objects, according to a logical rule.

First of all, students should select the relevant characteristics of the perpendicular lines from the definition: (a) two lines (in fact, two characteristics – they should be lines and there should be two of them); (b) both should be straight; (c) the angle between them should equal 90 degrees. Secondly, students need to be able to identify each characteristic in the objects presented to them, and, finally, to draw a conclusion (are they perpendicular lines or not, or do we need more information?), using a logical rule. Most children have a hard time doing all this independently, so their OBA is incomplete and very concrete.

In their classic article, Gal’perin and Talyzina (1957) criticized the practice of using of the first type of OBA and proposed another method of teaching, which makes it possible to provide the student with the means and methods of action of an appropriate quality and to make the given knowledge a real point of orientation for future actions. First of all, the authors contend that the definition of objects related to the concept, unlike their description, should be appropriately “operationalized”. This means that it should include attributes that can be used to establish their presence or absence in each object, when a student performs an “action of recognition”.

Such instruction, which results in the **second type of OBA**, gives the students a complete system of points of orientation and operations within the required class of tasks, in a finished form, as a “method of action”. Searching for them independently, by trial and error, is therefore not a relevant task for the student. The teacher’s task is to encourage the use of a given set of operations and their points of orientation for solving *every* task. This makes the proposed method a real instrument for executing an action under specific conditions, while variations in the types of problems make it possible to test the method under different conditions (and thereby to make it a real point of orientation).

Development of actions according to the **third type of OBA**, in turn, makes it possible to arm students with a “method of analysis” of the objective situation, so as to independently construct a way to solve the problem under the given changing, specific conditions (Gal’perin, 1966; Davydov, 1996; Ilyenkov, 1991). Instruction by this general method is a special action of educational research, as a result of which students should establish for themselves an objective connection between the given knowledge and its orienting content. The “generation” of such knowledge through action should be constructed on the basis of special “logical-genetic” reconstruc-

tion of the process by which a concept emerges (Davydov, 1996). This makes it possible to set tasks not only for qualitative mastery, but also for development of conceptual thinking, as the student and teacher move forward together through the subject matter.

Thus, in the Activity Approach, the main question is not what “methodological techniques” may be taught, to apply already “mastered” knowledge in practice, but rather how to find the necessary actions (since by no means all actions to which the given knowledge *might* be applied are suitable), how to implement them in educational practice, how to make the given knowledge a real point of orientation and means toward these actions from the outset – i.e., how to encourage students to use that knowledge and how to ensure their mastery or interiorization of these actions (Gal’perin, 1966).

The Concept of “Orientation Towards Given Knowledge” (OGK)

Gal’perin addresses the study of the psychological mechanisms of learning: “The construction of a process with certain properties that are possible only under certain conditions, allows us to find out these conditions. This constitutes the main, or, rather, the leading, method of studying these psychological phenomena. Only later, when the way to achieve this has been established, does the possibility arise of analysis and assessment of real phenomena” (Gal’perin, 1998, p. 288). In our view, the general mechanisms of analysis and assessment of real phenomena were not fully established by Gal’perin and the Activity Approach, and his method of systematic stage-by-stage formation made it possible to determine only *specific* conditions of the formation of *specific* subject-specific actions (see Sidneva, 2016). For example, the general principles of the formation of new concepts and actions did not become a real tool for assessing the effectiveness of different educational practices, although attempts to do this are being made (Stepanova, 2005; Lvovsky et al., 2015).

One of the conditions identified by Gal’perin as key for effective instruction is the relationship to given knowledge as an orientation for action. The student’s ability to grasp educational information in its orientation function is what we called “orientation towards given knowledge” (OGK).

We suggest that orientation towards given knowledge consists of two interconnected components:

1. The ability to perceive given knowledge (a text, a definition, a formula, etc.), as an instrument (a mediating tool) for certain actions (what questions it can answer, what problems a student can solve with it, etc.);
2. The ability to use the given knowledge (a text, a definition, a formula, etc.), rather than other knowledge, in solving these problems.

To diagnose OGK, we chose the above-mentioned task of recognizing objects that were described by the definition of a concept. What was the reason for our choice?

In a recognition action, the attributes specified by the definition can become real points of orientation, and the definition itself can play the role of a recognition “tool” (or it may not, and recognition will be mediated by something else). Thus,

a fairly simple diagnostic situation can be constructed. And finally, the absence of errors in recognition indicates that the given definition (as knowledge of essential attributes) is being used correctly in its orienting function.

So, for example, Gal'perin and Talyzina (1957) in their early works – on which we based ourselves when we chose a diagnostic situation – described children who, as a result of a formative experiment, performed a generalized recognition action, then examined any new concept from the point of view of a future recognition action: whether these attributes would allow objects to be recognized (for example, they might criticize a given definition if it did not allow the recognition of objects). “The aim of instruction as a specific social process,” writes Talyzina, “is not to encourage the child to rediscover this system of signs that was discovered long ago, but to use them as a model for ‘looking’ at objects ... from the standpoint that is represented in this concept” (Talyzina, 1975). The recognition action, described in detail in many works of the Gal'perin school as a psychological mechanism mediating the recognition of objects by a given definition (as “knowledge” about the object's essential attributes), may turn out to be appropriate for analyzing the formation of the orienting functions of concepts in schoolchildren.

Possible Differences in OGK Among Students from Two Different Educational Systems

Study of the conditions and quality of the formation of new concepts and activities can become a tool for evaluating the effectiveness of different educational systems. By “educational system,” we mean a set of educational principles and strategies that relate to goals, content, methods, forms of education (teaching), as well as grading systems.

The Developmental Education (DE) system of D. B. El'konin and V. V. Davydov (El'konin, 1966; Davydov, 1996) can be considered as application of the Activity approach to educational practice. The main differences between DE and the contemporary traditional education system (TE) concern, first of all, the type of given knowledge that constitutes the subject matter (these are theoretical concepts in DE and empirical ones in TE) and the way children's actions are organized (learning activity).

The foundations of the DE system, as Davydov wrote, are very close to the third type of OBA (Davydov, 1996), which gives students the opportunity to take in all the given knowledge necessary to solve specific problems. Instruction that tries to focus on the third type of OBA was organized so that the attributes put forward in the definition of the concept are not just part of the method of problem solving, but the students would also realize the need to use only these attributes and not others. This was due to the students' conscious assimilation of the functions of the these concepts in the whole system. The definition of such a function was the goal of a specific orienting action, which was called a “learning task” in El'konin's and Davydov's theory of Developmental Education (Davydov, 1996; Zukerman & Venger, 2010). For example, in studies by L.I. Aydarova (Aydarova, 1968), learning to distinguish a morpheme was based not only on its formal features (a prefix, suffix, etc.), but also on their “functional” meaning in conveying a specific message. These and other results were summarized by Gal'perin: The main goal of a teacher

who is trying to use the third type of OBA is to convey the function of a set of objects that the concept expresses (Gal'perin, 1966).

In curricula based on DE principles, most concepts are proposed as means of performing certain actions (Davydov, 1996). On the other hand, active and problem-oriented methods of instruction are widely used in DE, when teachers encourage students to independently seek new knowledge (Zuckerman & Venger, 2010). An interesting question, therefore, is whether students from the DE system will use given knowledge to solve problems more often and differently than TE students, and whether they will better recognize its orienting purpose.

Studies have shown that certain differences in cognitive and personality characteristics can be detected between DE and TE students, especially after fourth grade: DE students have better self-regulation (Repkina, 1997; Morosanova, Aronova, 2004); some cognitive abilities (mediated memory, nonverbal spatial thinking, nonverbal imagination) among DE students are also better, but some (effective generalization and verbal-logical thinking) show no significant differences from TE students (Shadrikov et al., 2011). DE students demonstrate a higher level of some mathematical skills (Pavlova, 2008), and also less external motivation and better psychological well-being, but without significant differences in "internal" motivation (Gordeeva et al., 2018). Some of these results are contradictory. In our view, it is more productive to explore those cognitive or personality differences that can be directly related to the specifics of the educational system.

Some empirical studies support this proposition. Thus, Zuckerman and Chudinova showed that fifth-graders in DE are better able to use prompts than TE students (Zuckerman & Chudinova, 2016). Furthermore, the results of the mathematical subtest of the PISA Program for International Student Assessment show that DE students learn better from previous tasks than TE students (however, this study was not conducted with fourth-graders, but with 15-year-olds) (Zuckerman & Ermakova, 2004).

So, we suggest that students in a Developmental Education (DE) system may demonstrate better OGK scores than students in a traditional education (TE) system.

Methods

Participants

The participants were 115 fourth-graders from one public school in Moscow, 61 boys and 54 girls (average age 10.16, SD 0.46). The participants were divided into two groups: 72 students in TE and 43 in DE.

Materials

Orientation towards given knowledge (OGK) – method of diagnosis. For our purposes, we chose the action of recognition. The general principles of such diagnostics are described in the works of Talyzina (1975), but we have made some modifications to suit our research objectives.

The participants were given the definition of a concept ("A mammal is an animal that feeds its young with milk") and the following instruction: "You need to

Table 1
Types of tasks

Type 1. Regular tasks (with all the necessary and sufficient conditions)	Correct answer	Correct justification
1. Leopard. This is a fast and cautious animal. It has a strong, muscular body. At 5–6 months, after the mother stops nursing the young, she begins to lead them to killed prey.	+	“It feeds its young with milk” / the appropriate words in the text are underlined
2. Perch. The perch’s body has an oblong shape. The female perch lays up to 800,000 eggs. A fish does not hatch immediately from the egg. First, an embryo develops in it, and it gradually grows and turns into a larva. The larva itself begins to obtain food and soon looks like an adult fish.	-	“It does not feed its young with milk” / the appropriate words in the text are underlined
3. Bat. Bats are small animals 4 to 16 cm long. Almost all species of bats produce offspring once a year. Usually they have just one baby. From the moment of birth, the baby feeds on its mother’s milk; the period of nursing depends on the type of bat.	+	“It feeds its young with milk” / the appropriate words in the text are underlined
4. Whale. Whales are huge marine animals. In cetaceans, the body has the shape of an elongated drop, which makes it easy for them to glide through water. But the baby does not suck milk, like other mammals: When it swims up to its mother’s belly, the mother squirts a stream of milk into the baby’s mouth.	+	“It feeds its young with milk” / the appropriate words in the text are underlined
5. Whale shark. Whale sharks are considered the largest species of fish. Such sharks are ovoviviparous, that is, the young hatch from eggs. After the female has laid her eggs, she leaves her offspring forever and is no longer interested in their fate.	-	“It does not feed its young with milk” / the appropriate words in the text are underlined
6. Dolphin. The dolphin’s body has a fusiform streamlined shape. Almost all members of the dolphin class have a protruding dorsal fin. The skin is elastic and smooth to the touch. A baby dolphin gets food by injection of its mother’s milk into its mouth.	+	“It feeds its young with milk” / the appropriate words in the text are underlined
Type 2. Provocative tasks (some necessary conditions are lacking)	Correct answer	Correct justification
7. Platypus [Only a picture of the animal was shown]	?	Not enough information
8. Milk snake. This is a medium-sized, lithe, and mobile snake from 35 cm to 1.4 m long, with a slightly pointed, shiny head and convex black eyes. The milk snake hunts at night. Its main food is rodents, usually mice and rats.	?	Not enough information
9. Cassowary. Cassowary is the Indonesian word for “horned cow”. Its length can reach 2 meters, and its weight 85 kg. It is extremely aggressive. With its 20-centimeter claws, a speed on land of 50 k/h, and the ability to swim, a victim has no chance of escape.	?	Not enough information
10. Bee. Bees are flying insects. In the spring, the queen bee lays her eggs. Young insects feed the queen and all the larvae with a special milk produced in their maxillary glands. First, the queen lays the larva in a wax cell, and then the nurse bees literally “fill” the larva with a nutrient mixture.	?	Not enough information

help a 4-year-old girl find a mammal among the other animals at the zoo, using the short texts that are posted on their enclosures. Select ‘+’ if it is a mammal, ‘-’ if not, and ‘?’ if there is not enough information to decide. Please explain all your answers”. Two groups of problems were given in random order: (a) problems with all the necessary and sufficient conditions to answer the question (regular tasks), and (b) problems that do not provide all the necessary conditions (provocative tasks). Examples of the problems are presented in Table 1.

Coding of OGK for assessment. We evaluated not so much the correct result that as whether it was justified, based on the given knowledge (the attributes specified in the definition) (see Table 1). If students give the correct answer (“+”, “-”, or “?”) and justify it with reference to the given definition in any form (orally or by underlining the key sentence in the texts), we encode it as 1. If they give the wrong answer, or the correct answer, but justifies it with reference to something else (“I know it”, “My Mom told me”, etc.), we encode it as 0. If students give the wrong answer, but justify it with reference to the given definition (for example, “A bee is a mammal because it feeds its young milk), we encode this answer as 0.5. Two experts did the coding, and the correlation between their assessments was 0.98 (Spearman’s R-coefficient).

The total OGK was evaluated on a scale of 1 to 10, depending on the number of tasks that were justified, one way or another, by the given knowledge.

We also calculated results according to two separate parameters:

1. OGK in regular tasks (% of regular tasks in which students use the given definition);
2. OGK in provocative tasks (% of provocative tasks in which students use the given definition).

Analysis of the reliability of OGKM showed that the Cronbach’s alpha coefficient between all 10 problems is 0.909 (the mean Spearman R-coefficient between all problems is 0.508). From this we can conclude that all the tasks measure one meaningful characteristic.

We also evaluated the external validity of the method, comparing the results with another procedure. We used the results of an independent state test for fourth graders (“Diagnostics of Metacognitive Skills in the Field of Mathematics and Natural Sciences”, DMSIMS, developed by the Moscow Center for the Quality of Education (Spetsifikatsiya ..., 2019). It assesses the metacognitive skills (cognitive, symbolic, problem-solving, and informational) which should result from studying mathematics and science in elementary school. During this test, the students were given a text and a series of problems to solve after reading a text. The Pearson’s correlation of DMSIMS with OGKM is $r=0.44$, $p<0.001$, so we can conclude that the OGKM has sufficient external validity.

Method of diagnosis of the ability to choose the most important thing in a text (“Choice of the main sentences”). The technique was designed specifically for students of grade 4. It is a modification of the “Choice of the main sentences” method designed for high school students by O.E. Malskaya, A.A. Sidel’nikova (Sidel’nikova, 1984; Korotaeva, 2019). We gave the students a text and asked them to “underline the main sentences of this text”. Given the students’ ages (fourth grade, 10–11 years), the text was not explanatory, as it was when given to high school students,

but descriptive, citing some facts about the problem and a few “empty” sentences. The criterion for the correctness of the answer was a choice of appropriate definitions and significant facts, rather than statements similar to the definitions, statements about the significance of the problem, etc. (see *Table 2*). We calculated how many significant sentences each subject selected (a number from 0 to 8). We expected that DE students would choose significant sentences more often, and insignificant ones less often.

Table 2

Significant and insignificant sentences in the text (“Choice of the main sentences”)

Significant sentences	Insignificant sentences
2. We can talk about symbiosis only when each of the two organisms benefits from the interaction.	1 ¹ . Symbiosis is a special type of relationship between two organisms.
3. Lichen is a symbiosis of fungus and algae.	5. Lichens are unique organisms.
4. A fungus absorbs water and the substances dissolved in it and delivers them to the algae, which, in turn, produces glucose from sunlight and water, which nourishes the fungus.	6. Lichens were first described by Theophrastus in the third century BC.
9. These organisms reproduce by fragmentation of the thallus or by special groups of cells that form inside the body of the lichen.	7. The filaments of a fungus are called hyphae.
11. In nature, lichens help create the soil.	8. The body of the lichen, formed by hyphae and algae cells, is called the thallus.
12. They secrete acids that break down the rock, forming soil.	10. There are many types of lichens.
13. Also, lichens help us to understand how polluted the environment is.	15. The recognition of environmental pollution using lichens is called lichen indication.
14. This is because lichens are highly sensitive to chemical pollution.	16. Lichens play an important role in nature.

¹Note. Order of the sentence in the text.

Method of diagnosis of logical skills. We chose only one skill for diagnostic purposes: the ability to find logical (conceptual) connections. This was one of the subtests of the GIT (Group Intelligence Test) (Burlachuk & Morozov, 2001). The subjects were given two terms in two columns (for example, “February” in the first column and “March” in the second); in the third column there was a term with a different conceptual content (for example, “Tuesday”). Students had to show that they understood the conceptual relationship between the terms in the first two columns by choosing a term from the fourth column that has that same relationship to the term in the third column (in our example, the options were “Sunday”, “month”, “Wednesday”, and “week”). The relationship here is one of sequence – “March” follows “February” – so the correct answer is “Wednesday”, which follows “Tuesday”. Forty such problems were provided; students could therefore get a maximum of 40 points. We chose this task for the diagnosis of logical skills, since it was important

for us to check to what extent orientation towards given knowledge is related to the ability to correlate concepts, since this relationship is not obvious (choosing attributes based on a definition and recognizing whether they are present can be done without such a skill, using only the rules of logical inference).

We also used data on the academic achievement of our participants (in mathematics, Russian, and science), with grades on a scale from 2 to 5.

Data processing

We used SPSS Statistics 23 for data processing.

Results

Descriptive statistics for OGK are presented in *Table 3*.

Table 3

Orientation towards given knowledge: Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
OGK total	113	.00	10.00	3.96	3.39

The distribution of OGK is not normal. As the diagram shows, 25.7% of the entire sample did not use the given definition (given knowledge) to solve the problems.

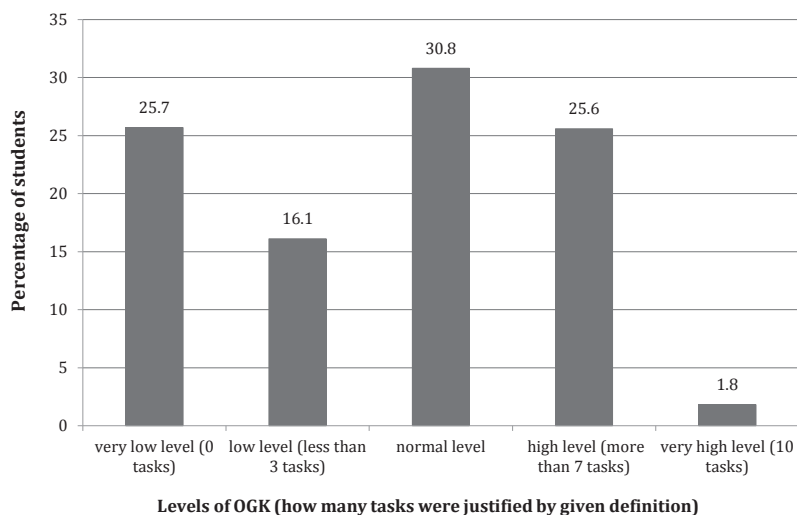


Figure 1. Total distribution of OGK (% of subjects for each value of the variable)

We also compared OGK for different types of problems (see *Table 4*). The results show that, as we expected, the regular tasks turned out to be simpler for subjects than more provocative ones (Wilcoxon Signed-Rank Test).

Table 4

Average percentage of correct answers for each type of task (regular and provocative)

	N	Mean	Std. Deviation
Regular tasks	115	46.74%	40.430
Provocative tasks	115	26.63%	31.262

The differences between the two groups of students (TE and DE) were significant (Mann-Whitney criteria for independent samples, $U = 2038.5$, $p < 0.01$). DE students generally use the definition much more often. *Figure 2* shows the percentage of subjects from the DE and TE groups (relative to the number of subjects in each group) who do not use the definition in every case. The differences between TE and DE are also significant for each type of problem ($U = 2104.5$, $p < .01$ for regular tasks and $U = 2045.0$, $p < .01$ for provocative tasks): DE students often use the given definition to solve problems in both cases.

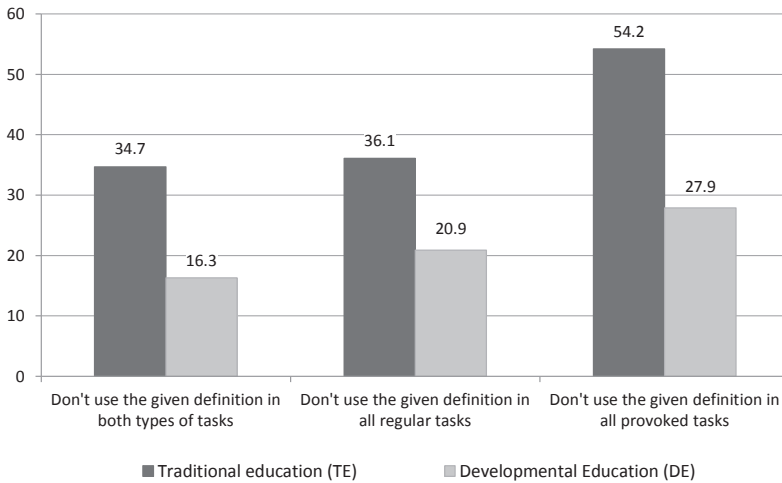


Figure 2. Percentage of subjects in each group who do not use the definition in solving each type of problem.

We used the Spearman R-coefficient to analyze the correlations between OGK and other characteristics. OGK significantly correlates with the ability to underline the most important thing in the text ($R = +0.345$, $p < 0.001$), the ability to correlate concepts ($R = +0.445$, $p < 0.001$) and with memory skills ($R = +0.195$, $p < 0.05$ for short-term memory and $R = +0.301$, $p < 0.01$ for long-term memory).

It is interesting that TE and DE students do not have significant differences in their ability to correlate concepts and in their memorization skills (according to the Mann-Whitney U criterion). There are differences only in the ability to correctly underline the main sentences in the text ($U = 1870.5$, $p < 0.05$; DE is significantly better).

OGK also correlates with academic achievement, but only in mathematics ($r = +0.22$, $p < 0.05$) and Russian ($r = +0.18$, $p < 0.05$). We found no significant connection with academic achievement in science.

Discussion

Students confront definitions of concepts every day at school. More often than not, after defining a new concept and providing the necessary explanations, the teacher requires students to be able to solve problems using this definition. As our study shows, some students (about 25 percent) not only do not understand how to use the definition to solve the problem, but even that it should be used at all. When we talk about OGK and its purpose in instruction, we mean perceiving any knowledge as a tool for possible future actions, and also the ability to rely on given rules and definitions for independent problem solving. Interestingly, we can “notice” such inability only in the conditions of the first type of OBA (according to Gal’perin) – in a situation, where students should search not only for the points of orientation but sometimes the actions too. This poses a very crucial problem not only for primary schoolchildren, but also for undergraduate students: Most of them believe that definitions should simply be memorized in order to reproduce them later (Korotaeva, 2019) .

One possible explanation for the results we obtained is that our participants (like most fourth graders) simply do not possess the ability to recognize a definition as a “conceptual” way of classifying objects, and do not realize that once that ability is formed, there will be no problem with orientation towards given knowledge. This is partly true, but in our view, it is only the technical side of the problem. What is important for us is how concepts and their definitions function, how they establish the specificity of the learning process as an assimilation of culture – orientation towards given knowledge versus orientation towards something else, to particular attributes of objects included in definitions, or to extraneous attributes.

If we analyze the internal structure of the action of recognition itself, we find that it is one of the few ways to deal with real objects insofar as they “belong” to a certain concept, with everything that “lies behind” it, the whole complex of mental functions that require mastery of the knowledge in question. If the students properly master this activity, it will not just “come in handy”, but will turn out to be a real working tool for mastering given knowledge, as conceptual mediation in solving problems in a given subject. The resulting ability to orient towards given knowledge can be meaningfully considered as a prerequisite for effective learning activity, since many of the actions that are part of the learning process – comparison, classification, etc. – are not about specific information, but general mental processes.

Why did the DE students demonstrate higher levels of OGK than TE students? Comparing the principles and methods by which learning activity is organized in these two educational programs, we note that in DE, particular attention is given to models for solving subject-matter problems (Davydov, 1996; Repkina, 1997). In the DE curricula, the students’ ability to switch from the model to the real situation that it describes is directly or indirectly tested and diagnosed. Apparently, the modeling skills acquired in problem solving allow children to learn how to perceive the subject matter, and, accordingly, the given knowledge, from the standpoint of

its general orienting functions in the environment. Such an orienting function of the given knowledge is considered by Gal'perin as the key characteristic of the third type of OBA (in comparison with the second type of OBA) (Gal'perin, 1966, p. 266).

It is interesting to compare our results with those of other diagnostic studies of students in various educational systems. Even in comparative studies of DE and TE-students based on comparing components of theoretical thinking such as ability to find a general method of solving tasks (see, for example, Zak, 1990; Rubtsov et al. 2019), some of them tried to find differences in ability to learn from given knowledge. One example is a relatively recent publication by G.A. Zuckerman and E.V. Chudinova (Zuckerman & Chudinova, 2016), on students' ability to meaningfully use short textual prompts in solving problems. This study found that fifth-graders in DE use prompts significantly better than TE students. The ability of students aged 14–15 to learn from previous tasks was evaluated by the PISA methods (Zuckerman & Ermakova, 2004), and with similar results: The DE students showed a higher level of development of this ability. Interestingly, the DE and TE students did not show significant differences in more traditional cognitive and metacognitive characteristics (IQ, memory, attention, and so on [Shadrikov, 2011]). From this we can conclude that the difference between the two groups is a result of the curriculum, and that, in comparing educational systems overall, subtle differences in the results should be taken into account.

Another interesting result of our study is that OGK is positively correlated with the ability to find significant sentences in the text. There are many studies in cognitive psychology that show that even with clear procedural knowledge of the subject, students have difficulty using it to solve problems, which researchers generally attribute to a lack of certain metacognitive factors, such as metacognitive regulation of cognitive processes (Kendeou, van den Broek, Helder, & Karlsson, 2014; Duke & Pearson, 2009).

A more complex situation is presented by the possibility of performing actions related to the given concepts, based on what has been read. Interestingly, the establishment of semantic links in the text is significantly improved when the students are invited to ask questions about this text (independently or from a general list of questions) (King, 1994; Oleynikova, 2012). In our view, when students ask questions, it prompts them to find situations and actions for which the information given in the text could become a point of departure, positively affecting their understanding of what was written.

Thus, students' lack of typical learning skills (with an emphasis on the main ones: systematization, generalization, etc.) can be directly interpreted as a lack of OGK, specifically in relation to the perception of knowledge as providing points of orientation and the ability to discover actions that correspond to given knowledge as an orienting "tool". Thus, students' lack of learning skills in working with texts (underlining the main point, systematization, summarizing, etc.) can be understood as a lack of OGK, including the perception of knowledge as providing orientation and the ability to choose actions that are appropriate to the given knowledge. No wonder there is quite a high correlation between OGK in recognition of concepts and in text comprehension. It is also interesting that OGK correlates with academic achievement, but only in Mathematics and Russian as school subjects, but not in Science. Perhaps this can be explained by the grading system: Science

is usually not considered an important subject in elementary school, and in most cases students are given quite high grades.

What is the importance of the results of our OGK research for issues of modern educational psychology? Of course, some of them can be described in the traditional terms of metacognitive skills. Metacognition concerns descriptive knowledge of and operational control over one's cognitive processes (Veenman, 2015). Another area of research into similar phenomena is the study of conceptual changes (Posner, Strike, Hewson, & Gertzog 1982; Vosniadou, 2013). Resistance to conceptual changes can be associated with the inability of students to relate the knowledge they have gained to their own actions. Often this is associated with the formation of meta-learning: students' theories about their learning and approaches to learning (Entwistle, 2000). So, with a "superficial" approach, the student perceives learning as memorizing the facts and reproducing them, referring to this knowledge as something that simply needs to be reproduced. But with a "deep" approach, the text is understood from the point of view of the connections it suggests: a specific system that directly corresponds to the meta-disciplinary structures of knowledge.

However, "resistance to conceptual changes" can be, in our view, more constructively understood as the students' inability to connect their knowledge with their own actions. Accordingly, the student has an opportunity to discover the necessary actions and their elements in the text. If the psychological mechanisms of orientation towards given knowledge are not formed, then this material will not be sought by the students. But, according to our assumption, problems of metacognition or meta-learning in education can be considered as an attempt to avoid changing the content and methods of education (this is the key point for the Activity Approach). The traditional solution of problems of superficial approaches to learning is to immediately create a new curriculum (for example, courses in logic, metacognitive skills, etc.), whereas the formation of this key metacognitive ability may, in all likelihood, be much more closely associated with a change in the content and teaching methods along the lines of the Activity Approach in educational psychology and didactics. So, we prefer to think of OGK not as a separately acquired ability, but as an essential condition for and product of Developmental Education.

Conclusions

The problem of applying knowledge to problem solving is one of the key issues in modern educational psychology. In this article, we suggest that this problem arises in children because they cannot "see" the future action that underlies the definition of the concept and for which the attributes of the concept will serve as a means (in the terminology of L. S. Vygotsky).

This ability, which we call "orientation towards given knowledge", distinguishes, as our study showed, students in the El'konin-Davydov educational system from students in the traditional system. As we also have shown, orientation towards given knowledge is closely related to the ability to underline the main sentences in a text, and this can be explained by the fact that underlining the main sentences is closely associated with the ability to formulate the key questions that the text answers (also the ability to see the actions "behind" the given knowledge). In sum,

orientation towards given knowledge can be considered an essential condition for learning and one of the most relevant issues for modern pedagogical psychology.

Acknowledgment

The study was supported by the Russian Foundation of Fundamental Investigations (RFFI No. 19-013-00717).

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Original manuscript received July 09, 2019

Revised manuscript accepted March 05, 2020

First published online June 15, 2020

To cite this article: Sidneva, A.N., Vysotskaya, E.V., Korotaeva, I.V., Mozharovsky, I.L., Shinelis, V.A. How Do Primary Schoolchildren Use Concept Definitions in Recognition Tasks? Orientation Towards Given Knowledge in Two Different Educational Systems. *Psychology in Russia: State of the Art*, 13(2), 29–46. DOI: 10.11621/pir.2020.0203

PSYCHOPHYSIOLOGY

The Influence of the Polymorphism of BDNF, HTR2A, and COMT Genes on the Perception of Emotionally Charged Images

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Background. The genes responsible for regulating neuro-chemical metabolism are capable of influencing emotional responses.

Objective. The goal is to determine the influence of the polymorphism of BDNF, HTR2A, and COMT genes on potentials evoked in response to faces with various emotional expressions and objects with different emotional valences.

Design. The stimuli set included 175 faces and 150 objects with neutral, positive, and negative emotional content. All images were unified in size and brightness and presented for 500 ms. The participants' task was to determine the emotional content of each stimulus. Each participant's EEG was recorded at 128 points and averaged in alignment with her responses. Six measures of ERP were recorded for each lead: three for faces with different emotional expressions, and three for objects with different emotional valences.

Results. We discovered that the BDNF and HTR2A gene polymorphism does not affect the visual perception of emotionally charged stimuli as reflected in changes of ERP. By contrast, participants in the COMT Met-Met group differed from participants in groups COMT Val-Met and COMT Val-Val in that their event-related potential (ERPs) for both faces and objects were characterized by an increase in P300 amplitude in their frontal, temporal, and parietal areas, predominantly in the right hemisphere. The COMT Met-Met participants were less successful in differentiating stimuli by their emotional valence.

Conclusion. The COMT gene mutation of the Met/Met type may lead to deficiencies in decision-making about the emotional valence of visual stimuli, as reflected in a substantial increase in the P300 response amplitude.

Keywords:
gene
polymorphism;
COMT; face;
object; emotion;
event-related
potential (ERP)

Introduction

Typical research on visual processes relies on averaging individual data gathered from different observers in order to determine common characteristics of visual perception; the observed individual differences are then treated as random fluctuations. However, in-depth analysis reveals that, quite often, these individual differences are really systematic and could reflect underlying mechanisms of human perception and behavior. If so, studying individual differences in visual perception can be instrumental in understanding perception's most profound mechanisms. Numerous studies acknowledge the existence of specific individual characteristics of visual perception that determine different degrees of successful image recognition within various emotional and semantic contexts. Substantial differences among individuals have been observed for various levels of information processing over the entire spectrum of visual perception (*e.g.*, Braddick et al., 2017; Grzeczowski, Clarke, Francis, Mast, & Herzog, 2017; López-Alcón, Marín-Franch, Fernández-Sánchez, & López-Gil, 2017; Sparrow, LaBarre, & Merrill, 2017; Witzel, O'Regan, & Hansmann-Roth, 2017).

Studying individual differences in cognitive processes has resulted, among other things, in a better understanding of the special role that neural mediators play in the functioning of brain structures; that, in turn, has attracted researchers' attention to the issue of the influence of the genotype on the organization of cognitive processes (Billino, Hennig, & Gegenfurtner, 2017). Twin studies have shown that genetic factors underlie about 50 percent of the differences in intelligence among people. We hypothesized that the genotype affects the perception of emotionally charged stimuli, which is reflected in corresponding changes in ERP.

In recent years, so-called genome-wide association studies (GWAS) have been launched, which have aimed to determine whether any specific areas of the genome are associated with human cognitive abilities (Deary, 2013; Deary et al., 2009; Plomin & Deary, 2015; Sternberg, 2012). These works did not reveal any specific genes that play a key role in intellectual differences. It is likely that a large number of genes affect a person's cognitive abilities, but each of them can make its own specific contribution.

Among the genes capable of influencing this perception, we highlight the following: the brain-derived neurotrophic factor (BDNF), 5-hydroxytryptamine receptor 2A (HTR2A), and catechol-O-methyltransferase (COMT). These genes determine specific protein structures, the duration of neural mediators' active presence in synaptic space, and synaptic plasticity.

The BDNF gene of the neurotrophic brain factor is linked to the plasticity of neurons. This gene is the key component in regulating the development, differentiation, and functioning of the neuron chains (Park & Poo, 2013). It plays an important role in the regulation of synaptic plasticity (Korte, Kang, Bonhoeffer, & Schuman, 1998) and the implementation of cognitive functions (Getzmann, Gajewski, Hengstler, Falkenstein, & Beste, 2013; Proenca, Song, & Lee, 2016). Reduction in its activity leads to impaired learning ability (Bartoletti et al., 2002), most likely as a result of memory problems. A number of recent studies attempted analyses of interconnections between the BDNF gene and some characteristics of visual perception, specifically visual-motor adaptation (Barton et al., 2014). Some researchers assume that there is a link between the BDNF genotype and visual-

spatial abilities (Alfimova et al., 2008). Also, there are some indirect indications that this gene could be implicated in visual recognition processes (Notaras, Hill, & van den Buuse, 2015).

The HTR2A gene defines the serotonin receptors, and thus, may influence the individual's emotional reactions. There are also indications that this gene's polymorphism is related to dynamic characteristics of cognitive processes (Golimbet, Volel, Dolzhikov, Korovaitseva, & Isaeva, 2014; Sukhodol'skaya, 2016; Švob Štrac, Pivac, & Mück-Šeler, 2016; Zainullina, Valiullina, & Khusnutdinova, 2016).

The crucial role of the COMT gene in decomposition of catecholamines determines the length of the monoamines' existence in synaptic space, which may affect specific characteristics of visual stimuli recognition and the categorization of visual stimuli with different emotional valences (Bunyaeva, Kovsh, Skirtach, & Il'in, 2016; Kovsh, 2016; Vorobyeva, Ermakov, Kovsh, & Abakumova, 2017).

Currently there is no empirical data that would confirm connections between the above-mentioned genes and the individual characteristics of visual perception in its various stages. However, their specific contributions to neurochemical metabolism may be indicative of such a connection.

The main goal of the present study is to explore and describe how BDNF, HTR2A, and COMT gene polymorphism influences the visual perception of different emotionally charged images.

It is worth mentioning that typical studies of genes' influence on the characteristics of cognitive processes are conducted within the framework of genetic and/or mental disorders (Dai et al., 2017; Fan et al., 2017; Ji et al., 2015; Lebe et al., 2013; Sujitha et al., 2014), whereas research on the impact of genotype on individual characteristics of cognitive processes in the general population is extremely limited.

Method

Participants

Fifty-four healthy young women, all students of Southern Federal University (SFU), Russia, ages 18 to 22, volunteered to participate in the study. They all had normal or corrected-to-normal vision.

Only women were tested, because there is evidence that the polymorphism of the studied genes can affect cognitive abilities of men and women in different ways (Harrison & Tunbridge, 2008; Tunbridge & Harrison, 2010).

The study was conducted in accordance with ethical standards consistent with the Code of Ethics of the World Medical Association (Declaration of Helsinki) and approved by the local SFU ethics committee.

Genotyping

Fifty-four participants were genotyped for the polymorphism of BDNF, HTR2A, and COMT genes, using samples of the buccal epithelium. Genotyping was performed with the allelic discrimination technique on a Biorad CFX-96 thermocycler (Berkeley, California, USA). For each of the genes studied, three variants of geno-

types were possible: major (without mutations), heterozygous (one mutant allele), and minor (both mutant alleles).

EEG registration was carried out on the Neurovisor 136 encephalograph-analyser from 128 monopolar registration points, using an MCScap-AC128 helmet equipped with a set of removable electrodes. The electrodes were positioned according to the standard “10–10” system for EEG registration and also in some positions of the “10–5” system, with the ear-placed electrodes as referents. Registration control and recording of the digitalized data was implemented within the NeoRec v. 1.4 software package on an $\times 86_64$ -compatible personal computer with a Windows 10 operating system. The EEG was registered in the 0.5–50 Hz frequency range with an additional filter of 50 Hz. The frequency of signal digitalization was 1 kHz. EDFBrowser software (Teunis van Beelen) handled the conversion of event markers into text format.

Stimuli

As visual stimuli, we used 450 black-and-white photographic images of either human faces (natural) or objects (both real and virtual); they were evenly divided into three groups by their emotional valence (*i.e.*, neutral, positive, and negative).

The emotional valence of the objects was determined by an expert group. The object was assigned a certain valence if all experts (seven people) independently gave it the same rating (neutral, positive, or negative).

Images of human faces were selected from the following databases: Warsaw Set of Emotional Facial Expression Pictures (WSEFEP) (Olszanowski et al., 2015); MMI Facial Expression Database (Pantic, Valstar, Rademaker, & Maat, 2005); and Karolinska Directed Emotional Faces (KDEF) (Lundqvist, Flykt, & Öhman, 1998). The library of face stimuli included images of 175 models. Each was represented by three photographs that differed in emotional facial expression: neutral, positive, and negative. Thus, there were 525 images of human faces in total.

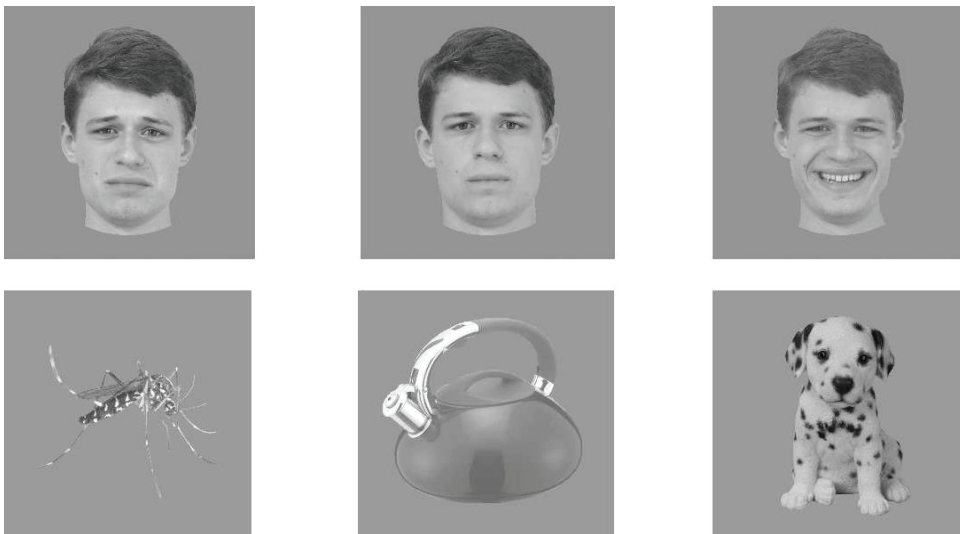


Figure 1. Examples of the stimuli used

All visual stimuli (objects and faces) were matched in size so that they would fit perfectly in a circle of 880 pixels in diameter (at an approximately 14 degree angle from the observer's perspective). They were also aligned by brightness and contrast and presented to participants on a grey background, whose brightness of 30 cd/m² per square meter was equivalent to the brightness of the image itself. *Figure 1* presents examples of the stimuli used.

Stimulation

The visual stimuli were administered using a tachistoscopic image presentation software package for the study of visually evoked potentials (Russian patent № 2015662151), which runs on an x386-compatible personal computer with an Ubuntu Linux 16.04 operating system. Stimuli appeared on the screen of the ViewSonic VX2263Smhl monitor with a pixel resolution of 1920 x 1080, and the dynamic contrast function was disabled for the duration of the study. Synchronization of EEG and the event markers was achieved by means of the TTL VGASens synchronization light sensor (photodiode) installed under the trigger zone of the monitor. The monitor calibration was performed using a 'TKA-ПІКМ'(02) brightness tester on 256 gradations of brightness.

Procedure

We used a 3 × 3 between-subjects design, with the following factors: Genotype (Val/Val, Val/Met, Met/Met) and Emotion (negative, neutral, positive). The trials were grouped into two experimental blocks according to the type of stimuli (faces or objects). The Emotions varied randomly within a block.

Visual stimuli were presented to the study participants for 500 ms each. In Experiment One, the participants' task was to identify the emotional expressions of the human faces being presented. In Experiment Two, the task was repeated using images of objects; the participants judged what emotional reaction each stimulus elicited. The participants indicated their respective decisions by pressing the designated key on the computer keyboard. The response input triggered the presentation of the next visual stimulus after a randomly selected pause within an interval of 500 to 1500 ms.

Data processing and analyses

Individual results were grouped according to the genotype of the BDNF, HTR2A, and COMT genes. The artefact-free EEG segments, encompassing intervals from 100 ms before the onset of the stimulus to 500 ms after it, were selected for subsequent averaging and processing. We averaged the responses to stimuli of a particular emotional valence with a minimum of 80 epochs per averaging.

The differences between the ERP measurements were calculated as follows. The amplitude of the ERP of each subject for each condition was evaluated every millisecond. After averaging the responses in each group with a certain genotype, differences in the amplitude of the compared ERPs were evaluated by the t-criterion (also every millisecond). To solve the problem of multiple comparisons, the Holm correction was used.

It is important to keep in mind that the emotional valence of the images of objects (unlike facial expressions) was not established a priori, but was decided upon and determined by the study participants. All statistical analyses were carried out with the EEGLAB (Delorme & Makeig, 2004) software package within the Matlab environment.

Results

Perception of human faces with different emotional expressions

In Experiment One, participants were to determine the emotional expression of human faces presented to them as target stimuli. We compared the ERP in response to faces with the same emotional expression between groups of participants with different genotypes for each of the genes under consideration.

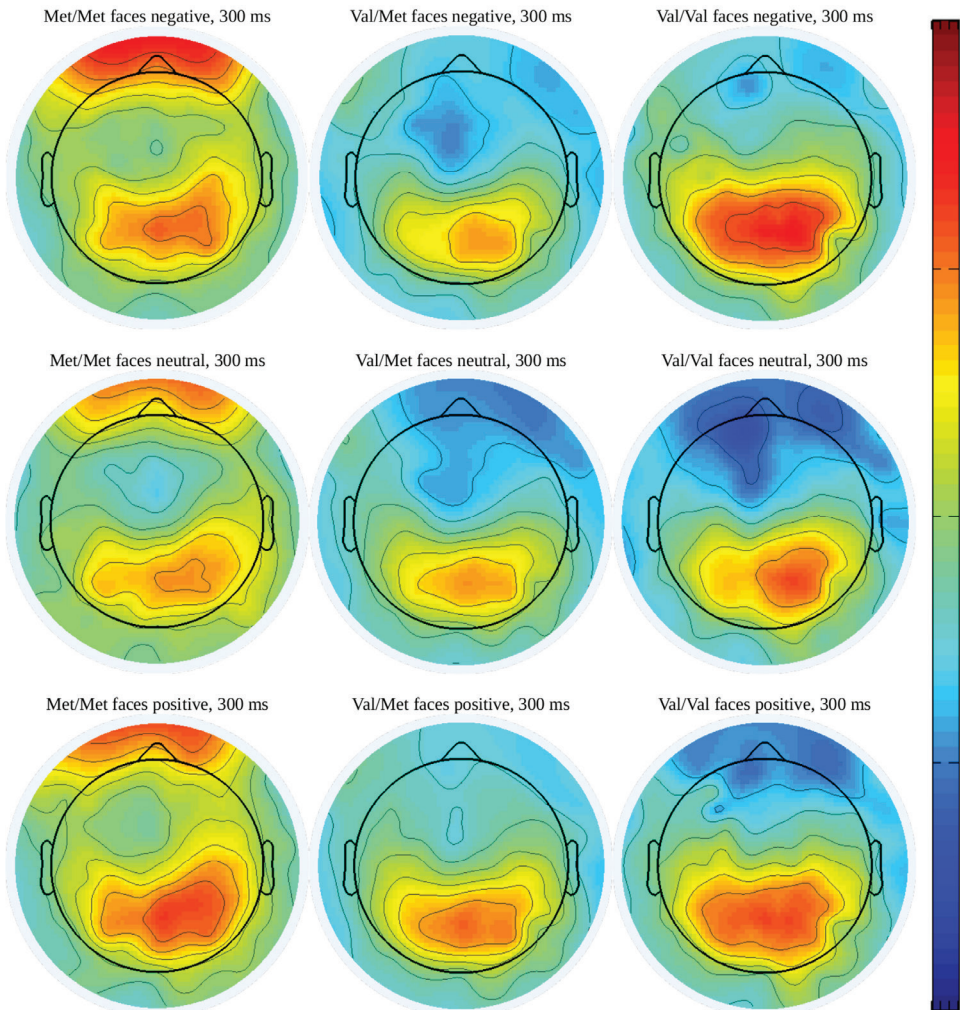


Figure 2. Potential maps with 300-ms latency in ERPs to faces with various emotional expressions among different COMT genotypes carriers.

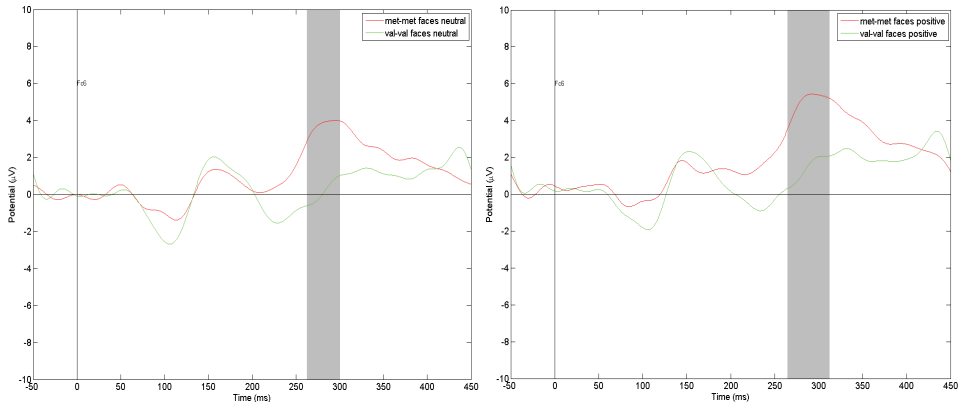


Figure 3. Comparison of the ERP scores at the T8 registration point to neutral and positive faces among different COMT genotypes carriers. The gray vertical bar represents the time interval when the amplitude difference is statistically significant ($p < .01$)

No statistically significant differences in participants' responses were detected in groups with different genotypes of the BDNF gene or in groups with different genotypes of the HTR2A gene. However, groups of participants formed according to differences in genotype of the COMT gene, showed statistically significant differences in their reactions to all types of emotional expression on the images of human faces.

There was little difference in ERP scores between groups with genotypes Val/Val and Val/Met of the COMT gene, but they both showed significantly different reactions than those in the group with the Met/Met genotype. Moreover, the greatest differences were observed when the P300 wave formed. This is well illustrated in the corresponding potential maps (Figure 2). To reflect the most salient changes in the P300 wave specifically, these maps correspond to the latency of 300 ms. The differences we observed manifested themselves in the increased amplitude of the P300 wave in participants in the group with the Met/Met genotype of the COMT gene.

Figure 3 (above) shows reactions to the images of human faces with neutral and positive emotional expressions at the same FC6 registration point as in the COMT Met/Met and COMT Val/Val groups. The grey vertical stripe depicts temporal diaspans within which differences in amplitude are statistically significant at $p < .01$. In both cases, P300 amplitude in the COMT Met/Met group is significantly higher than in the COMT Val/Val group.

Figure 4 (see below) features registration point maps that are characterized by statistically significant differences in the amplitude of the P300 wave in the groups under comparison. Red shows those positions in which we observed differences in response to faces with negative emotional expressions; yellow depicts registration points with differences in response to neutral facial expressions; and green represents registration points with differences in response to positive facial expressions. In the registration points marked in blue, significant differences were observed in response to all emotional expressions.

It is quite evident that these spatial distributions of between-group changes in P300 in the cortex are different across pairs of the compared groups. For example,

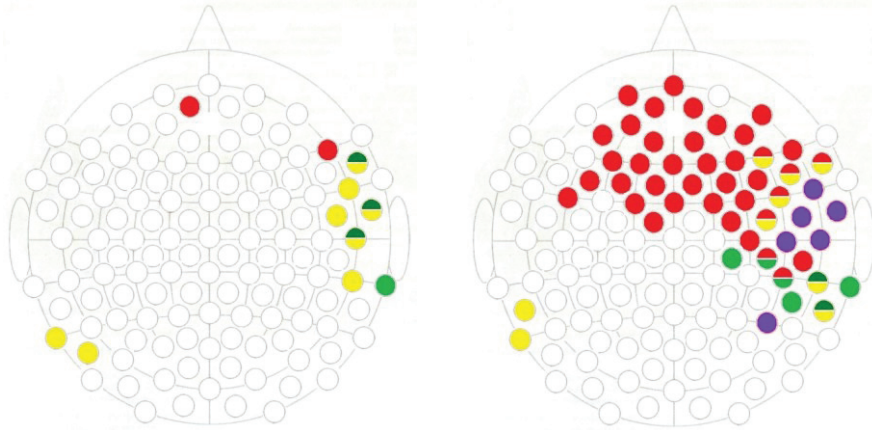


Figure 4. Registration points with significant differences in P300 amplitude (when the differences have a duration of 10 ms or more) in the ERPs to faces among different COMT genotypes carriers.

Note. On the left is the comparison between COMT Val-Val and COMT Met-Met; on the right is the comparison between COMT Val-Met and COMT Met-Met. The green color marks the points where the differences in responses to “positive” faces were found, red shows the “negative,” and yellow the “neutral” ones. The blue marks the electrodes where the reactions to all three types of stimuli were different.

for the COMT Val/Met and COMT Met/Met group comparison (on the right), these changes were exhibited in a large area of the cortex predominantly localized in the frontal and temporal registration points, with a subtle tendency for a shift toward the right hemisphere. On the map these areas are partially overlapping. By contrast, for the COMT Val/Val and COMT Met/Met group comparison (on the left), changes in P300 were more localized in the temporal area of the right hemisphere.

In other words, this pattern of results suggests specifically that gene mutation by both alleles is implicated in the visual perception of emotionally charged facial expressions.

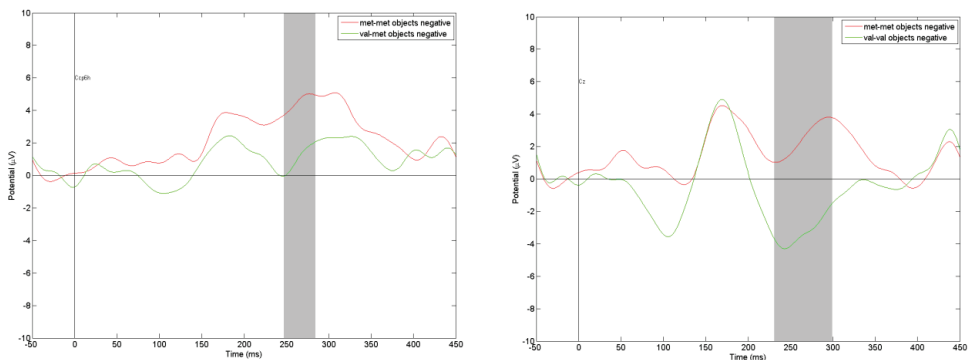


Figure 5. Comparison of ERPs in Fz registration point to “negative” objects among different COMT genotypes carriers. The gray vertical bar represents the time interval when amplitude difference is statistically significant ($p < .01$).

Visual perception of objects with different emotional valence

In Experiment Two, the participants' task was to indicate what emotional response (positive, negative, or neutral – no emotional response) the target stimuli (images of objects) elicited in them.

As in the pattern of results for images of human faces, mutations of genes BDNF and HTR2A were not associated with significant changes in the ERPs. However, a comparison of the reactions of those in groups with different genotypes of the gene revealed significant changes in P300 amplitude. *Figure 5* presents, as an example, the ERPs in response to objects judged as eliciting negative emotions. Once again, in line with the findings for facial expressions, the P300 amplitude increases dramatically in observers with the Met/Met genotype.

The same tendency is reflected in maps of potentials (see *Figure 6*).

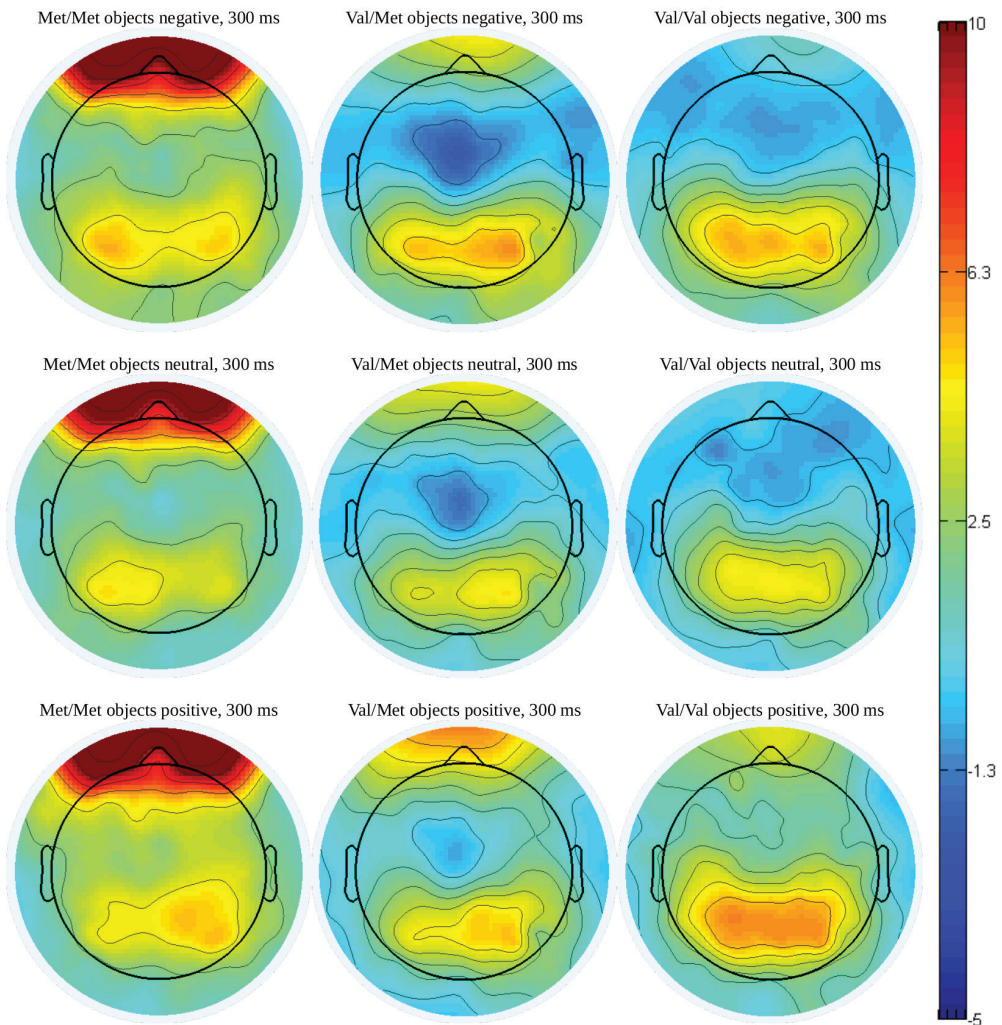


Figure 6. Potential maps with 300-ms latency in ERP to objects with various emotional valence among different COMT genotypes carriers

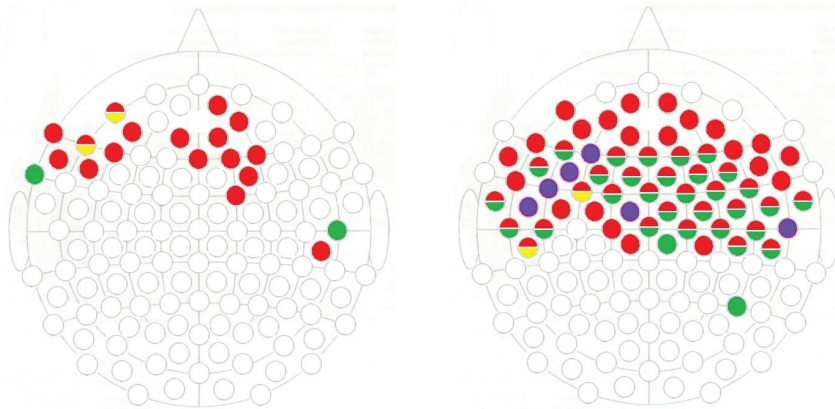


Figure 7. Registration points with significant differences in P300 amplitude (when the differences have a duration of 10 ms or more) in ERPs to objects among different COMT genotypes carriers.

Note. On the left is the comparison between COMT Val-Val and COMT Met-Met; on the right is the comparison between COMT Val-Met and COMT Met-Met. The green marks the points where the differences in responses to “positive” objects were found; red to the “negative” and yellow to the “neutral” ones. The blue marks the leads where the reactions to all three types of stimuli were different.

It is quite noticeable that the maps for the COMT Val/Met and COMT Val/Val groups (middle and right columns) differ slightly, whereas reactions in the COMT Met/Met group (depicted in the column on the left) are significantly different from the reactions in both of other groups.

The next representation (see Figure 7) features registration points for which differences in perception of visual stimuli (objects) with various emotional valence among compared groups were discovered.

As in the experiment with facial images, there were significantly more differences in the COMT Met/Met – COMT Val/Met pairwise group comparison than there were in the COMT Met/Met – COMT Val/Val group comparison, and changes in the P300 were found mainly in the frontal and temporal registration points. However, the shift to the right hemisphere is less obvious than in the above-mentioned.

Thus, the study results indicate that the genotype of the COMT gene, in particular, is implicated in the visual perception of stimuli with different emotional valences. Despite some specific differences between the tasks in Experiments One and Two, their respective patterns of results were largely similar. The main difference between the results of these two experiments was that the mutation of both alleles of the COMT gene was associated with even larger changes in evoked potentials for images of objects (Experiment Two) than for facial expressions (Experiment One), as reflected in the significant increase in the P300 amplitude.

Discussion

A comparison of the visual processing of neutral and emotionally charged stimuli shows that the latter elicit higher activation of the whole array of cortical and subcortical regions, including the amygdala and the prefrontal and visual cortex (Junghöfer, Bradley, Elbert, & Lang, 2001; Ohman & Mineka, 2001; Phan, Wager, Taylor, & Liberzon, 2002). Studies of the impact that emotionally charged visual stimuli have on ERP have a long and well-documented history (e.g., Codispoti, Ferrari, & Bradley, 2007; Eimer & Holmes, 2007; Hajcak, MacNamara, & Olvet, 2010; Herrmann et al., 2008; Olofsson, Nordin, Sequeira, & Polich, 2008). For that reason, our task was not to once again compare responses to stimuli with different emotional valence, but mainly to determine if polymorphism of certain genes affected the specifics of observers' perception of visual stimuli of the same emotional type.

The results of both experiments (facial expressions and images of objects) were similar, despite a key difference in their respective tasks: perceiving clearly categorized emotional expressions (human faces) in Experiment One versus forming one's own emotional response to otherwise unclassified visual images (pictures of objects) in Experiment Two. These different tasks, however, seemed to both evoke the same component of emotional empathy, indirectly indicating potential commonality in the respective underlying mechanisms. According to our results, in both cases the mutation of the COMT gene was specifically implicated in the particular ERPs.

The question then arises as to why this gene mutation would be responsible for changes in observers' reactions to emotionally charged visual stimuli. There is a probability that the reason is connected to the fact that the COMT gene controls production of the ferment responsible for dopamine decomposition. The mutation of both alleles of the COMT gene leads to the reduced production of that ferment, and thus to an increase in dopamine levels. Given that dopamine is one of the key neural mediators managing human emotionality, the explanation appears to bear sufficient plausibility.

According to one of the reviews on the topic, mutations of the COMT genes may result in emotional deregulation (Barzman, Geise, & Lin, 2015). Furthermore, these findings describe the influence of mutations of both alleles that lead to specific changes in the neural network of emotional response and regulation, which in turn creates a possibility of development of affective psychopathology (Montag et al., 2008). In fact, it may reflect some kind of genetic predisposition for non-flexible processing of affective stimuli and be a potential threat of emotional deregulation (Drabant et al., 2006). For example, it has been shown that the bearers of the COMT Met/Met genotype manifested lower emotional stability when exposed to emotionally negative stimuli (Smolka et al., 2005).

Thus, we reiterate that it is plausible to suggest involvement of a mutation in both alleles of the COMT gene in shaping perception and the generation of human emotions.

The next question we attempted to address in the current study is why these relationships are primarily reflected in the P300. As some research has demonstrated,

P300 is very sensitive to the state of the dopaminergic brain system (Nieuwenhuis, Aston-Jones, & Cohen, 2005; Polich, 2007). In other words, the genotype of the COMT gene determines characteristics of the dopaminergic system, which in turn influences P300 wave formation in response to emotionally charged stimuli, exactly as demonstrated in both experiments of the present study.

Why is the increase of P300 amplitude the most characteristic response to emotional stimuli in the case of the minor genotype of the COMT gene? It is customary to link characteristics of the P300 wave to dynamic characteristics of such complex cognitive processes as decision-making, planning, and voluntary attention (Gneditsky, 2003). It has been established that an increase in dopamine levels in the prefrontal cortex accelerates cognitive processes. As a result, carriers of two mutant alleles of the COMT gene have a greater chance of successfully completing challenging cognitive tasks. Specifically, these carriers demonstrate higher information processing speed and attention capacity (Bilder et al., 2002). An increase in P300 amplitude, as observed in the current study, might exactly reflect these cognitive advantages.

However, people with the COMT Met/Met genotype could be less successful when the cognitive activity requires a rapid attention shift from one task to another (Rosa, Dickinson, Apud, Weinberger, & Elvevåg, 2010). According to data reported in yet another study (Alfimova, Golimbet, Lebedeva, Korovaitseva, & Lezheiko, 2014), such people are less efficient in dealing with processing emotionally charged images. Thus, we must ask: What is predominantly reflected in P300 amplitude increase? Is it the successful completion of an experimental task, or the complexity of this task and the difficulty of its resolution?

The comparative analysis hints at how observers from groups with different genotypes of the COMT gene classified the same set of objects by emotional valence (Figure 8). We recall that the objects in Experiment Two, in our judgment,

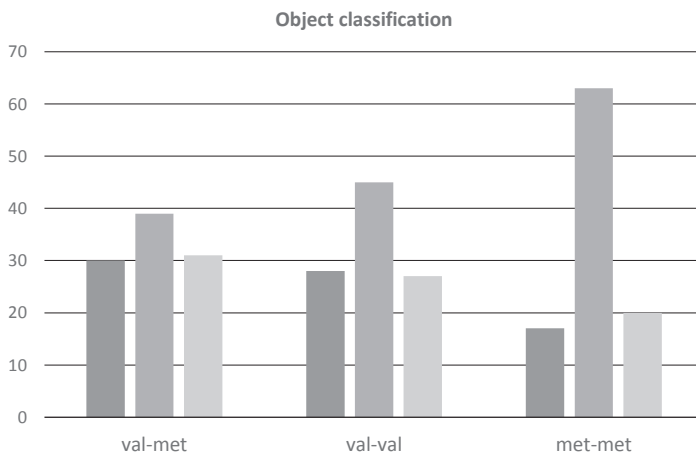


Figure 8. Percentage ratio (Y-axis) of objects with various emotional valence in groups with different COMT genotypes. The red bar represents the “negative” objects, yellow the “neutral,” and green the “positive” ones.

could have been split more or less equally into categories potentially perceived by the observers as either emotionally charged (positive or negative), or emotionally neutral. We observed the following pattern of results. Groups COMT Val/Val and COMT Val/Met classified objects very similarly: approximately 40% were perceived as neutral, while the rest split roughly evenly as positive and negative.

Quite a different result was recorded for the COMT Met/Met group: the proportion of objects classified as neutral was significantly higher there.

This outcome could be indicative of an elevated difficulty in determining the emotional valence of objects by the observers in that group. Such an explanation would be in line with some previous findings that demonstrated a lower capacity for the verbalization of emotions and feelings in carriers of the COMT Met/Met genotype (*e.g.*, Swart et al., 2011).

The study results allow us to suggest that the observed increase in P300 amplitude in representatives of the COMT Met/Met group was due to their struggle in differentiating emotionally charged stimuli. Indeed, it is known that, when the target stimulus is perceived by observers as neutral (emotionally indifferent), the P300 wave may not be generated. However, the more subjectively significant for the observer the stimulus is, the higher the P300 amplitude (Kropotov, 2010).

Conclusion

Our study has demonstrated that the polymorphism of BDNF and HTR2A genes does not affect perception of images containing emotional information. By contrast, it also demonstrated that mutations of both alleles of the COMT gene, which are responsible for elevated levels of dopamine in the brain, resulted in increased difficulty in making decisions about the emotional valence of visual stimuli, as reflected in the increase of P300 amplitude in the frontal, temporal, and parietal areas of the cerebral cortex. When the emotional expression is perceived, the area of ERP changes shifts toward the right hemisphere. When the observers assess the emotional valence of objects, an increase in amplitude of P300 occurs in both hemispheres.

This study was limited to only a few of the genes that could potentially influence the course of cognitive processes associated with the perception of the emotional content of images. Obviously, this list is not complete, and it is necessary to continue the search for genes associated with cognitive functions. In addition, it is important to pay attention to the possible linkage of these genes, when it is a certain combination of their mutations that gives a certain result.

Acknowledgements

Supported by Ministry of Education and Science of the Russian Federation, project No 25.3336.2017/ПЧ.

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Original manuscript received April 05, 2019

Revised manuscript accepted December 09, 2019

First published online June 25, 2020

To cite this article: Ermakov, P.N., Borokhovskii, E.F., Babenko, V.V., Alekseeva, D.S., Yavna, D.V. (2020). The Influence of the Polymorphism of BDNF, HTR2A, and COMT Genes on the Perception of Emotionally Charged Images. *Psychology in Russia: State of the Art*, 13(2), 47–63. DOI: 10.11621/pir.2020.0204

Diagnosing Human Psychoemotional States by Combining Psychological and Psychophysiological Methods with Measurements of Infrared and THz Radiation from Face Areas

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Background. One promising direction in development of contactless techniques for assessment of the human psychoemotional state (PES) is elucidation of the relationships between psychophysiological indices and electromagnetic radiation in the IR and THz ranges.

Objective. To present a complex approach to assessing PESs based on combining psychological testing and psychophysiological diagnostics with measurements of radiation in the IR-THz range from face areas.

Methods. Stressful psychoemotional states were provoked by physical or cognitive stressors. The PES was monitored by psychological testing and registration of heart rate, photoplethysmogram, galvanic skin response, and respiration rate. The facial images in the IR-THz range were extracted by an IR/V-T0831C detector (NEC, Japan).

Keywords: psychoemotional (stressful) states; psychophysiological diagnosis; psychological testing; instrumental contactless psychodiagnostics; infrared radiation; terahertz waves

Results and Discussion. Different PESs are characterized by different specific patterns of psychophysiological parameters. Scores on the anxiety test are highly correlated with scores on the chronic stress questionnaire, but there are no reliable links between the data of psychological tests and the psychophysiological indicators. This discrepancy allows us to assume that for reliable identification of PESs, it is necessary to combine these technologies into one diagnostic complex. We found statistically significant correlations between the intensity of the IR-THz image in the forehead and the galvanic skin response.

Conclusion. For the effective diagnosis and forecast of changes in the PES, it is important to consider both the psychological and physiological data. Despite the relatively low signal-to-noise ratio and low frequency of image recording, it is possible to extract informative THz parameters of the broadband IR-THz signal and associate them with psychophysiological reactions. The improvement of IR-THz detectors and the development of new processing methods will allow wide use of the THz range for remote assessment of human PESs in real time.

Introduction. Problem Statement

The development of modern technologies for diagnosis of a person's psychoemotional state (PES) (emotions, stress, anxiety, etc.) has been characterized by the transition from contact methods to remote ones (bio radar, laser Doppler vibrometry, eye tracking, audio and video recording, etc.), which allow PESs to be assessed in real time without contacting the object under study (Chernorizov et al., 2016).

One promising area is analysis of the relationship between the objective (psychophysiological) indicators of PESs and a person's own electromagnetic radiation in the infrared (IR) range (Cardone & Merla, 2017; Cardone, Pinti, & Merla, 2015; Hong & Hong, 2016; Ioannou, Gallese, & Merla, 2014; Pavlidis & Levine, 2001; Puri, Olson, Pavlidis, Levine & Starren, 2005). Changes in PES cause changes in the reflection coefficient of the skin surface, which is an objective diagnostic criterion (Kudryashov, Perov, & Rubin, 2008). Most of the natural radiation from the surface of human skin lies in the IR range and corresponds to wavelengths from 4 to 50 μm , while its maximum falls on waves with $\lambda = 10 \mu\text{m}$ (Bowling Barnes, 1963). Functional infrared thermal imaging (fITI) is today considered an upcoming, promising methodology in the diagnostics of PESs. Changes in local temperature associated with the activity of the facial muscles involved in the expression of emotions can be measured remotely using an IR digital camera (Kosonogov, 2017). This allows non-contact recording of a set of stereotyped patterns of facial muscle activity and, thus, recognizing the emotions associated with these patterns. Several studies have confirmed a clear correlation between emotions, stress levels, pain, and anxiety, on the one hand, and changes in blood flow in the facial skin, on the other (Cardone & Merla, 2017; Ioannou et al., 2014).

The development of the terahertz (THz) imaging technique ($\text{Tera} = 10^{12}$, $1 \text{ THz} = 1 \times 10^{12} \text{ Hz}$) in recent years has raised the question of whether human radiation in this frequency range provides additional information. The main purpose of the THz technology of wavelength range vision systems is to provide remote

real-time image acquisition. Two main approaches are used to get a THz image of an object: passive and active visualization. Active visualization is based on the illumination of the object by an external source of THz radiation. Even though THz waves are non-ionizing, this does not mean they are fully safe for human beings. The mechanism of interaction of THz waves with biological systems suggests that intense THz pulses can cause significant non-thermal biological effects (Hough et al., 2018; Huntsche & Stopper, 2012). However, even low-intensity radiation can cause various bioeffects (Pakhomov, Akyel, Pakhomova, Stuck, & Murphy, 1998). In passive imaging, the THz image is extracted from the thermal radiation emitted by the body of persons or objects being inspected.

It is expected that expanding the IR range to the THz frequency range should lead to informative contributions determined by such physiological indicators as peripheral blood circulation and sweating, and related changes in the refractive index of the skin and its transmittance. This should allow recording of changes in the psychological state of people by recording their physiological parameters. The THz range occupies an intermediate position between the optical and radio bands, and in the wavelength scale it is defined as a range from 30 to 1,000 microns (Lee, 2009). In high frequencies, the THz range overlaps with the far IR range, and at low frequencies with the microwave range (Angeluz et al., 2014). THz radiation has several unique features (high sensitivity, resolution, reliability), which are used in applied research for the development of diagnostic systems for THz tomography in medicine, biology, pharmacy, and the food industry (Smolyanskaya et al., 2018; Sun et al., 2017; Yang et al., 2016; Zhang & Xu, 2010).

In our previous work (Berlovskaya et al., 2019) we proposed a new approach to the THz diagnostics of human PESs, based on analysis of the THz contribution to the total signal, while simultaneously recording IR and THz emissions (IR-THz image) from a subject's face in situations of physical stress (short, intense physical exercise: functional squat test), emotional stress (weak electrical stimulation), and information stress (cognitive load: simple mental arithmetic calculations). The data were compared with those of similar measurements at rest. The IR-THz image processing algorithm we developed allowed extraction of the informative contribution determined by the THz radiation, from the total signal perceived by the recording system. We showed that by using cluster analysis of IR-THz images, it is possible to divide the test subjects into classes according to the reaction of the circulatory system under stressful conditions: In some people stress enhances the blood flow, while in others it causes vasospasm and, as a result, a decrease in the intensity of blood circulation. These data are in good agreement with Lawler's (1980) data on two different – sympathetic and parasympathetic – types of responses in stressful situations, and Friedman & Rosenman's (1959) data on the tight correlations of the risk of cardiovascular disorders in personality types “A” and “B”.

The purpose of the present work is to develop a complex approach to diagnosis of PESs by combining psychological and psychophysiological data with physical measurements based on correlations between an IR-THz image of a subject's face and the galvanic skin response. The study was part of an interdisciplinary approach to the diagnosis of human PESs, based on the analysis of a combination of physiological, psychological and behavioral data (Chernorizov et al., 2016; Isaychev et al., 2012; Lebedev, Isaychev, Chernorizov, & Zinchenko, 2013;). One of the im-

portant tasks of this and our previous work (Berlovskaya et al., 2019) has been to search for the possibility to incorporate the data of physical measurements of human electromagnetic fields into the integral psychophysiological assessment of PESs. In accordance with this task, the experiments included registration of physiological parameters of PESs and, in parallel, the IR-THz radiation from volunteers' faces in different stressful situations (tasks with cognitive, physical, or physiological loading). The results of the IR-THz radiation analysis were used selectively to find the correlation of the parameters of IR-THz images with the data of measurements of such informative indicators of PES as galvanic skin response.

Methods

Main Goal and General Design of the Experiments

The main goal of the work was to supplement the psychophysiological assessment of PESs with data of the physical measurements of human passive electromagnetic fields in the extended IR-THz range. Accordingly, the experiments included simultaneous registration of physiological parameters of PESs and IR-THz radiation of volunteers in stressful situations with cognitive, physical, or physiological loading. Based on physiological measurements and psychological testing, a comprehensive psychophysiological assessment of the subjects' PESs was performed. Analysis of the IR-THz radiation captured from the participants faces was used to find the correlation of the parameters of IR-THz images with measurements of the galvanic skin response.

Participants

Thirty-two volunteer students (ages 17–24, mean age 20.8, SD = 5.53, 17 females) participated in the experiments. All gave written informed consent to the conditions of the experiment.

Methods of Stimulation and Registration

Psychological Testing

Before the experiments, the Spielberger State-Trait Anxiety Inventory, adapted into Russian by Khanin (Batarshhev, 2005) and the Leonova questionnaire (Leonova, 2016; Vodopyanova, 2009) were used to determine the individual level state anxiety (degree of anxiety at the time of experiment) / trait anxiety (anxiety as a personal characteristic) and the degree of chronic stress, respectively.

Psychophysiological Stimulation and Registration

Traditional functional trials (FTs) were used to provoke changes in PES (Ioannou et al., 2014): 1) FT with physical loading, FTP: 5-minute intensive exercises on a stationary bike-ergometer; 2) FT with emotional loading, FTE: electro-skin stimulation by a current of 17–20 mA with an interstimulus interval of 26–34 sec or, in a special series, the presentation of sharp, unpleasant, loud screams; 3) FT with cognitive loading, FTC (mental multiplication of two-digit numbers).

Each FT was preceded by registration of psychophysiological indicators in a state of quiet wakefulness (background, BG). The duration of a single FT was 3 minutes. Before each test, the 10-second instruction was given. The time interval between FTs was 30 seconds in order to reduce the effect of previous stimulation. The entire experiment with a single subject took 17 minutes.

To generate stressors and register established physiological stress markers (heart rate, HR; galvanic skin response, GSR; photoplethysmogram, PPG; respiration rate, RR) the following experimental setup was used:

1. Encephalan-EEGR-19/26 portable telemetric EEG-recorder (Medicom-MTD, Russia).
2. Egoskop software package (version 3.3.2, developed by Medicom-MTD, Russia) (Egoskop, 2019).
3. A seat for the subject with the possibility of fixing the head and with a back-rest drive.

We used the length of the GSR line as the main indicator of episodic stress. This indicator includes both the tonic and phasic components of GSR. The tonic component reflects the protracted changes of the human functional state in minutes and hours. The phasic components, which mainly contribute to the GSR, reflect short-term changes in response to stimulation (from 1.5 to 10 sec). Thirty seconds was enough to restore the initial background level, from which the next portion of phasic components of the GSR to the stressor stimulus was calculated.

Measurement of IR-THz Images

Registration of IR-THz images was carried out using a 320×240 -pixel microbolometer-based NEC IR/V-T0831C camera with the macro lens NEC IR/V-TL028. We did not use any filters, so the sensitivity of this camera system was in a spectral range from 1 to 30 THz (Terahertz Imager, 2019). The minimal detectable power (MDP) of this camera without a filter was about 100 pW at 1 THz and about 30...50 pW at 4 THz (NEC, 2014). The MDP at shorter wavelengths down to 10 μm was in the same order of magnitude (Oda, 2012). That means the detection system's sensitivity was almost constant over the wide spectral range from infrared to terahertz. The typical range of sensitivity of high-performance thermal imaging cameras is limited by 7...14 μm (FLIR, 2020). Therefore, the range of sensitivity of the camera used in our study and of any thermal infrared imaging camera system are only slightly overlapping. This is very important, because our detection system is significantly different from those used in earlier studies (e.g., Puri et al., 2005; Znamenskaya, Koroteeva, Isaychev, & Chernorizov, 2018).

In the process of recording and analyzing IR-THz images, we found that involuntary head movements associated with the stabilization of the body in space have a noticeable effect on the results of image processing. In order to minimize this, all subjects were positioned in a chair in a reclining position, with a headrest (Berlovskaya et al., 2019).

In view of our previously obtained data, the frontal and periorbital areas of the face were chosen as zones of interest (ZI) for analysis of IR-THz images (Berlovskaya et al., 2019).

Research Procedures

Experimental Procedure

The first (preliminary) stage included (1) questioning of the subjects to fill in the consent form for participation in the experiment, (2) psychological diagnosis of state/trait anxiety (STAI-K) and chronic stress (Leonova questionnaire), (3) measurement of blood pressure and heart rate. The goal of this stage was to obtain information about the psychological and physiological state of the subjects, which might have an impact on their PESs in the functional trial.

The second (basic) stage included synchronous registration of passive electromagnetic radiation from the person tested in the IR-THz range and of psychophysiological indicators (ECG, PPG, GSR, RR) during the process of modelling stressful situations (FTP, FTE, FTC). The goal of this stage was to identify specific patterns of psychophysiological reactions and of passive electromagnetic radiation from the person tested in the IR-THz range, which can be used to diagnose PES changes under the influence of various stressors.

The values of all indicators recorded in the FT were then compared to the values of the same indicators obtained at rest (background state, BG).

Special Analysis of Psychological Testing Data

The level of state/trait anxiety and the severity of chronic stress of the subjects were assessed according to the scales prescribed by the tests of STAI-K and A.B. Leonova, respectively (Batarshev, 2005; Vodopyanova, 2009; Leonova, 2016). In particular, according to the STAI-K scale, subjects who scored 0–30 points, 31–45 points, or 46 and more points, are referred to groups with low, moderate, and high anxiety, respectively.

Special Analysis of Psychophysiological Data

During FT implementation, the following psychophysiological indicators were recorded and then analyzed:

1. heart rate (HR), determined by ECG, which was recorded using electrodes on the subject's forearms (cut-off frequency of low and high frequency filters – 0.5 Hz and 70 Hz, respectively; rejection filter – 50 Hz);
2. respiratory rate (RR), defined as the number of “inhale-exhale” cycles per minute;
3. amplitude of the systolic wave of PPG (ASW) used to assess the peripheral blood flow and the tone of resistive vessels (cut-off frequency of low and high frequency filters – 0.5 Hz and 10 Hz, respectively);
4. Kerdo index (IK) (Kerdö, 1966): $IK = 100 \times (1 - DBP / \text{pulse})$, where DBP is the diastolic blood pressure (mm Hg); pulse rate (beats per minute); at $IK > 0$, sympathetic influences dominate in the activity of the vegetative nervous system (VNS), parasympathetic influences dominate at $IK < 0$, functional balance between sympathetic and parasympathetic divisions of the VNS is observed at $IK = 0$ (Minvaleev et al., 2018);

5. the normalized length of the line, the envelope of the GSR profile (GSRL), which was recorded by the Fere method (the frequency of the probe current is 140 ± 14 Hz, and the amplitude is not more than $0.15 \mu\text{A}$). The GSRL was calculated as the sum of the absolute differences between adjacent GSR amplitudes measured at the sampling rate of 250 Hz: The sampling period (SP) equals $1 \text{ sec} / 250 = 0.004 \text{ sec}$, or 4 ms). For example, the sum of the differences, the number of amplitude counts, and the time of the analyzed GSR are 0.66, 6, and 27.5 sec ($6 \times 4 = 24$ ms, or 0.024 sec), respectively. Then the normalized value $\text{GSRL} = 0.66 / 0.024 = 27.5$. Thus, the GSRL is proportional to the amplitude and frequency of the signal, namely, the more time-varying the GSR signal, the greater the GSRL.

Special Analysis of IR-THz Images

1. First step of analysis

Within the selected resulting zone of interest (ZI) for a series of images taken in a calm state (background state, BS), the average value of each pixel of the analysis area is calculated:

$$p(x, y) = \frac{\sum_{i=1}^n p(x, y, i)}{n} \quad [1]$$

where: $p(x, y)$ is the average intensity of a pixel with coordinates (x, y) ; $p(x, y, i)$ is the intensity of a pixel with coordinates (x, y) on the image number i ; n is the quantity of images.

2. Second step of analysis

For an array of images obtained in the FT, a list of image numbers is generated which correspond to the maximum values of synchronously recorded GSRs. Further, within the ± 2 seconds interval with respect to each GSR peak mark, averaging is performed in the subject's forehead for the same area of images obtained during this time interval. Thus, a surface is formed of average ratings for a stressful (FT) or calm background state (BS). The average value for the pixels of the area of these images is determined as follows:

$$p_a(x, y) = \frac{\sum_{h=1}^H \sum_{l=T1(h)}^{T2(h)} p(x, y, i)}{\sum_{h=1}^H (T2(h) - T1(h))} \quad [2]$$

where: $T1$ is an array of lower limits of averaging intervals; $T2$ is an array of upper bounds of averaging intervals; H is the number of averaging intervals. $T1$ and $T2$ arrays are defined as:

$$\begin{aligned} T1(i) &= (a(i) - tl) \cdot k \\ T2(i) &= (a(i) + tr) \cdot k \end{aligned} \quad [3]$$

where: a is an array of GSR maximum time stamps; $a(i)$ is the i -th time stamp; k is the number of recorded images per second (for a given archive, $k = 8$); tl is the start time of the averaging interval in the vicinity of the maximum; tr is the end time of the averaging interval in the vicinity of the maximum.

3. Third step of analysis

The intensities of the resulting zone of interest (ZI) are calculated as the difference between the average values of pixel intensities in stress (FT) and calm (background) states:

$$r(x, y) = p_a(x, y) - p(x, y) \quad [4]$$

where: $r(x, y)$ is the pixel of the resulting area with coordinates (x, y) ; $p_a(x, y)$ is the average value of a pixel of the excited state region with coordinates (x, y) ; $p(x, y)$ is the average value of a pixel of the region of the quiescent state with coordinates (x, y) .

4. Fourth (final) step of analysis

Based on the resulting region r , the surface is built for the “height of points” with coordinates (x, y) which correspond to the value $r(x, y)$. Positive and negative height values of this surface are an increase or decrease in the intensity of IR-THz radiation at the moments that are synchronized with the peaks of simultaneously recorded GSRs. Heights around zero characterize the absence of changes in the intensity of radiation (see *Figures 3–5* in “Results and Discussion”, below).

To obtain a pseudo-color IR-THz image, a histogram was constructed, all points of which were divided into three clusters by using two adaptive thresholds $P1$ and $P2$, varying from frame to frame, while maintaining a symmetrical arrangement relative to the maximum of the histogram (for an algorithm for such a clustering, see Berlovskaya et al., 2019) (see below. *Figures 3–4*).

Statistical Analysis of Group Data

For the above general statistics (mean, standard deviation, etc.), the analysis was performed with ANOVA calculation software (stats 3.5.1), following pair-wise comparisons of the results using the t-test with Tukey’s range test for multiple comparisons.

To classify subjects into groups according to several psychological and psychophysiological parameters, statistical data processing was performed using the R language (version 3.5.1) (RCore Team, 2019) and the RStudio interactive development environment (version 1.1.463) (RStudio Team, 2018). Subjects were clustered using the k-means method (Hartigan & Wong, 1979), implemented in R as part of the basic stats package; the NbClust package was used to determine the optimal number of clusters (Charrad, Ghazzali, Boiteau, & Niknafs, 2014). The factoextra (Kassambara & Mundt, 2017) and ggplot2 (Wickham, 2009) packages were used to present clustering data with application of the principal component analysis (PCA) (Mardia, Kent, & Bibby, 1979).

To establish the relationships among psychological, psychophysiological, and physical data, the Spearman rank correlation method was used.

Results and Discussion

Psychological Testing and Psychophysiological Experiments

Complex Character of Connections Between Psychological and Psychophysiological Indicators of Stressful PES

The averaged group data of psychological measurements are presented in *Table 1* and *Figure 1*.

Table 1

Descriptive statistics of psychophysiological parameters (indexes) registered in different functional trials

Physiological index	HR				GSR				ASW			
	BG	FTC	FTE	FTP	BG	FTC	FTE	FTP	BG	FTC	FTE	FTP
Functional trial (FT)	BG	FTC	FTE	FTP	BG	FTC	FTE	FTP	BG	FTC	FTE	FTP
Number of subjects	32	32	32	32	32	32	32	32	32	32	32	32
Average value	73.6	89.6	72	97.2	186	384	422	302	2.69	1.88	1.95	5.08
Standard deviation	12.4	16.5	12.2	21.3	173	322	279	299	2.04	1.64	1.95	2.98

Note. For abbreviations, see “Methods”, above. For description of the table with indication of reliability of differences among indexes (GSR, ASW) in FT (FTC, FTE, FTP) and the same indexes in BG, see text below.

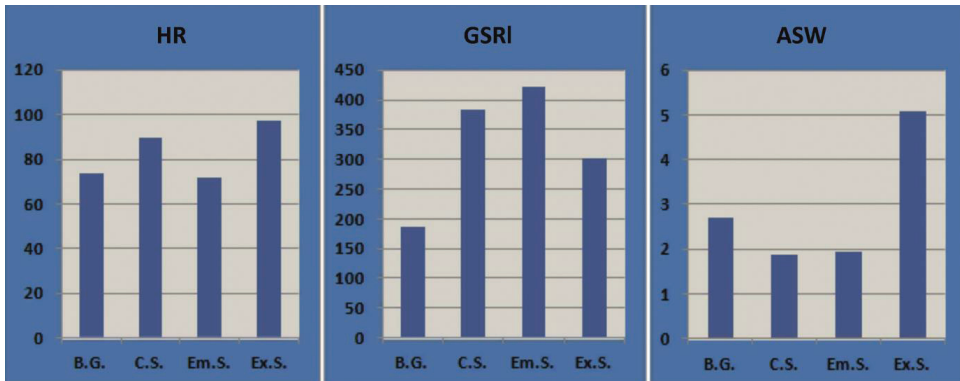


Figure 1. Averaged psychophysiological parameters of PES in different functional trials. The diagrams are constructed according to Table 1. HR – heart rate; GSRI – normalized length of the GSR profile (conventional units); ASW – amplitude of systolic wave of PPG (conventional units); B.G. – registration of indicators in background (calm) state; C.S. – FT with cognitive loading (FTC); Em.S. – FT with emotional loading (electro-skin stimulation) (FTE); Ex.S. – FT with physical exercises (FTP). For details concerning measuring of indexes, see section “Special Analysis of Psychophysiological Data”, above.

To assess the significance of the differences between the mean values of psychophysiological parameters in different FTs, the ANOVA method was used with

subsequent pairwise comparisons through the t-test with Tukey correction for multiple comparisons. The resulting data (Table 1, Figure 1) illustrate the marked differences of the relationships of different psychophysiological indicators of PES with different FTs. For example, the HR has higher values in FTC and FTP as compared to BG and FTE. The differences between these FT pairs are statistically significant. Within the pairs there are no differences: $df=3, F=18.9, p<0.001$; the size of η^2 effect is 0.314; in t-tests of pairwise comparisons, all $p<0.001$.

GSR indicators in FTC and FTE have large values, which are significantly different from BG and do not differ between themselves: $df=3, F=4.6, p<0.01$; the size of η^2 is 0.101; in t-tests of pairwise comparisons all $p<0.05$.

ASW indicators in FTP have a greater value than in other FTs: $df=3, F=5.24, p<0.01$; the size of η^2 effect is 0.114; in T-tests of pairwise comparisons $p<0.05$.

Thus, each FT is most fully characterized by a specific pattern (vector) of psychophysiological indicators. It can be assumed that the contribution of each of the indicators to the total diagnostic complex depends, at least, on a combination of two factors: the subjective importance of the stressor for the recipient and his/her particular psychophysiological status. By psychophysiological status (PFS), we mean an individual's (or group's) resistance to various stressors, as well as ways to respond to stress (coping strategies). Such factors as genetic predisposition, type of higher nervous system, personality traits, coronary types of behavior "A" or "B" have a significant impact on PFS. To identify statistically significant relationships between different indicators of PES, we averaged the values of the psychological and psychophysiological indicators across the group ($n=32$) for all FTs and thereby defined the group Psychophysiological Status. For comparative analysis, these data are combined in Table 2 with measurements of IR-THz radiation.

Table 2

Group psychophysiological status of all the subjects who participated in the experiments ($n=32$)

Descriptive statistics for the whole group (n = 32)									
Indicators of PES	IK	SPILB.R	SPILB.P	Ch. St	ITRf	ITRo	HR	GSR	ASW
Mean	0.039	39.6	44.2	45.7	3.69	0.656	72	422	1.95
Standard error	0.0293	1.61	2.2	2.05	0.685	0.645	2.16	49.3	0.344
Median	0.0484	40	43	44.4	4	0.5	70.7	354	1.06
Standard deviation	0.166	9.09	12.4	11.6	3.87	3.65	12.2	279	1.95

Notes. The table shows the results of statistical analysis of psychological tests, psychophysiological experiments, and measurements of IR-THz radiation, averaged over all FTs. IK – value of Kerdo Index; Ch.St – scores on Leonova questionnaire; SPILB.R – indexes of state anxiety (STAI-K test); SPILB.P – indexes of trait anxiety (STAI-K test); ITRf – intensity of THz radiation on the forehead; ITRo – intensity of THz radiation in the periorbital area. For other abbreviations see "Methods" above.

Data of Table 2, processed by Spearman rank correlation, are presented in Table 3.

Table 3

Matrix of Spearman rank correlation coefficient (ρ)

		IK	Ch.S	SPILB.R	SPILB.P	ITRf	ITRo	HR	GSR
IK	Spearman's ρ	–	0.008	-0.015	0.034	0.023	0.159	-0.052	0.147
	p -value	–	0.966	0.934	0.851	0.902	0.384	0.777	0.421
Ch.S	Spearman's ρ		–	0.672***	0.778***	0.326	-0.125	0.03	0.13
	p -value		–	<0.001	<0.001	0.069	0.496	0.869	0.477
SPILB.R	Spearman's ρ			–	0.751***	0.022	-0.146	0.097	0.084
	p -value			–	<0.001	0.907	0.427	0.597	0.649
SPILB.P	Spearman's ρ				–	0.276	-0.15	0.103	0.176
	p -value				–	0.127	0.413	0.576	0.336
ITRf	Spearman's ρ					–	0.196	-0.225	0.334*
	p -value					–	0.283	0.216	0.048

Notes. Significances: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
For abbreviations see Notes to Table 2.

Table 3 clearly illustrates the statistically significant positive correlations between the scores of the STAI-K test and those of the Leonova questionnaire. The lack of reliable correlations between the data of psychological tests and physiological indicators should also be noted. Such a discrepancy between the results of psychological and physiological measurements suggests that for reliable identification of PESs, using only psychological or only psychophysiological techniques is not enough, and these different technologies should be combined into a united diagnostic complex.

The following section illustrates the use of this complex psychophysiological approach to the assessment of PESs of volunteers in a situation of FTE (FT with emotional loading).

Using a Set of Psychological and Psychophysiological Indicators for the Complex Assessment of PES

For integrated psychophysiological assessment of the PES, we used the individual scores of psychological testing (Spielberger-Khanin test and Leonova questionnaire) in combination with values for HR, ASW, RR, and GSR, which were registered in the FTE while a sharp, unpleasant, loud scream was used as a stressor.

Twenty-seven volunteers took part in this special experimental series (ages 17–24, mean age 19.1 ± 4.2 , females 14). First, the values for HR, ASW, RR, and GSR

for background were recorded (3 min), after which the participant was subjected to 3 minutes of loud shouts (5 shouts in total) at intervals of 20 to 30 seconds. The dependent and independent variables were the value of the physiological indicator and the number of the shout (between 1 and 5), respectively. The resulting records were cleared of artifacts, and the average values were calculated. For each subject, the average values of the indicators at the time of each shout were calculated; these were then used for the linear regression procedure by the method of least squares. Thus, the experiments with shouts was characterized by two types of indices: the intercept and the slope of the line. The first index may be described as the average value of an indicator, and the second as the speed, at which the reaction of the subject fades before each new shout. The mean values of the baseline recording were subtracted from the values of the intercepts. These indicators were then used as a measures of PES change.

The statistical data obtained in this way and characterizing the PES in the FTE situation, were then used for clustering the subjects (for methods of statistical processing and clustering, see “Methods”, above). The preliminary number of clusters was estimated as 2–3, using the NbClust package (Charrad et al., 2014). Both hypotheses (2 or 3 clusters) were visually tested by reducing the dimension of the data by the principal component method (PCA) (Mardia et al., 1979) and projecting the clusters onto first two principal components. As a result, three linearly separable clusters were identified (Figure 2), using the packages factoextra (Kassambara & Mundt, 2017) and ggplot2 (Wickham, 2009).

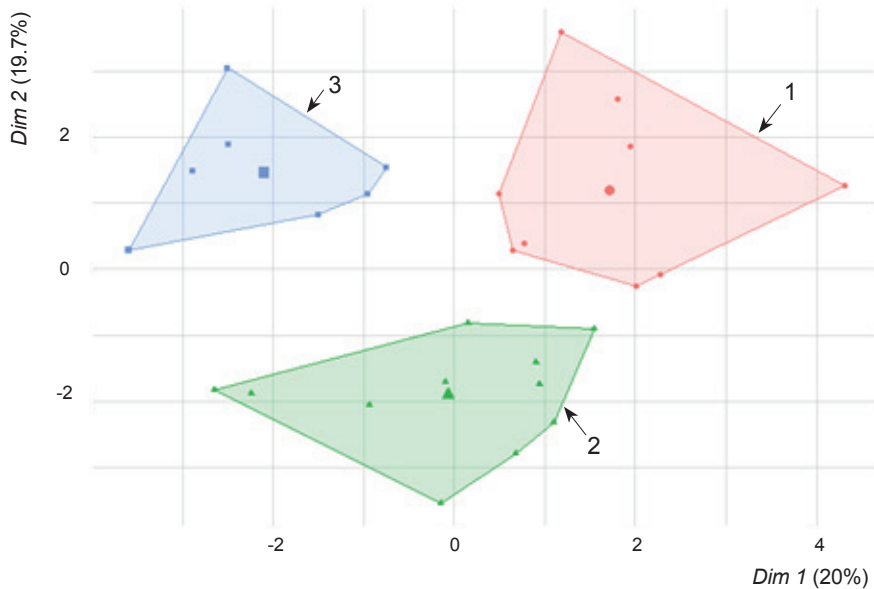


Figure 2. Clusters of subjects in the space of two main components (Dim 1 and Dim 2). On the axes of the graph are the coordinates of the subjects (the values of the first two components), as well as the percentage (%) of variance explained by each component. On the graph itself, the test subjects and centroids corresponding to each cluster are represented by circles (in cluster 1), triangles (in cluster 2), and rectangles (in cluster 3). The subjects of the same cluster are within a single polygon. For more details, see the text.

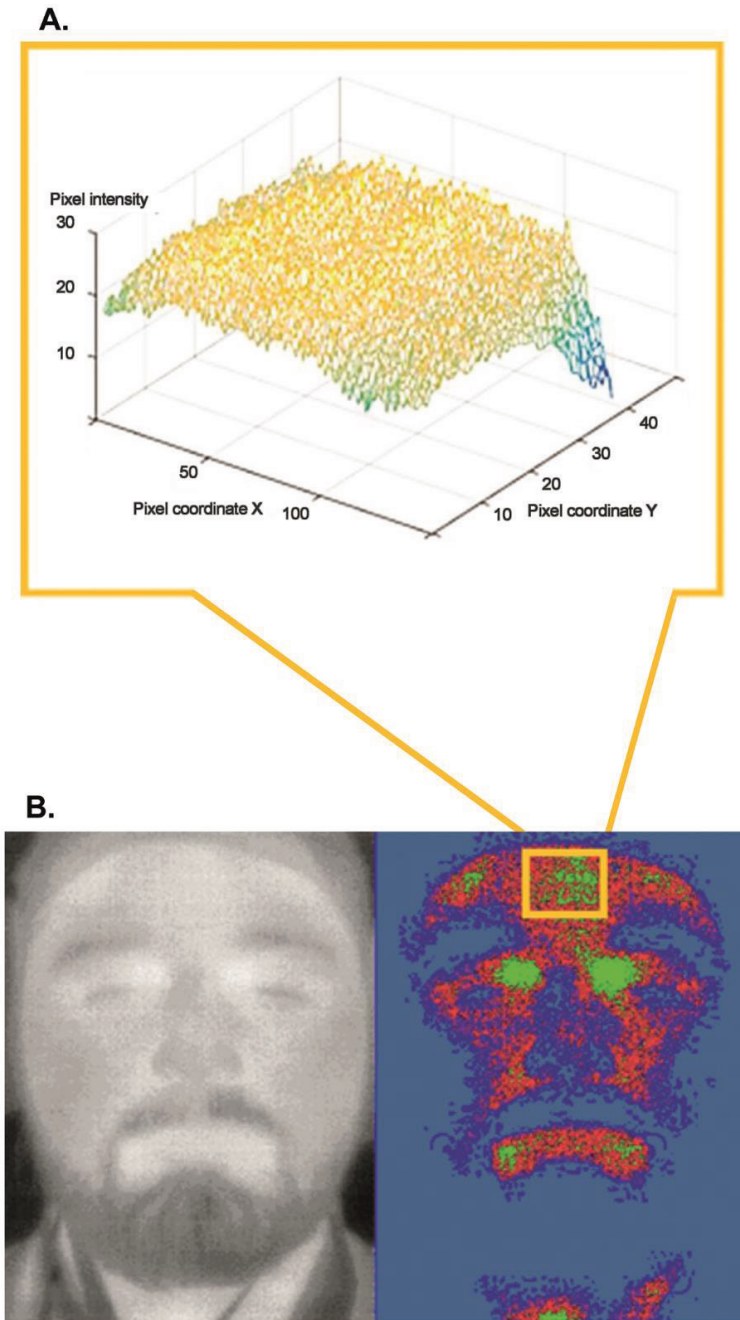


Figure 3. IR-THz image for the forehead zone of interest (in yellow square) at background state (BG)

A. Pixel coordinates of the IR-THz image are indicated along the X and Y axes, and pixel intensity along Z axis ($50 \times 150 \times 30$). The area limited by $X \times Y$ pixels represents the forehead area. The coordinates of Z pixels denote the intensity of THz radiation, varying from low values (blue pixels) to high ones (red pixels). **B.** The original IR-THz image in black and white (left) and pseudo-color image (right).

To assess the quality of clustering, we used the Dunn index (Dunn, 1974; Song, Di Matteo, & Aste, 2012) implemented in the *f* package (Handl, Knowles, & Kell, 2005; Hennig, 2018). There are several variants of the index. We applied the most commonly employed version, the ratio between the minimum averaged difference between clusters and the maximum averaged difference within a cluster. For our case, the ratio is 0.91, which indicates a statistically reliable distribution of subjects in clusters.

When analyzing the results of such complex clustering (*Figure 2*), it is important to pay attention to the fact that the same clusters contain subjects who would be in different groups, if only psychological tests or only psychophysiological indicators were used to classify their PESs. For example, cluster 1 of subjects with a high level of anxiety and chronic stress includes the persons with high scores on the STAI-K test and Leonova questionnaire, as well as subjects with a slow decay of the GSR (the psychophysiological indicator of low anxiety and stress). On the other hand, clusters 2 and 3 include persons with relatively low anxiety and chronic stress. In cluster 2 there are subjects having the lowest scores on the test and questionnaire (low level of anxiety and chronic stress) and average values for GSR reduction (relatively high anxiety and stress). And the subjects from cluster 3 are characterized by the very rapid decrease of GSR (low level of anxiety) associated with average scores on psychological testing (average anxiety and stress).

This complex clustering allows us to conclude that for effective diagnosis and, especially, prediction of PES changes, it is important to consider both psychological (subjective) and psychophysiological (objective) data. The need for such an integrated approach is a matter of debate. For instance, Hong & Hong (2015) propose to extract stress-induced thermal imprints through the differential IR energy between the philtrum (part of the maxillary area) and the forehead, disregarding personal factors. In our view, an effective assessment of PESs and prediction of their changes over time is possible only when we have information about the individual's psychophysiological status (PFS; defined above). Both the psychological and physiological parameters of this status should be considered in the diagnosis of PES, as part of the reference base (along with the current background functional state).

Correlation of the Results of Analysis of Remotely Recorded IR-THz Images with Contact Measurements of GSR

To study the correlations of radiation in the IR-THz range with the GSR, the FTE series was selected, where the changes in the GSR in response to the stressor (a weak electric shock) are best expressed against the background of small values of ASW and HR (*Figure 2*). *Figures 3–5* represent the results of measuring the spatial distribution of IR-THz emissions in the forehead (for a description of the method for constructing “activation IR-THz surfaces”, see “Special Analysis of IR-THz Images” section, above).

The *Table 3* data (see above) indicate that there is a statistically significant moderate correlation between the intensity of the IR-THz signal in the forehead and the GSR (Spearman coefficient = 0.334, $p < 0.05$). These data coincide with the data of Puri et al. (2005), which showed that the affective stressful states of computer users are correlated with increased blood flow in the frontal vessels of the forehead. That flow dissipates convective heat, which can be monitored through IR imaging. Hong

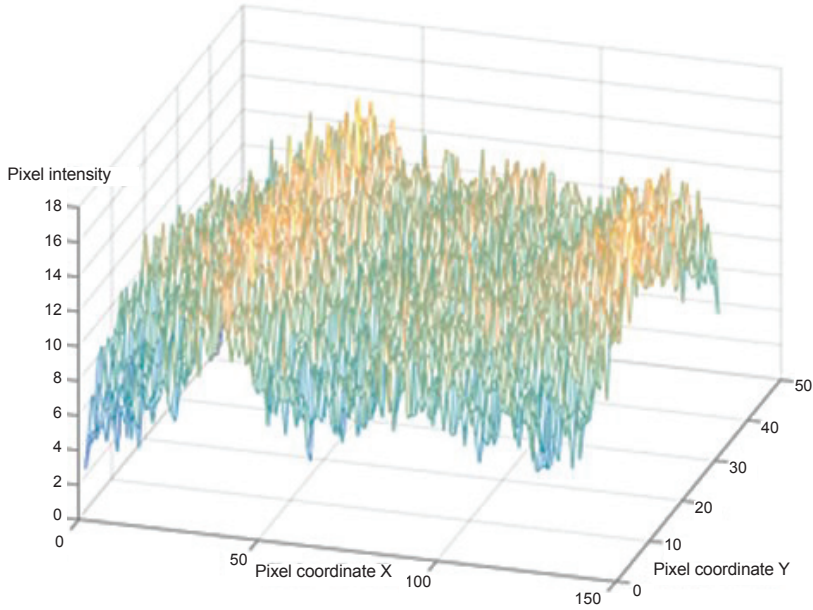


Figure 4. The result of the IR-THz image subtraction for the calm state (Figure 3) from the IR-THz image for the excited (FTE) state. Both IR-THz images (for BS and FTE) were obtained for the moments when the amplitude maxima of the synchronously recorded GSR were observed. For abbreviations, see Figure 3A.

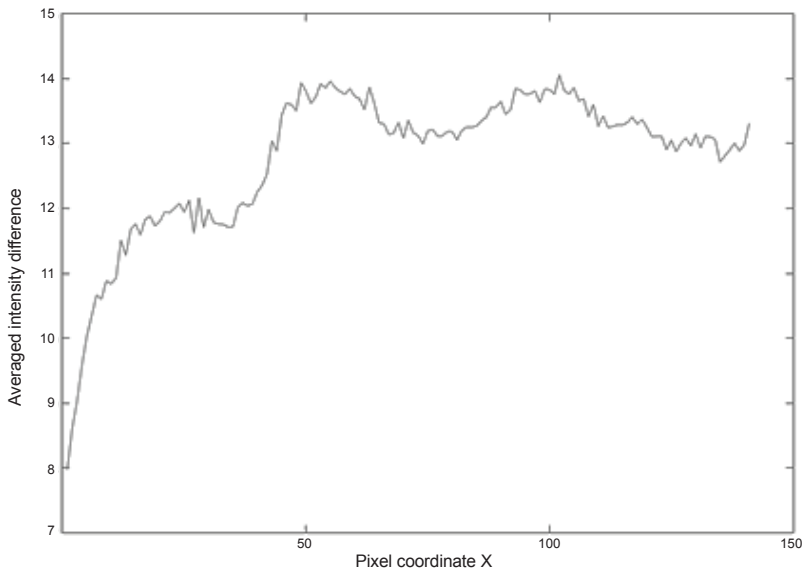


Figure 5. Distribution of data presented in Figure 4 with averaged values across Y axis and spanned along X axis which is the width of forehead zone of interest (Figure 3). Higher Intensity values indicate more intense IR-THz radiation in the FTE situation.

(2016) also used IR signals from blood vessels in the human forehead to establish a classification model of emotional and physical stress.

It is important to note that this correlation is observed in the range of ± 2 seconds relative to each GSR peak. This is quite a significant result, considering that all currently available measurements of IR radiation (without expansion into the THz range) and GSR indicate the presence of a long time lag between the appearance of the IR signal (> 10 s) and the generation of the GSR (3–5 s) (Ioannou et al., 2014).

There are questions about the origins of these discrepancies for the informativeness of measurements in the IR and IR-THz ranges. What is the role of the expansion of IR radiation in the THz range? Are there specific sources of THz radiation in a living body?

Despite the presence of the electric fields in the body and associated streams of differently charged atoms and molecules, as well as the translocation of polar molecules in the life cycle of any cell, the range of the electromagnetic spectrum in nature is very limited: This is either a static field (the potential of a resting membrane) or low-frequency oscillations Hz range (ion permeability kinetics) (Romanenko, Begley, Harvey, Hool, & Wallace, 2017). However, H. Fröhlich (Fröhlich, 1968) put forward a hypothesis about the existence of electromagnetic oscillations in living cells with frequencies up to several THz. The existence of longitudinal electric modes in biological systems is based on the unique dielectric properties of cell membranes and weak molecular bonds – for example, hydrogen. Research on the role and importance of collective interactions in biological systems has been a subject of relatively new scientific interest (Weightman, 2012). The results of these studies are to some extent consistent with Fröhlich's initial theoretical conclusions about the role and significance of THz radiation in biology. In brief, Fröhlich suggested that there is a system of dipole oscillators capable of forming long-range Coulomb interactions. Energy exchange is carried out with the help of energy quanta in a limited frequency range, and the whole system “generates a branch of Z-longitudinal electrical oscillations” (Fröhlich, 1986), with a limited frequency range. Moreover, if such a system has a stable and sufficient supply of energy, then it is possible to attain a steady state, which may be far from thermodynamic equilibrium (Fedorov, Serdyukov, Cherkasova, Popova, & Nemova, 2017).

The hypothesis that the sweat ducts of human skin can be the biological equivalent of helical antennas and, consequently, resemble their electromagnetic behavior when receiving signals in the THz frequency range (Kochnev, Betzalel, Ben Ishai, & Feldman, 2018), has been actively developed and received experimental confirmation in recent years. The sweat glands are controlled by the central nervous system; when activated, they release sweat into the sweat ducts – small tubular structures distributed throughout the outer layer of the skin – which in turn deliver sweat to the surface of the skin, where it evaporates. Signals from the sweat ducts are promising for the development of remote sensors for stress states and physiological parameters based on diagnostics of THz signals. It has been shown that sweating from the pores of the fingers can be recorded on IR images and perspiration drops may appear and disappear in less than 1 s. Their dynamics correlate well with the GSR signal (Znamenskaya et al., 2018).

Limitations

In the process of recording and analyzing IR-THz images, it was found that involuntary head movements associated with the stabilization of the body in space have a noticeable effect on the results of image processing, and this must be taken into account when further developing sensors for diagnosing PESs in real time (Berlovskaya et al., 2019).

Conclusion: Main Experimental Findings and Directions for Future Research

The results indicate that the subjective data of psychological testing of PESs may not coincide with the data of objective psychophysiological measurements. Perhaps these misalignments are due to the fact that for the assessment of PESs, different markers are distinguished and compared, namely, “direct” or primary, and “indirect” or secondary ones. Direct markers of PESs are those physiological processes that are directly involved in realizing the PES (first of all the hypothalamic-pituitary-adrenal axis). Indirect markers of PES are those psychological reactions and states that are the result of the restructuring of physiological processes under the influence of individual experience. It follows that for effective diagnosis and prediction of PES changes, it is important to consider both psychological (subjective) and psychophysiological (objective) data. The only question is how to organize the integration of these heterogeneous data and to consider their contribution to the complex assessment of PESs.

Of the greatest interest for applied psychophysiology is the correlation of the intensity of IR-THz radiation in the forehead with GSR, the most popular indicator of PESs. Along with data concerning the possibility of using THz waves for assessment of blood vessels (Berlovskaya et al., 2019), this opens up prospects for the development a new methodology for distant monitoring of the PES, based on IR-THz imaging of the face.

Our experiments showed that when a subject inhales, the intensity of the THz contribution to the total IR-THz signal of the radiation from the regions of the wings of the nose decreases. This phenomenon can be used to develop algorithms for contactless registration of the respiratory rhythm based on the analysis of THz images (Berlovskaya et al., 2019).

The results of this work and our previous research (Berlovskaya et al., 2019) show that, despite the relatively low signal-to-noise ratio and low frequency of image recording, it is possible to extract informative THz parameters of the broadband IR-THz signal and associate them with psychophysiological reactions (vascular system, GSR) confirmed by other methods of objective monitoring. It is obvious that improvement of IR-THz detectors and the development of new processing methods will allow wide use of the THz range for remote assessment of human PESs.

Acknowledgements

The research was supported by the Russian Foundation for Basic Research (project No. 17-29-02487). The authors acknowledge partial support from the Ministry of Science and Higher Education within the State assignment FSRC “Crystallography and Photonics”, Russian Academy of Science, and the M.V. Lomonosov Moscow State University Program of University Development up to 2020.

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Original manuscript received May 14, 2019

Revised manuscript accepted February 24, 2020

First published online June 25, 2020

To cite this article: Berlovskaya, E.E., Isaychev, S.A., Chernorizov, A.M., Ozheredov, I.A., Adamovich, T.V., Isaychev, E.S., ... Manaenkov, A.E. (2020). Diagnosing Human Psychoemotional States by Combining Psychological and Psychophysiological Methods with Measurements of Infrared and THz Radiation from Face Areas. *Psychology in Russia: State of the Art*, 13(2), 64–83. DOI: 10.11621/pir.2020.0205

EEG Patterns in Early Childhood Differ Between Children Prone To Reward “Bad” or “Good” Actors

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Background. Early childhood is a critically important period of development for the formation of personality. Many studies provide convincing proof that elements of moral behavior are observable already in the early stages of ontogenesis. Of particular interest for psychophysicologists is the question of whether the capacity for moral evaluation in younger children can be reflected in specific EEG patterns characteristic of them.

Objective. To establish specific patterns of EEG oscillations, including the frontal alpha-rhythm asymmetry, in young children who are prone to evaluate differently the behaviors of “helping” and “hindering” puppets.

Design. Fifty-six children aged 16 to 42 months participated in the study. To measure the level of moral evaluation in children, we used the method designed by B. Kenward and M. Dahl, with some modifications. The EEG was recorded when children distributed resources among the puppet-actors.

Results. When deciding how to distribute resources among the puppets, the children with a higher moral evaluation index demonstrated an overall higher alpha rhythm amplitude, as well as a specific pattern of theta rhythm amplitude. The moral evaluation indices correlated with alpha asymmetry in the EEG loci F7 and F8.

Conclusions. 1. Significant differences in EEG patterns were found between the children who showed different levels of moral evaluation. Children with higher indices of moral evaluation showed a higher alpha rhythm amplitude when deciding how to distribute resources among the puppets, depending on the puppets’ “helping” or “hindering” behavior. 2. The theta rhythm oscillation patterns differed significantly between the samples of children with different moral evaluation indices. 3. Alpha asymmetry in the dorsolateral prefrontal cortex (loci F7, F8) was correlated with the moral evaluation indices, indicating an increased activation in the prefrontal regions of the left hemisphere in children with a more developed understanding of moral behavior.

Keywords:
children,
early age,
moral evaluation,
alpha asymmetry,
EEG

Introduction

Moral behavior is considered as a form of prosocial behavior. Some researchers define morality as a set of prescribed norms that reflect concern for the well-being, rights, fairness, and justice of other people (Dahl & Killen, 2018; Turiel, 2015). Early childhood is seen as a period of development critically important for the formation of personality. Morality builds up through the processes of social interaction, self-reflection, and making judgments. Peer interaction plays a key role because it allows children to experience conflicts that make them reflect, summarize, and form an assessment of their daily interactions. A distinctive feature of moral behavior is its intentionality, which includes an understanding of individual goals and intentions. Intentionality can be viewed in line with understanding the mental states in other people (theory of mind). The process of moral evaluation gets increasingly complicated with the development of one's capacity to reflect upon others' internal states. At preschool age, it is still relatively difficult for children to understand the internal states of others (Killen, 2014).

In early childhood, the individual's motivational sphere starts developing, while definite behavioral patterns, attitudes toward other people, and elementary concepts of morality and ethics are being formed (Barsukova, 2010; Shelina, 2012). With that in mind, a considerable amount of research has recently been carried out to study the formation of moral behavior in the very early stages of ontogenesis (Decety, 2011; Güroğlu, 2011; Young, 2012). It has been demonstrated that even in infancy, children can share objects and try to console a person who looks frustrated (Dunfield, 2010; Paulus, 2012; Svetlova, 2010; Warneken, 2006).

It has been observed that 18-month-old children are already capable of providing the basic forms of instrumental help (for example, a child can pick up a fallen object to pass it to an experimenter who cannot reach it by himself), deliberately sharing resources (such as toys and other things belonging to the child), and consoling a frustrated person (Dunfield & Kuhlmeier, 2010; Paulus & Moore, 2012; Svetlova, 2010). It was discovered that one-year-old children choose more often to help other individuals in whose behavior they see prosocial tendencies (Dunfield & Kuhlmeier, 2010). Children aged between one and two years who are more prone to console others (Zahn-Waxler, 1992) are also better at controlling their negative feelings (Hoffman, 2000).

Morality research includes studies with younger children aimed at measuring their capacity to make moral evaluations. This capacity comprises both cognitive and emotional processes and plays a key role in prosocial motivation, as well as in making decisions in response to different social stimuli (Cowell & Decety, 2015). It is a common practice to assess children's capacity for moral evaluations within the context of fictional situations showing an interaction of "good" and "bad" actors. A child is asked to distribute a finite number of resources (such as sweets or toys) among those actors, following a demonstration of their interaction (Kenward & Dahl, 2011; Sampaio & Cabral, 2015).

In the past decade, neural mechanisms underlying prosocial and moral behaviors are drawing increased attention from researchers (Decety, 2012; de Greck, 2012; Mathur, 2010). EEG-based research is being devoted to studying the relationship between the functional asymmetry of the cerebral cortex and characteristics of moral behavior at different stages of a child's personality development. A smaller

alpha rhythm amplitude in a certain cortex region (or hemisphere) is thought to be an indicator of relatively more activity present there (Bazanova, 2012). There is evidence that the hemispheric asymmetry of the alpha rhythm amplitude in the frontal cortex can be associated with individual differences in social behavior, as well as a capacity to control one's negative feelings both in adults (Harmon-Jones, 2004; Wheeler & Davidson, 1993) and children (Buss, 2003; Smith, 2010). A number of studies show a positive relationship between children's moral behavior and their ability to control their negative emotions (Decety & Meyer, 2008; Moore, 2007).

It should be noted that analysis of the EEG is traditionally based on considering changes in the amplitude/power of different rhythms. It is recommended that their specific frequency ranges be defined relative to first finding the subject's individual alpha frequency range, which is particularly important when studying children (Bazanova, 2012).

Several works have explored possible relationships between various EEG indices and prosocial behavior (Gallo, 2018) and the development of moral evaluation (Cowell, 2015), both in children and adults. However, it is not yet clear whether the level of a child's capacity for moral evaluation might be reflected in specific EEG patterns under relevant experimental conditions.

Thus the aim of our work is to find out whether there are specific patterns of EEG oscillations, in particular frontal alpha rhythm asymmetry, in children aged about 1.5–3.5 years, depending on their capacity to morally evaluate the actions of interacting puppets. The children are divided into two samples based on their moral evaluation development. The EEG frequency ranges are defined individually for each subject.

Basic goals of the study:

1. To compare the patterns of EEG oscillations under a sustained attention condition between the two groups of children based on their level of moral evaluation;
2. To compare the patterns of EEG oscillations in the two groups of children under condition of making a moral evaluation of puppets' actions and distributing resources among the puppets;
3. To assess a possible relationship between the indices of prefrontal alpha asymmetry and the level of moral evaluation development in children.

Hypothesis: The level of moral evaluation development in early childhood may be reflected in specific EEG patterns in a condition of sustained visual attention and in the course of moral evaluation and distribution of resources among puppets.

Methods

The participants comprised 56 children (23 boys, 33 girls) aged 16 to 42 months. The mean age was 30.5 ± 6.5 (SD) months. The criteria for exclusion from an experimental sample were a birth weight less than 2.5 kg, known genetic disease, medical records showing CNS disorders, and clearly distinguishable left-handedness (a child prefers to use his/her left hand when manipulating objects and drawing).

To measure the moral evaluation index for each subject, we used a modified version of the method used by B. Kenward and M. Dahl (Kenward & Dahl, 2011).

Each child observed two scenes enacted by three puppets (manipulated by the experimenter): “neutral”, “good”, and “evil.” Both scenes started with the “neutral” puppet climbing up stairs, but half-way up it started showing difficulties in getting to the next step (the experimenter said: “Oh, I’m so tired. Who would help me step up?”). In the first scene, the “good” puppet helped the “neutral” one to step up. In the second scene, the “bad” puppet hurt the “neutral” one by pushing it down the stairs, while the latter puppet was saying: “Oh, that hurt me so much!”). After that, the “good” and “bad” puppets were placed before the child on the table and he/she was asked to evaluate their behaviors by distributing between them five cardboard “cookies”. The individual index of moral evaluation (IME) for each child was calculated according to *Table 1*.

Table 1
Indices of moral evaluation (IME)

cookies given to the “good” puppet	cookies given to the “bad” puppet	Score	cookies given to the “good” puppet	cookies given to the “bad” puppet	Score
0	5	1	2	3	11
0	4	2	2	2	12
0	3	3	2	1	13
0	2	4	2	0	14
0	1	5	3	2	15
1	4	6	3	1	16
1	3	7	3	0	17
1	2	8	4	1	18
1	1	9	4	0	19
1	0	10	5	0	20

EEG was recorded in two conditions: (1) in a wakeful resting state with sustained visual attention (SVA) and (2) during moral evaluation of the puppet’s behavior (distribution of resources). To provide sustained attention, the children were asked to focus on a screen with the video of a rotating ball with a changing geometric pattern (the EEG was recorded for 20–30 seconds). This method is commonly used when registering EEG in younger children (Marshall, 2008; Orekhova, 2006). The EEG record duration when children were distributing resources depended on how much time they needed to fulfill the task. The mean record duration was 28.8 ± 16.2 seconds, with minimal and maximal values being from 10 to 74 seconds. The EEG was recorded while the children were being held on the lap of their parent.

The EEG was recorded by Mitsar-EEG-10/70-201 encephalograph with WinEEG software (Mitsar, Russia) in 16 leads: prefrontal (Fp1, Fp2), frontal (F3, F4), posterior lower frontal (F7, F8), central (C3, C4), mid-temporal (T3, T4), posterior-temporal (T5, T6), parietal (P3, P4), occipital (O1, O2). Linked earlobe

electrodes were used as a reference electrode. The cutoff frequencies of high- and low-pass filters were 0.3 and 30 Hz, respectively; the EEG sampling rate was 250 Hz. The data were analyzed with the help of the WinEEG software. The EEG first underwent visual assessment to remove fragments with artifacts. For further processing, EEG segments with a duration of at least 10 seconds were divided into epochs of 2.56 seconds each. The EEG fragments were Fast-Fourier transformed with 50% overlap. The Butterworth filter with a passband of 2–25 Hz was used.

EEG parameters were calculated in individual frequency ranges. The individual alpha rhythm frequency range for each child was determined relative to the average frequency value of power spectra curve intersections when overlapping the cases of alpha synchronization and desynchronization in C3 and C4 leads. Desynchronization of the central alpha rhythm was normally observed when the child executed his/her own movements within the “perception and repetition of action” trial (not considered in this article), whereas synchronization occurred during the period of relative rest. The upper values of the theta rhythm and the lower values of the beta rhythm frequency ranges were determined relative to the individual alpha rhythm frequency range. Based on the known literature data (Marshall, 2008; Stroganova, 1999), the lower theta rhythm frequency range value was set at 3 Hz, and the upper beta rhythm frequency at 18 Hz. The amplitude values of each rhythm were log-transformed to normalize the distribution ($\lg, \mu\text{V}$). Values that went beyond the three sigma limits were discarded. The alpha rhythm asymmetry values were calculated based on the amplitude values in symmetrical leads using the formula ($\lg A_2 - \lg A_1$), where $\lg A_2$ and $\lg A_1$ are the decimal logarithm of the amplitudes for the left and right hemispheres, respectively.

To determine the differences in EEG patterns recorded both in the SVA and resource distribution conditions, repeated-measures ANOVA was used for comparing the groups of children who have either high or low IME. To determine a possible relationship between the IME values and alpha asymmetry in the prefrontal cortex, the Pearson parametric r criterion was used. Because the log-transformed EEG amplitudes were normally distributed, the IME parameters were then also normalized using Box-Cox transformations. The differences in the children's age (between the two IME groups) and in their IME values (between boys and girls) were estimated with the use of the t -test for independent samples.

Results

The IME values were calculated based on how the children evaluated the puppets' actions with a mean score of 13.7 ± 4.9 (mean \pm SD) points. This means that the children more often welcomed the behavior of the “good” puppet than the “bad” one. To establish specific features of EEG rhythms in children with different moral evaluation indices, the children were divided into two groups. Group 1 included 22 children, with IME below the sample mean, ranging from 1 to 13 points (8.7 ± 3.4); Group 2 included 34 children with IME above the sample mean, ranging from 14 to 20 points (17.0 ± 2.2). The mean age of children in Group 1 was 31.5 ± 5.9 months; in Group 2 it was 29.8 ± 6.8 months. There were no statistically significant differences between the groups in their age ($t = 0.92, p = 0.35$). In the group of boys, the average IME values were 13.6 ± 6.1 points; in the group of girls, 13.8 ± 3.9 points.

No significant differences were identified either between boys and girls in their IME ($t = 0.09, p = 0.92$).

The EEG rhythm amplitude differences depending on the children’s IME were analyzed with the repeated measures ANOVA, with the main factors being the IME group (inter-subject factor Group) and EEG loci (intra-subject factor Locus). For the SVA condition, the main effect of the Group factor was insignificant, as well as the effect of its interaction with the Locus factor. The only significant main effect was that of the Locus factor.

Analysis of the differences in EEG amplitudes during the task of resource distribution showed a number of significant effects (Table 2).

Table 2

ANOVA results for EEG rhythm amplitudes in children based on their IME and EEG locus when distributing resources

Theta rhythm			Alpha rhythm			Beta rhythm		
Group	Locus	Group × Locus	Group	Locus	Group × Locus	Group	Locus	Group × Locus
F(1, 26); η_p^2	p; F(15, 390); η_p^2	F(15, 390); p; η_p^2	F(1, 29); η_p^2	p; F(15, 435); η_p^2	F(15, 435); p; η_p^2	F(1, 27); η_p^2	p; F(15, 405); η_p^2	F(15, 405); p; η_p^2
0.003	22.022	2.153	3.582	8.818	1.744	1.023	29.377	1.400
0.958	0.000**	0.007*	0.068	0.000**	0.040*	0.320	0.000**	0.143
0.000	0.458	0.076	0.109	0.233	0.056	0.036	0.521	0.049

Note. Group – two groups with different IME; Locus – 16 EEG loci. Significance: * $p \leq 0.05$, ** $p \leq 0.001$

The theta and alpha rhythm amplitudes turned out to be affected significantly by the Locus factor and its interaction with the Group factor, while the beta rhythm amplitude was only affected by the Locus factor.

The means of log-transformed amplitudes for alpha and theta rhythms in each EEG locus during the task of resource distribution among the puppets are shown in Figure 1. For the alpha rhythm, note that its amplitude in a group of children with higher IME has higher values in 14 (of 16) loci if compared with a lower IME group. The method of individual contrasts (F-statistics) showed that these differences reach statistical significance in the temporal leads (T3, T5, T6) and the central lead of the left hemisphere (C3).

Although a significant interaction effect of the Group and Locus factors for the theta rhythm amplitudes was found, the method of individual contrasts did not show significant amplitude differences in each individual EEG lead. However, we can see in Figure 1 the pattern of differences in theta rhythm amplitudes for all EEG loci in general.

It is known (Gallo, 2018; Schulte-Rüther, 2007) that prosocial behavior and moral judgement are in the first place controlled by the frontal and prefrontal cortex regions (EEG loci Fp1, Fp2, F3, F4, F7, F8). Of interest is that the left and right hemispheres contribute differently to the manifestation of prosocial behavior and moral judgments. Based on this premise, we tried to determine a possible relation-

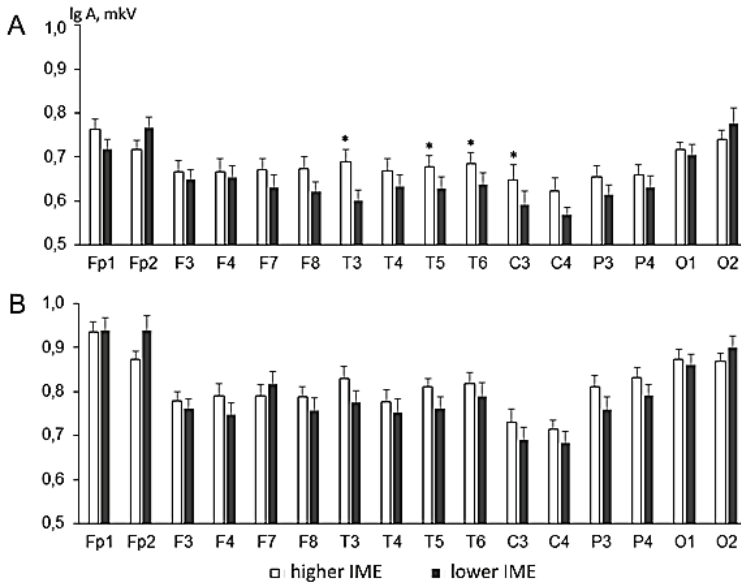


Figure 1. Alpha (fragment A) and theta (fragment B) rhythm amplitudes in children with higher IME (white columns) and lower IME (black columns) (index of moral evaluation).

Note. X-axis – EEG loci. Y-axis – mean EEG amplitudes with standard errors (lg (A), μ V). Significant differences are marked by “*” for $p \leq 0.05$.

ship between individual IME scores and interhemispheric alpha asymmetry indices, taken as indicators of hemisphere activation and calculated for corresponding pairs of left and right frontal electrodes. For the condition of resource distribution among the puppets, significant correlations were found between IME values and frontal cortex alpha asymmetry indices for the pairs of electrodes F8/F7 ($r = 0.46$, $p = 0.006$) and Fp2/Fp1 ($r = -0.34$, $p = 0.02$). The F4/F3 asymmetry index correlated with IME non-significantly ($r = 0.05$, $p = 0.73$). The remaining pairs of electrodes (C4/C3, T4/T3, T6/T5, P4/P3, O2/O1) were also routinely checked for significant correlations; there were none. After applying the Bonferroni correction method according to the number of calculated measurements, the only still sufficiently significant ($p < 0.05$) correlation was that with the F8/F7 alpha rhythm amplitude ratio. The lower alpha rhythm amplitude in the left hemisphere relative to the right one in children having higher IME scores indicates that, during the process of moral evaluation, the more activated left frontal cortex is associated with a higher level of moral evaluation development in younger children.

Discussion

The aim of the present work was to study possible neural correlates of moral behavior in early childhood based on the modified method of moral understanding assessment by Kenward and Dahl (Kenward & Dahl, 2011). We examined the

patterns of EEG in different experimental conditions in children having different scores for moral evaluation.

It was found that alpha and theta rhythm amplitudes differed significantly when the children were deciding how to distribute resources (cookies) among the “good” and “bad” puppets, if compared between the groups having higher and lower indices of moral evaluation. The higher IME group was characterized by a higher alpha rhythm amplitude. Taking into consideration the known role of alpha rhythm in inhibiting irrelevant signals (Bazanova & Vernon, 2014), we assume that an overall larger alpha rhythm amplitude in the higher IME group of children in the process of decision-making when distributing available resources among the actors may indicate that they possess a more optimal ratio of excitation and inhibition, higher emotional stability, and attention focus when fulfilling the task.

The topographical patterns of theta rhythm amplitude under the same condition also differed significantly between the studied groups. It is known that theta rhythm oscillations may reflect the processes of memorizing and retrieving information from memory, both in children and adults (Cuevas, Raj, & Bell, 2012). Thus, the differences we found may be associated with how the children engaged their cognitive resources when actualizing memory traces relevant to the task in regard to the puppets’ actions and deciding how to reward them afterwards.

In addition, we managed to find a significant correlation between the children’s IME score and the alpha asymmetry index in the dorsolateral prefrontal cortex (EEG loci F7, F8) when they distributed “cookies” among the puppets. Based on the idea that the level of cortex activation can be reflected in attenuated power of the alpha rhythm (Bazanova, 2011; McManis, 2002; Marshall & Meltzoff, 2011) and that a higher activation of the left frontal regions is associated with a greater ability to resist negative emotions (Mikhailova, 2017; Stroganova, 1999) and with so-called perceptual sensitivity, seen as a feature of temperament (Lobue, 2011), we presume that the more activated left prefrontal cortex underlies a more appropriate and socially acceptable evaluation of the puppets’ actions when performing moral evaluation of those observed characters.

The results of our study agree well with the conclusions made by some other researchers who demonstrated that the prefrontal cortex is involved in the process of analyzing situations that require knowledge of norms and rules (Prehn et al., 2008; Kostromina, 2017). Furthermore, the activation of the dorsolateral prefrontal cortex is associated with the ability to imagine other people’s emotional states (Decety & Moriguchi, 2007). It has been shown that an increased activation in the dorsolateral (BA 9) and frontopolar (BA 10) areas of the prefrontal cortex is registered in adults when they focus on their own emotional experiences, as well as when they try to interpret the emotions of others in photos (Schulte-Rüther, 2007). It is thought that understanding of others’ emotions (emotional empathy) is critically important in social interactions, moral decision-making, prosocial behavior, and in making moral judgments (Yodina, 2017).

To conclude, the results of our study show that children aged 16 to 42 months possess the capacity to positively evaluate moral behaviors performed by observed characters. The alpha and theta rhythm amplitude patterns differed between the groups of children who have higher or lower IME scores. The higher left prefrontal cortex region activation was characteristic of children who more often rewarded

the “good” puppet. Based on these results and the conclusions of other authors, we suggest that at least during an early childhood period, children who tend to reward more often actors who behave prosocially, themselves have a more developed ability to intentionally control their own behavior and emotions. The results show that there is a neural substrate of moral behavior even in very young children.

Conclusion

1. Children who demonstrate different levels of development of moral evaluation also have different patterns of EEG when performing relevant tasks. Children with a higher index of moral evaluation have a relatively increased alpha rhythm amplitude when deciding how to distribute resources between the “good” and “bad” puppets. We assume that the larger alpha rhythm amplitudes characteristic of them under a specified condition testifies to an optimal ratio of the processes of neural excitation and inhibition, emotional stability, and attention focus when fulfilling the task.
2. The topographical patterns of theta rhythm oscillations are different in the two groups of children and may be associated with how they engage their cognitive resources in memorizing and retrieving information relevant to the task in regard to the puppets’ actions, which is needed to then decide how to distribute available resources among them.
3. Frontal alpha rhythm asymmetry during the task of resource distribution correlated with the children’s moral evaluation index. The correlation was significant for the pair of EEG loci F7 and F8, which correspond to the dorsolateral prefrontal cortex. We assume that increased activation of the left prefrontal cortex when deciding how to reward the puppets may serve as a prerequisite for the more appropriate and socially acceptable evaluation of others’ behaviors observed by younger children.

Acknowledgements

The study was funded by the Russian Foundation for Basic Research (RFBR) and the Ministry of Education, Sciences and Youth of the Republic of Crimea, under research project No. 17-415-92001 “r_a”

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Original manuscript received February 11, 2019

Revised manuscript accepted March 15, 2020

First published online June 25, 2020

To cite this article: Orekhova, L.S., Makhin, S.A., Mikhailova, A.A., Pavlenko, V.B. (2020). EEG Patterns in Early Childhood Differ Between Children Prone To Reward “Bad” or “Good” Actors. *Psychology in Russia: State of the Art*, 13(2), 84–95. DOI: 10.11621/pir.2020.0206

CLINICAL PSYCHOLOGY

Validation of Emotional Thermometers as Screening Tools for Mexican Patients Undergoing Breast Biopsies

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Background. The need to evaluate the emotional changes women experience during the diagnostic stage of breast cancer creates the need for easily applicable short screening tools; thus, evaluations which rely on a single question and visual analogical scales are widely used in hospital environments.

Objective. This study aimed to determine the optimal cut-off points for anxiety, depression, and stress emotional thermometers measured against the Hospital Anxiety and Depression Scale anxiety and depression sub-scales (HADS-A and HADS-D), and the Cohen Perceived Stress Scale-14, respectively; in addition, the study aimed to evaluate the prevalence of these changes in women scheduled for breast biopsies.

Design. The study included 221 women who were scheduled for breast biopsies; their ages ranged between 28 and 80 years old. They were individually evaluated using the Emotional Thermometers, the HADS-A, the HADS-D, and the PSS-14 before undergoing their biopsies. Data from 203 participants were analyzed.

Results. The following optimal cut-off points were obtained: 3 for the anxiety emotional thermometer (*ET*) (sensitivity 0.71, specificity 0.25); 3 for the depression *ET* (sensitivity 0.87, specificity 0.34); and 4 for the stress *ET* (sensitivity 0.80, specificity 0.43). According to these cut-off points, 56% of the patients exhibited anxiety, 40% exhibited depression, and 55% exhibited stress.

Conclusion. Using emotional thermometers to screen anxiety, depression, and stress is therefore recommended in the context of breast biopsies.

Keywords:
emotional thermometer;
breast biopsy;
anxiety;
depression; stress

Introduction

Breast cancer is the second most common cancer in the world and the most frequent cancer in women, with approximately two million new cases in 2018 (Ferlay et al., 2019). The early detection of breast cancer is a fundamental strategy for its diagnosis, treatment, and control. In Mexico, the Secretary of Health has placed a permanent screening program in specialized units for women between the ages of 40 and 69 (Uscanga-Sánchez et al., 2014). Of women undergoing a mammography screening, 2-4% are referred for biopsies due to breast abnormalities (Alikhassi et al., 2015; Luiten et al., 2019).

The lesions suspected to be malignant are diagnosed using minimally invasive methods such as stereotactic and ultrasound-guided biopsies, which present the least risks of infection, tissue damage, and invasiveness (Gutwein et al., 2011). Despite this fact, women who undergo these procedures still demonstrate anxiety, physical discomfort, emotional stress, perceived stress, and moderate pain before, during, and after the biopsy procedures. These effects may persist for several weeks after the procedure, even after a woman receives a negative diagnosis for cancer (Bredal et al., 2013; Humphrey et al., 2014; Miller et al., 2013; Miller et al., 2014; Witek-Janusek et al., 2007).

The risk of a possible diagnosis, the invasiveness of the procedure, anxiety as a personality trait, chronic stress, and the level of coping skills are some of the most important psychosocial variables associated with anxiety before and after a breast biopsy (Raineri et al., 2019).

It has been recommended that all oncological patients undergo psychological evaluation as part of their standard treatment. Detection and treatment of psychological problems has been justified by the fact that patients with higher levels of psychological discomfort require more medical services, exhibit low adaptation to disease, are less likely to adhere to treatment plans, and have a higher degree of difficulty in making decisions. They also show more dissatisfaction with the medical care received, and a lowering of quality of life; such psychological discomforts are also associated with lower longevity (Jadoon, et al., 2010; Vázquez et al., 2013).

Furthermore, it has been found that stress and anxiety can influence post-surgery recovery time, the use of analgesics, and the length of hospital stay (Jiménez-Jiménez et al., 2013; Mavros et al., 2011; Montgomery et al., 2007; Tefikow et al., 2013).

Previous studies have shown that anxiety has negative consequences before, during, and after biopsy procedures. As far as we know, there have been no studies in Mexico that report on anxiety levels, depression, or stress in patients during biopsy programs; nor are there studies that validate an analogous visual scale to measure these variables.

The use of short screening tools such as visual analogue scales (VAS), which are easily implemented in hospital environments, is recommended for identifying patients who initially display symptoms of anxiety and/or depression; these patients can then be referred for subsequent and more thorough examinations so that they may receive adequate psychological care (Almanza-Muñoz et al., 2009; Boyes et al.,

2013). Some researchers have found a substantial correlation between the levels of stress, anxiety, and depression measured by VAS, and those measured by the Cohen Perceived Stress Scales (PSS) and the Hospital Anxiety and Depression Scale (HADS) in both medical personnel (Lesage et al., 2012) and cancer patients (Grassi et al., 2009; Lambert et al., 2014).

Roth et al. (1998) developed a distress thermometer for patients with prostate cancer. Subsequently, Mitchell et al. (2010) validated an emotional thermometer (ET) that incorporates analogue visual scales for depression and anxiety in cancer patients before their first chemotherapy treatment. However, as suggested by Ma et al. (2014), additional studies are needed to determine the accuracy and optimal cutoff point for ETs in different populations, as well as under different medical conditions, since the use of short scales as a screening tool for emotional changes during the diagnostic stage, particularly during breast biopsy, has not been widely studied.

The National Comprehensive Cancer Network (NCCN, 2018) recommends using the distress thermometer developed by Roth et al. in 1998. However, in some countries, including Spanish-speaking regions, the translation of the term “distress” is problematic because of a lack of a precise conceptual and operational definition of the term; thus it results in the use of different assessment tools. Additionally, different terms are used as synonyms for distress: *i.e.*, stress, anxiety, anger, tension, confusion, depression, intrusion, being sad, and feeling bad (Donovan et al., 2014; Gil et al., 2005; Montgomery & McCrone, 2010; Muszbek et al., 2006; Potter, 2007; Romito et al., 2013). This imprecision results in a risk of measuring different dimensions, whereas terms such as depression, anxiety, and stress are easily translated and understood, leading us to recommend measuring each of these variables separately.

Most studies of emotional thermometers have been carried out in Europe; thus, data is needed from Latin America and at different stages of cancer development (Harju et al., 2019).

The main objectives of this study were to determine the optimal cut-off points for the anxiety *ET*, depression *ET*, and stress *ET* measured against the Hospital Anxiety and Depression Scale for anxiety (HADS-A), the HADS for depression (HADS-D), and the Perceived Stress Scale (PSS-14), respectively, in women scheduled for breast biopsies, and to evaluate the prevalence of anxiety, depression, and stress in this population.

Methods

Participants

A non-probabilistic sample was used. A total of 221 women scheduled for ultrasound or a stereotactic-guided breast biopsies was invited to participate in the study. Of these, three refused to participate and nine did not complete the survey; six women did not meet the inclusion criteria, which included: 1) falling within the range of 28 to 80 years of age; 2) having had no previous breast biopsy; 3) being able to read and write in Spanish; and 4) having had no previous diagnosis of

cancer, psychiatric disorder, or mental deficiency. In the end, the data from 203 participants were analyzed (Figure 1).

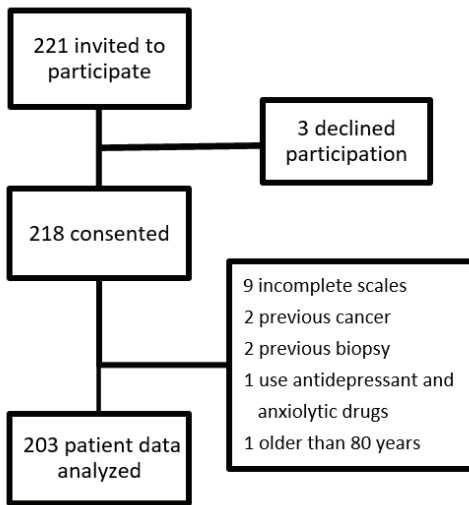


Figure 1. Flow diagram

The study was approved by the Bioethics Committee of the Bernardo Sepúlveda Hospital of the Secretary of Health of Nuevo León (protocol #14/597), where it was conducted. The samples were collected between January 2015 and December 2016.

Procedure

All patients who required biopsies due to abnormalities in their mammograms had been referred to the psychology department for evaluation by the surgeon of the breast disease clinic and the department of radiology. After signing the informed consent form, each individual patient underwent a semi-structured interview for the collection of sociodemographic data; then they were individually evaluated using the Emotional Thermometers, the HADS-A, HADS-D, and the PSS-14 before undergoing their biopsy. Each patient was briefly informed of what the emotional thermometer consists of and the variables being studied: anxiety, depression, and stress. The application of the evaluation instruments was conducted in the psychology department of the hospital by trained psychologists.

Questionnaires

A sociodemographic questionnaire was used for obtaining information regarding each woman's age, level of education, marital status, number of children, and socioeconomic status. To evaluate anxiety, depression, and stress, the following tools were used.

The *Hospital Anxiety and Depression Scale (HADS)* was developed by Zigmond and Snaith in 1982 and comprises a total of 14 questions: seven for measuring anxiety (HADS-A) and seven for measuring depression (HADS-D). The Spanish version of the scale developed by Tejero, Guimerá, and Farré (1986) which has a Cronbach's alpha coefficient of .80, was used in the present study. The HADS evaluates the psychological aspects of anxiety and depression, but does not consider symptoms such as insomnia, fatigue, and appetite loss. In each subscale, readings above the cut-off point of 8 indicate changes on the clinical level.

The *Perceived Stress Scale (PSS-14)* of Cohen, Kamarck, and Mermelstein (1983) contains 14 questions and evaluates the degree to which life situations are perceived as stressful by an individual. The questions are classified on a 5-point Likert scale (0 = never, 1 = almost never, 2 = sometimes, 3 = often, and 4 = very often). A larger score indicates a greater level of stress. The present study used the scale's Mexican version developed by González and Landero (2007). González-Ramírez, Rodríguez-Ayán, and Hernández (2013) proposed that a standard deviation above the mean can be used as an indicator of clinical stress.

The *Emotional Thermometer (ET)*, developed by Mitchell et al. (2010), is a combination of five visual analogical scales that measure stress, anxiety, depression, anger, and the need for help. These scales contain 11 degrees from 0 to 10, with 0 representing the absence of the emotion, and 10 the maximum level of the perceived emotion. The recommended cut-off point for all the scales is 3 vs 4, with a sensibility of 92% and specificity of 61% for the anxiety thermometer, and a sensibility of 60% and specificity of 78% for the depression thermometer, as compared with the HADS subscales. For the present study, only the anxiety and depression thermometers were used, and a thermometer for measuring stress was added.

Statistical analysis

The statistical analyses were performed using Windows program SPSS 21. For validating the optimal cut-off point of the anxiety *ET*, the point system of the HADS-A subscale was used (cut-off 7 vs 8); for the depression *ET*, the point system of the HADS-D was used (cut-off 7 vs 8), as recommended by Mitchell et al., (2010); and for the stress *ET*, the point system obtained in the PSS-14 was used, as recommended by González-Ramírez, et al. (2013). They propose that the average of the group, plus one standard deviation, should be considered as indicative of stress on a clinical level (cut-off 27 vs 28).

Using a 2×2 table, the Positive Predictive Values (PPV) [true positive/total positive] and Negative Predictive Value (NPV) [true negative/total negative] were obtained. A Receiver Operating Curve (ROC) was generated through which the Area Under the Curve (AUC), sensibility, and specificity were obtained. A Spearman correlation was performed to determine the effect size (small = .10, medium = .30, and large \geq .50) between the variables (Téllez et al., 2015). Finally, based on the cut-off points, the frequencies and percentages of women who exhibited anxiety, stress, and depression were obtained.

Results

Socio-demographic data

Of the 221 patients who consented to participate, 203 were evaluated using the various tools. The average age of the participants was 48 years (SD = 10.9), 64.8% lived in a conjugal relationship, and 28.6% were employed. The average number of years of education was 8.4 (SD = 3.7), and the average monthly income was 193 U.S. Dollars (SD = 214 USD).

Properties of the ETs as diagnostic tests

Table 1 presents the cut-off points that are considered most adequate according to the ROC. For the cut-off point of 3 on the anxiety ET, an AUC of .789 was obtained [95% confidence interval (CI) = .726, .852; $p = .000$]; for the cut-off point of 3 on the depression ET, an AUC of .855 was obtained [95% CI = .784–.925; $p = .000$]; and for the cut-off point of 4 on the stress ET, an AUC of .734 was obtained [95% CI = .629–.839; $p = .001$].

Table 1

Psychometric properties of the ETs

	Sensitivity	Specificity	PPV	NPV	Accuracy
ET Anxiety Cut-off 3	0.71	0.25	0.75	0.70	.789
ET Depression Cut-off 3	0.87	0.34	0.25	0.97	.855
ET Stress Cut-off 4	0.80	0.43	0.15	0.96	.734

ET= Emotional Thermometer, PPV=Positive Predictive Value, VPN=Negative Predictive Value

The correlation analysis between the scales shows a positive correlation with a large and statistically significant effect size between the HADS-A subscale and the ET anxiety scale ($r_s = .633$, $p = .01$), as well as between the HADS depression subscale and the ET depression scale ($r_s = .566$, $p = .01$). A positive correlation with a medium-large effect size was also found between the PSS-14 and the ET stress scales ($r_s = .403$, $p = .01$).

Prevalence of anxiety, depression, and stress according to the cut-off points obtained

The average score on the anxiety ET was 3.7 (SD = 3.2) and for the HADS-A was 7.7 (SD = 4.2); for the depression ET the average score was 3.2 (SD = 3.3) and 3.7 on the HADS-D (SD = 3.1). The average obtained for the stress ET was 4.0 (SD = 3.0), and on the PSS-14 the average was 21.3 (SD = 7.5).

According to the cut-off points used in the ETs, 56% of the patients exhibited anxiety, 40% exhibited depression, and 55% exhibited symptoms of stress (Figure 2).



Figure 2. Prevalence of anxiety, depression, and stress

Discussion

The primary objective of this study was to determine the optimal cut-off points for the anxiety and depression thermometers as compared to the HADS scale for evaluating anxiety and depression, and the same for the stress thermometer measured against the PSS-14. Although the thermometers were applied to women who had not yet been diagnosed with cancer, a cut-off point of 3 for anxiety and depression, and 4 for stress, coheres with the results of Mitchell et al. (2010), who suggested a cut-off point of 3 vs 4 for all the thermometers used with cancer patients; and with those of Beck et al. (2016), who found a cut-off point of 4 for anxiety and 3 for depression in patients with different types of cancer. Shahvaroughi et al. (2019) have also established a cut-off point of 3 for the Persian version of the anxiety and depression thermometers in Iranian patients with advanced cancer.

Some other studies have found different cut-off points than we did in this study. For instance, Teixeira et al. (2020) found a cut-off point of 5 vs 6 for anxiety, and 4 vs 5 for depression in a validation of emotional thermometers in Portuguese patients receiving treatment for different types of cancer. Civilotti et al. (2020) applied the distress thermometer against HADS in patients with a recent diagnosis of breast cancer, recommending a cut-off point of 4 for anxiety, depression and distress. A systematic review by Harju et al. (2019) found that most authors suggest a cut-off point to be equal or higher than 4 for anxiety and depression thermometers. Probably the differences in the results of those authors and our study is due to the different instruments used to validate the thermometers.

The original study involving the emotional thermometers developed by Mitchell et al. (2010) found an average of 4.78 for anxiety level and 2.34 for depression, while our study found average levels of 3.7 for anxiety, 3.2 for depression, and 4 for stress. These scores are higher than those reported by Hinz et al. (2019) in the general German population; they found an average of 1.3 for anxiety level and 1.6 for depression. The slight differences in the results obtained in both studies may be explained by differences between the medical conditions and demographics of the patients.

The averages of 7.7 for anxiety measured using the HADS-A, 3.7 for depression measured using the HADS-D, and 21.3 for stress using the PSS-14 corroborate the results obtained by other authors for anxiety and depression before biopsies (Lampic et al., 2001; Dey et al., 2002; Kamath et al., 2012). On the other hand, Gibbons et al. (2016) obtained an average of 23.4 for stress at the time of diagnosis.

In the present study, the anxiety, depression, and stress *ETs* displayed adequate levels of sensibility at $>.70$, demonstrating that they have a great ability to detect patients undergoing these changes; however, they also displayed low levels of specificity at $<.50$, which may hinder their ability to screen those without such changes, thus potentially increasing the probability of false positives. However, in the present study scenario, it is preferable to detect the majority of patients who do exhibit emotional changes.

As for the predictive value, it was observed that the depression and stress *ETs* display a high NPV, thus reflecting a low prevalence of these symptoms in the studied population (Colimon, 1990); however, a high NPV minimizes the false negatives, and an optimal cut-off point for screening based on a specific population requires a minimum number of false negatives (Bidstrup et al., 2012). The predictive values for both positives and negatives for the anxiety *ET* yield a result of 70%, reflecting a prevalence of approximately 50%. This is in agreement with the prevalence results obtained in this study based on the cut-off points selected.

However, the AUC provides a means to discriminate between those people who experience the variable of interest vs those who do not. An AUC value between 0.7 and 0.8 is considered in line with acceptable discrimination (Hosmer & Lemeshow, 2000), in addition to being an indicator of diagnostic exactness (Schubart et al., 2015). The three thermometers we measured achieved adequate AUC values, which, in addition to the results obtained from the correlation between the *ETs*, the HADSs, and the PSS-14, indicates that the *ETs* may be used to detect patients who require a more thorough evaluation for anxiety, depression, and stress. These results for sensibility, specificity, and AUC are similar to those reported by Mitchell et al. (2010) for selected cut-off points in patients with cancer.

In our sample, 56% of the patients exhibited anxiety, 40% exhibited depression, and 55% exhibited stress symptoms; that is, approximately half of the patients presented some type of emotional change related to the biopsy procedure. In a study of the diagnostic period involving mammograms and biopsies, Lampic et al. (2001) found that of 509 patients, 46% exhibited anxiety and 11% exhibited depression. In a recent study, Moseholm et al. (2016) found that 34% of a sample of 666 patients with all types of cancer, exhibited anxiety, and 24% exhibited depression before the diagnosis. Similar data was found by Civilotti et al. (2020) in Italian women with newly diagnosed cancers; 52.1% of the women affected by breast cancer presented anxiety symptoms, whereas 33% presented depressive symptoms. Regarding stress, Turkoglu and Mutlu (2016) found that 33% of patients exhibited stress before undergoing any type of biopsy.

Research into psychological disorders and tools used during the diagnostic process could help identify women who are at risk for chronic psychological problems and social isolation during their cancer treatments. This in turn could help identify risk and protective factors for these women and help to develop specific intervention techniques for them (Kamath et al., 2012). For example, Perlman et al. (2016) suggest that strategies for improving the mood of women who are facing breast biopsies could greatly benefit them. Téllez et al. (2016) and Sánchez-Jáuregui et al. (2018) used an intervention with hypnosis and music, and found a decrease in anxiety, stress, and pain, as well as an increase in optimism and well-being both before and after the biopsy. Furthermore, to improve the biopsy experience, Soo et

al. (2019), recommend giving information about the procedure before the biopsy, providing a comfortable and private waiting room space, and using local anesthesia, anxiolytics, or psychotherapeutic interventions such as hypnosis, relaxing music, and guided meditation.

To the best of our knowledge, ours is the first study reporting the adequate adaptation of ETs for women scheduled for breast tissue biopsies. The thermometers are a useful and reliable tool to screen emotional changes in a hospital environment, allowing medical personnel to identify patients who display results above the cut-off point, and to channel them for more thorough psychological evaluation.

Finally, although the importance of evaluating psychological changes during the medical procedures and the usefulness of short tests such as ETs has already been demonstrated, less than 15% of medical personnel use screening tools in clinical practice (Mitchell et al., 2008). Therefore, we strongly recommend using this tool as a regular part of the medical routine in the context of the diagnosis of breast cancer.

Conclusion

The evaluation of emotional changes during the biopsy procedure for suspected breast cancer is important. The anxiety, depression, and stress ETs are precise screening tools when used with the cut-off points suggested in the present study. In addition, they are low-cost and easily applicable in a hospital context.

Limitations

Our study has some limitations, such as the fact that the validation of the emotional thermometers was done by comparing them with the HADS subscales, in which low scores of anxiety and depression were obtained. Thus, in future studies it would be advisable to use other standardized diagnostic scales, such as the Structured Clinical Interview for DSM-IV to confirm the results. It is also important to consider that the population we studied has a low degree of education and income, so the results cannot be generalized to populations with different characteristics.

Acknowledgements

This research was supported by the Mexican Avon Breast Cancer Crusade, 2016 (Project No. 66).

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Original manuscript received November 05, 2019

Revised manuscript accepted April 18, 2020

First published online June 25, 2020

To cite this article: Sánchez-Jáuregui, T.J., Juárez-García, D.M., Téllez, A. (2020). Validation of Emotional Thermometers as Screening Tools for Mexican Patients Undergoing Breast Biopsies. *Psychology in Russia: State of the Art*, 13(2), 96-108. DOI: 10.11621/pir.2020.0207

Task Switching in Normal Aging and Mild Cognitive Impairment: A Diffusion Model Analysis of Reaction Times

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Background. Aging is associated with decline in various cognitive functions, including task switching – the ability to shift quickly between tasks and mind-sets. Previous research has shown that older adults exhibit less efficient task switching. Mathematical modeling of cognitive processes involved in switching between tasks may shed light on the sources of switching inefficiency in normal and pathological cognitive aging.

Objective. To investigate possible sources of task-switching decline in normal and pathological (mild cognitive impairment, MCI) cognitive aging using the Diffusion Model (DM).

Design. 57 young adults, 34 healthy older participants, and 5 MCI-diagnosed older participants performed the commonly used Number-Letter switching task. Reaction times (RT) and accuracy were measured and Diffusion Models were fitted to individual reaction time distribution to obtain parameters characterizing processes involved in task switching: active, controlled task-set reconfiguration; passive, automatic task-set inertia; and response caution.

Results. Older age and MCI-pathology-related effects on switching efficiency were found for RT and, partly, for accuracy. After controlling for possible age differences between the two older groups, active processes of task-set reconfiguration had a clear MCI-related deficit, while passive, automatic task-set inertia components only exhibited a general effect of aging (pathological or not). Response caution was only related to older age, with no MCI effect.

Conclusion. Effortful task-set reconfiguration is sensitive to both age and MCI pathology, while passive processes of task-set inertia dissipation is only subject to age changes. The results support the idea of different dynamics of controlled and automatic cognitive processes in normal and pathological (MCI) aging.

Keywords:

cognitive aging, mild cognitive impairment, task switching, drift-diffusion model, task-set reconfiguration, task-set inertia, response caution

Introduction

Normal and pathological aging are characterized by various types of cognitive decline. A typical correlate of aging is the decline of cognitive control (or executive) functions. Cognitive control is crucial for goal-directed behavior under changing and less structured conditions (Lezak, 1982), so its decline leads to less effective adaptation. Among cognitive control functions, task switching that is responsible for cognitive flexibility (also termed “shifting” in the executive functions literature) may especially be affected by aging. Task-set switching implies the ability to quickly transit from performing one task to performing another, and is generally related to the ability to change one’s mindset (Jersild, 1927). In cognitive control studies, task-switching ability is often tested experimentally with tests involving alternation between two simple tasks, such as judging digits’ parity or deciding whether a letter is a vowel or a consonant (Rogers & Monsell, 1995).

Reduced switching efficiency has been reported both for non-pathological aging (Kray & Lindenberger, 2000; Wasylyshyn, Verhaeghen, & Sliwinski, 2011) and pathological aging (Hutchison, Balota, & Duchek, 2010). In a previous study, we showed that there are signs of less effective task switching even in young, cognitively healthy individuals with an elevated genetic risk of developing dementia (ApoE-e4 carriers; Velichkovsky, Roshchina, & Selezneva, 2015). These results, among others, indicate that exploring task-switching performance may be a promising early indicator of age-related cognitive decline. In this study, we applied the methodology of drift-diffusion models (DDM) of reaction times (RTs) for a more detailed assessment of task-switching processes in healthy controls (both young and old) and a sample of persons with mild cognitive impairment (MCI).

The DDM Approach and Task Switching

The diffusion model approach (Ratcliff, 1978) to RT in two-choice decisions analysis assumes that the processing of a task is well described as a noisy process of evidence accumulation towards a response criterion. According to this model, a stimulus acts as a source of data which is consistent with one of the response alternatives and continuous evidence accumulation acts as a basis for decision making. Stimulus processing, from this point of view, is assumed to have a constant slope (drift rate, ν), and the normally distributed noise explains RT incongruence in subsequent trials. The amount of evidence needed to be accumulated before a response can be elicited is also one of the diffusion model parameters (response criterion, a). Moreover, the relative position between two response barriers at the start of the decision process can be biased towards one of the response barriers (i.e., representing an a priori bias; starting point, z). The diffusion model also considers RT as reflecting both the decision and non-decision processes; therefore, a separate parameter is presented in the diffusion model – the non-decision time (t_0).

The main advantages of applying a diffusion model to RT/accuracy data are the introduction of a common metric for assessing individual performance of a task (Voss, Nagler, & Lerche, 2013) and more exhaustive data utilization (i.e., actual RT distributions for two response alternatives). Furthermore, diffusion model

parameters can be mapped onto psychologically meaningful variables that are essential in a certain task processing. In the case of non-decision time (t_0), these corresponding cognitive processes are stimulus encoding and motor-response execution. However, in the specific task-switching paradigm, this parameter can also reflect active, effortful, voluntary task-set reconfiguration or preparation (Schmitz & Voss, 2012). Drift rate (ν), which is usually interpreted as the speed of information uptake, corresponds to a later phase of information processing when a certain task-set is applied to a stimulus to generate a response. Consequently, in the task-switching context, drift rate is thought to reflect target task-set readiness and carry-over effects from previous trials – that is, passive and automatic processes of task-set inertia (Schmitz & Voss, 2012). The response criterion (a) is basically viewed as representing caution while making a decision (Ratcliff & McKoon, 2008). From the task-switching perspective, it is reasonable to suggest that response caution may increase in switch trials, as they are more resource-demanding than repeat trials (Schmitz & Voss, 2012).

Method

Sample

Ninety-six research volunteers participated in the study. They made up three groups: 57 healthy young adults (mean age = 25.5, range = 19–33, 38 female and 18 male), 34 healthy older adults (mean age = 58.5, range = 45–73, 20 female and 14 male), and 5 older participants with MCI (mean age = 73.6, range = 62–86, all female). All participants from the healthy older group were tested with Alexander Luria's neuropsychological test battery and the Montreal Cognitive Assessment Scale (MoCA) and scored at least 26 points on the latter, indicating absence of dementia. Participants with MCI were outpatients examined at the Geriatric Psychiatry Division of the Mental Health Center (Moscow, Russia).

Experimental Task

A variant of the Number-Letter task was used (Rogers & Monsell, 1995), commonly employed to assess task-switching efficiency in various populations. The screen was divided into four quadrants and a number-letter pair was presented sequentially in each quadrant in counterclockwise order. When a pair was presented in either of the upper quadrants, the task was to classify the stimuli according to the number's oddness. Participants were instructed to indicate whether a letter was a consonant or a vowel when a pair was presented in the two bottom quadrants. Tasks were alternated regularly and in a strict order, allowing participants endogenous cueing. The answer was given by pressing either the 'Z' or 'I' key on the keyboard, as they corresponded to the response categories ('Z' for odd numbers and vowel letters; 'I' for even numbers and consonant letters). The response-stimulus interval (RSI) was set to 500 ms, and stimuli were displayed until a response was given with a button press with the left and the right hand. There were no task pure-blocks, so only local switch costs could be estimated. The participants performed 24 training trials, preceding 128 test trials.

Procedure

Testing was run in individual sessions. Each participant read the on-screen instruction and was assisted by a session administrator. The number-letter task was always the first task in a series of executive tasks (antisaccade task and n-back task, not reported here). It was administered to an older participant immediately after mental state testing in case of a suitable result (e.g., at least 26 points in MMSE). The transition from training to test session was explicitly cued. Completion of the task took up to 8 minutes in younger adults and up to 15 minutes in elders.

Data Analyses

Trials from the training session were excluded from future analysis, as well as RT outliers from 128 test trials. We did not remove post-error trials and our outliers exclusion criterion was the presence of an observation in 95% of the most prolonged RTs, merged from all the groups. We also included data from participants with any accuracy scores, as we did not have a priori assumptions about MCI or healthy older groups' representative accuracy scores.

We conducted two main branches of analyses, one based on RT and accuracy scores and the other upon estimated diffusion model parameters. Both were supposed to consider performance in repeat and switch trials separately, assuming that the difference between them represents local switch costs. In the RT/accuracy set of analyses, we averaged the performance of each participant in two types of trials and conducted a mixed 3×2 ANOVA with Group (young, older, MCI) as a between-subjects factor and Trial type (repeat, switch) as a within-subjects factor. The same was done for the estimated DM parameters. We used the *fast-dm* software (Voss & Voss, 2007) and its implementation of the Kolmogorov-Smirnov (KS) method to estimate a separate model for each participant in each trial type. Most of the DM parameters were free to vary across conditions with the exception of the starting point, which was fixed in the middle between response barriers, and inter-trial variability of the starting point and drift rate variability, which were set to zero.

Results

Descriptive statistics for behavioral data are presented in Table 1. RT/accuracy group differences in both trial types are shown in Figure 1. Group mean estimates for diffusion model parameters in each of the trial types are shown in Figure 2. Each individual model fit was at least reasonable, and good in most cases (KS $ps > 0.1$).

A significant main effect of Trial type was found for RT ($F(1, 93) = 266.9, p < 0.001$) and for accuracy ($F(1, 93) = 21.9, p < 0.001$), indicating longer RT and more error-prone processing in switch relative to repeat trials. The effect of Group was significant for RT ($F(2, 93) = 33.17, p < 0.001$), but not for accuracy ($F(2, 93) = 2.02, p = 0.138$), reflecting the increase in RT which propagated from young adults to older adults (post Tukey hoc test; $p < 0.001$) and from healthy older adults to the MCI-diagnosed group ($p < 0.001$), and similar accuracy across groups. The two-way Group \times Trial interaction was significant for RT ($F(2, 93) = 6.54, p = 0.002$) and only marginal for accuracy ($F(2, 93) = 2.16, p = 0.12$), indicating larger RT

local switch costs for healthy older adults and even larger switch costs for MCI-diagnosed participants. Post hoc tests revealed no differences in accuracy between groups ($p > 0.1$ in all pairs).

Table 1

Descriptive statistics for RT (ms), accuracy (proportion correct), and diffusion model parameter estimates of young, healthy older, and MCI-diagnosed participants, split by the trial type.

Trial	Young		Older Healthy		MCI	
	M	SD	M	SD	M	SD
Repeat						
RT	972	386	1276	439	2484	1022
Accuracy	0.93	0.11	0.86	0.21	0.8	0.25
Non-decision time	0.3	0.1	0.42	0.16	1.13	0.68
Drift rate	1.97	1.09	1.22	0.87	0.86	0.81
Response criterion	2.04	0.5	2.29	0.71	2.77	0.92
Switch						
RT	1582	505	2139	741	3680	1078
Accuracy	0.9	0.13	0.85	0.21	0.8	0.32
Non-decision time	0.46	0.23	0.85	0.44	2.12	1.66
Drift rate	1.07	0.51	0.89	0.73	0.52	0.49
Response criterion	2.59	0.62	2.78	0.75	3.21	0.79

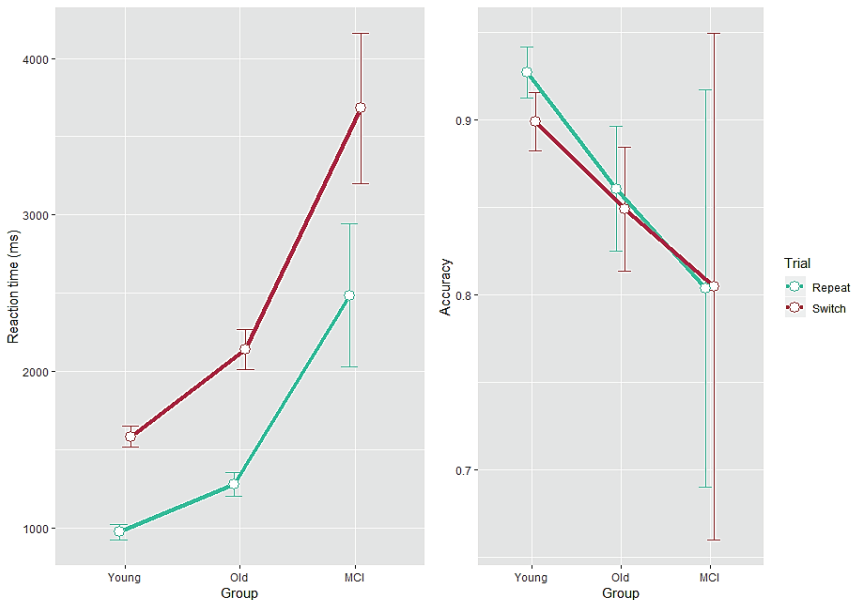


Figure 1. Reaction time (left panel, ms) and accuracy (right panel, proportion correct) as a function of Group for each Trial type. Error bars indicate one standard error from the mean.

For non-decision time (t_0), we found main effects of Group ($F(2, 93)=43.96$, $p<0.001$), and Trial ($F(1, 93)=53.71$, $p<0.001$), and a significant interaction between them ($F(2, 93)=12.03$, $p<0.001$), indicating an increase for older participants relative to young adults (Tukey post hoc Bonferroni-corrected tests; $p<0.0005$) and a steeper effect for the MCI group (as compared with the healthy older group; $p<0.0001$). For drift rate (v), we found main effects of Group ($F(2, 93)=5.87$, $p=0.004$), Trial type ($F(1, 93)=88.97$, $p<0.001$), and a significant interaction ($F(2, 93)=7.87$, $p<0.001$). In contrast to t_0 , the most pronounced effects on v were found in young adults. Post hoc tests revealed that young adults and healthy older adults differed significantly ($p<0.02$), while there was no specific effect for the MCI group compared with the healthy older group ($p>0.1$). For response criterion (a), we found main effects of Group ($F(2, 93)=4.19$, $p=0.018$) and Trial ($F(1, 93)=72.04$, $p<0.001$), but no interaction ($F(2, 93)=0.15$, $p=0.86$), indicating similar response-criterion differences in all groups. Tukey tests showed that increase of caution on the part of healthy older adults compared with young adults was marginally significant ($p=0.1$) and the MCI-diagnosed participants were no more cautious than the healthy older adults ($p>0.1$). However, young and MCI participants differed significantly ($p<0.03$).

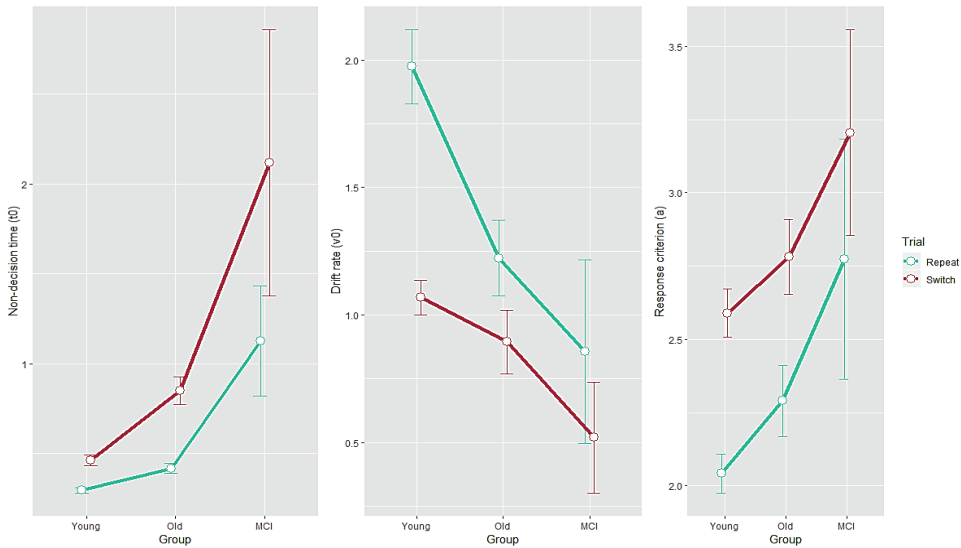


Figure 2. Diffusion model parameter estimates as a function of Group for each Trial type. Non-decision time (t_0), drift rate (v) and response criterion (a) are shown in the left, middle and right panel, respectively. Error bars indicate one standard error from the mean.

As the healthy older group and the MCI group differed significantly by age (the MCI group being older, $p<0.05$), the obtained effects may be due to normal, non-pathological aging processes, which may occur in MCI-diagnosed people along with many other pathological processes. To address this issue, we performed an additional analysis, statistically controlling for possible age differences. To this end, we regressed each dependent variable (RT, accuracy, t_0 , v , a) on age (simple linear regression) in all three groups and repeated the above analysis on regression residuals. In so doing, we hoped to cancel out possible effects of age. We hypothesized

that if there is a genuine MCI effect, the young group and the healthy older group will cease to be statistically different, but the MCI group will still differ significantly from them.

Descriptive statistics for RT and accuracy after controlling for age are given in Table 2. Group mean estimates for residual RT and accuracy in each of the trial types are shown in Figure 3.

Table 2

Descriptive statistics for residual RT, accuracy, and diffusion model parameter estimates of young adults, older adults, and MCI-diagnosed participants.

Trial	Young adults		Older adults		MCI-diagnosed adults	
	M	SD	M	SD	M	SD
Repeat						
RT	-267.69	385.49	-624.77	453.7	286.34	872.85
Accuracy	0.015	0.111	0.007	0.208	-0.023	0.255
Non-decision time	-0.055	0.105	-0.359	0.182	0.161	0.587
Drift rate	0.456	1.094	0.18	0.87	0.026	0.794
Response criterion	-0.253	0.496	-0.315	0.706	0.029	0.858
Switch						
RT	342.66	503.44	238.85	718.77	1483.19	926.83
Accuracy	-0.013	0.126	-0.005	0.206	-0.022	0.326
Non-decision time	0.112	0.232	0.072	0.449	1.149	1.559
Drift rate	-0.45	0.514	-0.149	0.718	-0.31	0.503
Response criterion	0.294	0.62	0.176	0.735	0.461	0.837

The same analyses as above were conducted on the residuals. For RT, a mixed ANOVA found a main effect of Group ($F(2, 93) = 11.1, p < 0.001$), a main effect of Trial ($F(1, 93) = 266.9, p < 0.001$), and a significant interaction between them ($F(2, 93) = 6.54, p < 0.01$). Post hoc tests revealed that there was a systematic increase in RT from the young adults through the healthy older participants (who, however, did not differ from each other, $p > 0.06$) to the MCI group ($p < 0.001$ in comparisons with both young and older healthy adults) and that switch trials were processed slower than repeat trials. Importantly, the two-way interaction was driven by the MCI group having significantly slower RTs than both the young and the healthy older groups in the switch trials. For accuracy, only a main effect of Trial was found ($F(1, 93) = 21.9, p < 0.001$), again indicating more errors in the switch trials. Post hoc tests revealed no differences in accuracy for either pair of groups.

Descriptive statistics for residual DM parameters are given in Table 2. Group mean estimates for each parameter in each of the trial types are shown in Figure 4. However, the DM parameters have lost their direct psychological interpretation (i.e., t_0 as time), because RTs (non-negative by definition) were not used, but rather residuals (which can be negative). So, now parameters can be negative and it is not the parameters' values in themselves, but their relation to each other, that matters.

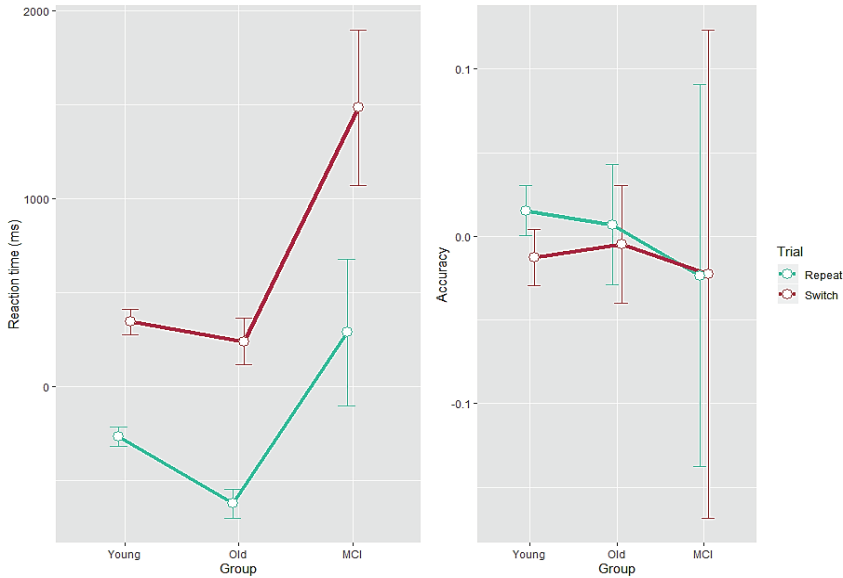


Figure 3. Residual reaction time (left panel, ms) and residual accuracy (right panel, proportion correct) as a function of Group for each Trial type. Error bars indicate one standard error from the mean.

For the “non-decision time” (t_0 , which can now be negative), an ANOVA revealed all three effects: a main effect of Group ($F(2, 93) = 18.1, p < 0.001$), a main effect of Trial ($F(1, 93) = 53.7, p < 0.001$, switch trials having larger t_0), and a significant interaction between them ($F(2, 93) = 12.0, p < 0.001$). Tukey’s post hoc test revealed that the Group effect consisted in the young and the healthy older groups forming a homogenous cluster ($p > 0.05$) and the MCI group differing from them with significantly higher t_0 values ($p < 0.001$ when comparing with healthy older adults). Post hoc t -tests showed that the Group \times Trial interaction was driven by a tendency of the MCI group to have higher t_0 in specifically switch trials. For the drift rate (ν), only a main effect of Trial ($F(1, 93) = 89.0, p < 0.001$) and the two-way Group \times Trial interaction ($F(2, 93) = 7.87, p < 0.001$) were found. Post hoc t -tests revealed that this interaction was quite different from the interaction obtained for residual t_0 . Residual drift rate did not differ between groups in switch trials after controlling for age ($p > 0.05$), but was significantly more negative in the young group in repeat trials (indicating quicker accumulation of information in repeat trials than in switch trials in the young group, $p < 0.02$). Thus, there was no genuine MCI effect for drift rate after controlling for age in switch trials, and in repeat trials the healthy older and the MCI groups still did not differ in drift rate after controlling for age ($p > 0.1$). For the response criterion (a), only a main effect of Trial ($F(2, 93) = 72.0, p < 0.001$) was found, indicating more cautious processing in switch trials. Importantly, there remained no group differences after controlling for age ($p > 0.05$ comparing each pair)

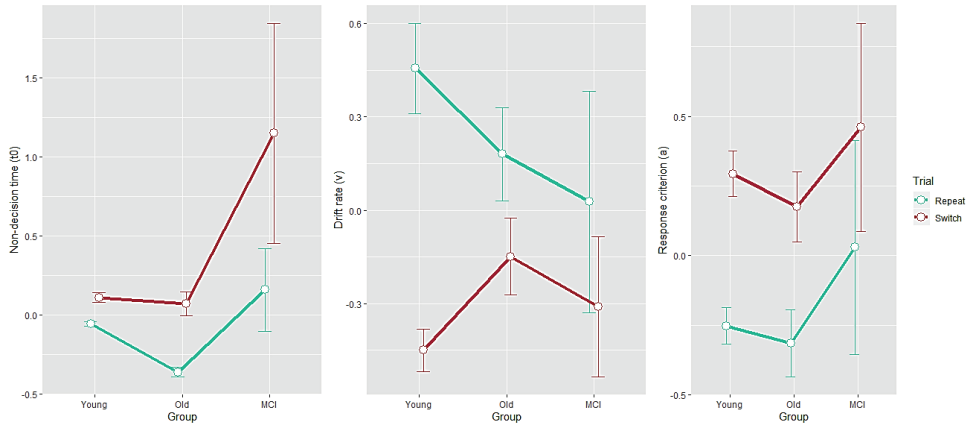


Figure 4. Diffusion-model parameter estimates as a function of Group for each Trial type. Non-decision time (t_0), drift rate (v), and response criterion (a) are shown on the left, middle, and right panel, respectively. Error bars indicate one standard error from the mean.

Discussion

We compared task-switching performance in healthy young, healthy older, and MCI-diagnosed participants using a standard RT/accuracy analysis, and compared estimated parameters for a DM model of simple decision-making processes involved in task switching. We performed standard mixed ANOVAs as well as mixed ANOVAs after controlling for possible age effects.

For RT and accuracy, we found that there was a systematic increase in RTs with age, which was especially pronounced in the MCI group. Switch trials were specifically involved. This supports a considerable amount of previous results (Mayr & Kliegl, 2000; Kramer, Hahn, & Gopher, 1999), that task switching is cognitively demanding, is subject to both non-pathological and pathological aging, and may even serve as an indicator of subtle cognitive deficits in clinically healthy populations (Velichkovsky et al., 2015). Also, we found that accuracy displayed generally the same trends (larger error-related switch costs associated with advancing age and pathology) which – as typically found (Starns & Ratcliff, 2010) – were weaker, reflecting the general tendency to trade speed for accuracy in highly functioning subjects such as ours. Thus, the standard RT/accuracy analysis supported the relatively well-established findings about task-switching performance in normal and pathological cognitive aging.

Our analysis of age and MCI effects on DM parameters may be of more interest, as there are only a few such studies (e.g., Karayanidis, Whitson, Heathcote, & Michie, 2011). As explicated in the Introduction, the advantage of the analysis of DM parameters is that it allows us to find age and MCI effects on specific cognitive processes involved in the task switching. From this point of view, the most important research question for a theory of task switching in older age is whether active, controlled, endogenous processes of task-set reconfiguration (t_0) are affected differently than passive, automatic, exogenous processes of task-set inertia (v , interfer-

ence). We made the reasonable hypothesis that t_0 (task-set reconfiguration) would specifically be affected (which should result at least in a combination of a significant Group effect and a significant Group \times Trial interaction, with t_0 increasing with age and being specifically large in the MCI group in switch trials). This is because voluntary controlled processes are typically deficient in older/demented populations (the frontal hypothesis of aging – Greenwood, 2000). We also speculated that drift rate (task-set inertia) should not be affected, as it is more an automatic process. It is a truism that automatic processes are relatively intact in both normal and pathological cognitive aging (Duong, Whitehead, Hanratty, & Chertkow, 2006; de Paula et al., 2012; Salthouse, Toth, Hancock, & Woodard, 1997).

Contrary to this, our first analysis (without controlling for age) showed that both the active and passive processes (both t_0 and ν) are affected in a way that suggests a general aging effect and a specific MCI effect. For the task-set reconfiguration, this is perfectly understandable, and finding it was actually the goal of this study. However, the involvement of task-set inertia is more interesting. One explanation could be that task-set inertia is about the dissipation of interference from the irrelevant task. Of course, a deficit in interference control is a hallmark of cognitive aging (Hasher & Zacks, 1988), which would lead to a conclusion that the obtained effects on drift rate are driven by inhibitory deficits. However, inhibitory deficits in aging are actually deficits of *voluntary* inhibition (i.e., interference control) – the most basic of the basic executive functions, according to A. Miyake and N. Friedman (2004). These may be fundamentally different from automatic interference suppression and the passive dissipation of interference which is assumed by the task-set inertia account of task switching (Allport, Styles, & Hsieh, 1994; Allport & Wylie, 2000).

Running the second analysis (after controlling for age) shed some light on this issue. The results for the active task-set reconfiguration process (t_0) clearly demonstrated the predicted group differences and two-way interaction. The MCI group had systematically higher task-set reconfiguration overhead, while the healthy older subjects did not differ from the young adults in this respect (and even outperformed them numerically), after controlling for age differences. Concerning interaction, there was a specific increase in the duration of task-set reconfiguration processes in the MCI group in switch trials. This fully corresponds to our predictions. However, the task-set inertia had a different pattern of MCI-related effects – after controlling for age effects, the MCI and the healthy older group ceased to differ, while the young group had a quicker information-processing speed in repeat trials. So, if anything, there is no specific drift rate deficit associated with the MCI pathology that is different from normal cognitive aging. This suggests a differential pattern of cognitive decline in the active, controlled task-switching processes and in passive, automatic task-switching processes. This is in perfect correspondence with the general idea that controlled processes are the ones most affected in pathological cognitive aging. Automatic processes seem to decline similarly in pathological and normal cognitive aging, at least in the task-switching case.

Response criterion was the last DM parameter we analyzed. A trivial result was found that response caution is higher in the more difficult switch trials. We initially found a clear Group effect, with the healthy older group and the MCI group exhibiting more cautious processing. After correcting for age differences,

the group differences vanished. This means there is no specific response caution effect associated with the MCI pathology, but a general aging effect on response caution. The effect of age on response caution has already been well documented and is sometimes thought to underlie RT slowing in older subjects (Ratcliff, Thapar, Smith, & McKoon, 2005).

Conclusions

In this paper, we fitted DM models to task switching performance data in young, healthy older, and MCI-diagnosed older participants. We found evidence that active, controlled processes of task-set reconfiguration were specifically affected by pathological cognitive aging (MCI) as well as by normal cognitive aging. For passive task-set dissipation, there was only a general effect of aging, with no specific effect of MCI pathology. Response caution was also unrelated to MCI, while it exhibited the standard aging effect. These results support the notion that controlled and automatic cognitive processes have different trajectories in normal aging, and especially in pathological cognitive aging.

Acknowledgements

This research was supported by the Russian Foundation for Basic Research under grant No. 19-013-00806.

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Original manuscript received September 25, 2019

Revised manuscript accepted April 05, 2020

First published online June 25, 2020

To cite this article: Velichkovsky, B.B., Tatarinov, D.V., Khlebnikova, A.A., Roshchina, I.F., Selezneva, N.D., Gavrilova, S.I. (2020). Task Switching in Normal Aging and Mild Cognitive Impairment: A Diffusion Model Analysis of Reaction Times. *Psychology in Russia: State of the Art*, 13(2), 109–120. DOI: 10.11621/pir.2020.0208

A Russian Version of the Acceptance of Modern Myths about Sexual Aggression Scale: Validation with a Female Online Sample

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Background. Rape myths are usually described as a widely-accepted set of false beliefs and attitudes about victims and perpetrators of sexual assault. These beliefs serve to deny, downplay, or justify sexual violence that men commit against women. The Acceptance of Modern Myths about Sexual Aggression (AMMSA) scale assesses those stereotypical beliefs about sexual aggression in a more subtle way than traditional measurements of rape myths, which often use rather blatant wording.

Objective. To develop a Russian version of the sixteen-item AMMSA scale.

Design. Our design was non-experimental. Participants were recruited online. In total, data of 270 Russian female participants and 131 German female participants were analyzed using exploratory and confirmatory factor analysis. Convergent and discriminant validity were assessed using correlational analyses with other constructs that are believed to be related to AMMSA to different degrees (hostile sexism, benevolent sexism, traditional gender role preferences, and impression management).

Results. It was found that the Russian AMMSA, just like the German AMMSA, was unidimensional, normally distributed, had high internal consistency, and showed good construct validity.

Conclusion. The validation of a Russian version of the AMMSA forms an important first step for studying beliefs about sexual aggression in Russian society. The Russian AMMSA scale is a valid and reliable instrument for measuring modern myths about sexual aggression. Future studies are needed to test whether there are gender differences in the Russian population.

Keywords:

AMMSA; rape myths; rape myth acceptance; scale construction; sexism; violence against women.

Introduction

Violence against women is very prevalent in today's society. The World Health Organization (2016) reports that 35% of women worldwide have experienced physical and/or sexual violence in their lifetimes. Thus, women's fear of being raped is very widespread, and it not only restricts their freedom, but also decreases their quality of life (Mirrlees-Black & Allen, 1998). The negative impact of rape on women's mental health has been the subject of many studies, which show rape as a severe trauma that may lead to post-traumatic stress disorder (see Campbell, Dworkin, & Cabral, 2009; Clum, Calhoun, & Kimerling, 2000; Frazier, Conlon, & Glaser, 2001); depression (Acierno et al., 2002; Clum et al., 2000); fear and anxiety (Siegel, Golding, Stein, Burnam, & Sorenson, 1990; Ullman & Siegel, 1990); and substance abuse (Ullman, Townsend, Filipas, & Starzynski, 2007).

Another challenge that women face is a non-supportive social environment when reporting a rape. Social attitudes that blame the victim, and an overall non-supportive social network, may be important factors that discourage victims from reporting their experiences. Some research findings even indicate post-traumatic disorders arising as a result of a non-supportive reaction (Yamawaki, Darby, & Queiroz, 2007).

An influential conceptualization of the sociocultural context of negative reactions toward rape victims is the concept of rape myths, which was first defined and introduced into social psychology by Martha Burt (1980). According to Burt, rape mythology may reinforce a culture of rape by defining rape too narrowly, thus excluding the experiences of many women, and downplaying the severity and consequences of rape. Burt also introduced one of the first questionnaires measuring rape myth acceptance (RMA).

Over the years, rape myth acceptance has been studied in relation to its cognitive, affective, and behavioral effects (see Bohner, Eyssel, Pina, Siebler, & Viki, 2009). For example, numerous studies have shown that RMA results in disbelief of victims' statements (*e.g.*, Bohner & Schapansky, 2018), victim blaming, and lenient judgments of perpetrators in specific rape cases (*e.g.*, Eyssel & Bohner, 2011; Hockett, Saucier, & Badke, 2016; Krahe, 1991; Pollard, 1992; Peterson & Muehlenhard, 2004; Ryan, 2011).

Studies of gaze behavior have also shown that people high in RMA quickly detect stereotypical cues linked to victim blaming (Süssenbach, Bohner, & Eyssel, 2012) and look less at the alleged perpetrator than at the victim when assigning guilt and blame (Süssenbach, Eyssel, Rees, & Bohner, 2017). To give a final example, men who are high in RMA, or have been exposed to high-RMA responses of others, show greater rape proclivity (Bohner, Pina, Viki, & Siebler, 2010; Bohner, Siebler, & Schmelcher, 2006). Hence, understanding the role of rape myths and their impact on victims and society is extremely important for victims' well-being and recovery (Moor, 2007).

In this article, we focus on RMA in Russian respondents. As there is no established RMA measure available in Russian, we developed such an instrument and then validated it by examining its intercorrelations with various scales. We did this in comparison with an established German questionnaire by studying both Russian and German samples. Before we present our study, we first sketch developments in the definitions and measurement of RMA over the last four decades.

Rape Mythology

One of the first definitions of rape myths was given by Burt (1980), who described them as “prejudicial, stereotyped, or false beliefs about rape, rape victims, and rapists” (p. 217). Burt also presented examples of rape myths, such as “she asked for it” or “no harm was done” (see also Burt, 1991). Later this concept was extended by Lonsway and Fitzgerald (1994), who defined rape myths as “attitudes and beliefs that are generally false, but are widely and persistently held, and that deny and justify male sexual aggression against women” (p.134). The definition of rape myths was specified further as “descriptive or prescriptive beliefs about rape (*i.e.*, about its causes, context, consequences, perpetrators, victims, and their interaction) that serve to deny, downplay, or justify sexual violence that men commit against women” (Bohner, 1998, p. 14).

The most common rape myths discussed in the literature include: 1) disbelief of rape claims: “Most charges of rape are unfounded”; 2) blaming the victim: “Women often provoke rape through their appearance and behavior”; 3) belief that only certain types of women are raped: “Only bad girls get raped”; 4) exoneration of the perpetrator: “Rapists are sex-starved, insane, or both”; 5) denial of marital rape: “Husbands cannot rape their wives”; and 6) denial of any injury: “Women enjoy rape” (Bohner et al., 1998; Bohner et al., 2009; Burt, 1980; Edwards, Turchik, Dardis, Reynolds, & Gidycz, 2011; Lonsway & Fitzgerald, 1995; Payne, Lonsway, & Fitzgerald, 1999).

Rape myths affect not only how our culture stereotypically defines rape – *i.e.*, only acknowledging a narrow set of atypical assaults, such as when a stranger attacks a woman outdoors and uses extreme physical violence, as “real rape” – but also how rape victims see themselves (Krahé, Bieneck, & Scheinberger-Olwig, 2007; Littleton & Axsom, 2003; Littleton, Breitkopf, & Berenson, 2007; Peterson & Muehlenhard, 2004). One of the possible consequences of holding the “real rape script” is rape victims’ conceptualization of their own experience.

Rape victims may be divided into two groups: those who acknowledge their experience as rape, and those who do not because their experience does not conform to the “real rape script” that they endorse (Bondurant, 2001; Kahn, Mathie, & Torgler, 1994). Rape scripts also present an “ideal victim” image, which describes a non-intoxicated “respectable” victim who had no prior contact with the perpetrator (Hockett et al., 2016). Hence, women who do not fulfill this stereotype are often not seen as rape victims and may not even identify themselves as such. This belief makes women more vulnerable (Turchik, Probst, Irvin, Chau, & Gidycz, 2010) because they might miss clues in situations that do not resemble the “real rape script,” and thus be more likely to be victimized.

Measurement of Rape Myth Acceptance

Over the years, many different instruments for measuring RMA have been developed (for reviews, see Bohner, 1998; Lonsway & Fitzgerald, 1994). However, in recent years the use of these scales has consistently presented one common problem: Respondents’ answers are often close to the low point of the response scale, which positively skews the RMA distribution and produces low RMA mean scores (Bohner, Siebler, & Schmelcher, 2006; Gerger, Kley, Bohner, & Siebler, 2007).

Therefore, these statistics do not necessarily reveal a low level of RMA in the studied population, but might instead reflect impression management (based on an increased awareness of politically correct answers), as well as historical changes in the content of rape myths (Gerger et al., 2007). Thus, rape myths today may be both more subtle and expressed less willingly than in the past.

In a similar way, it has been suggested that sexism, along with other prejudices such as racist attitudes, has currently become more covert and is no longer as direct as its “old-fashioned” expression (Swim, Aikin, Hall, & Hunter, 2005). Thus, Swim and colleagues (2005) proposed the concept of modern sexism, which is characterized by the denial that sex discrimination still exists, and the belief that government and news media are too concerned about attitudes toward women.

Following the lead of modern sexism research and importing its ideas into the realm of rape myth assessment, Gerger and colleagues (2007) developed a new RMA scale. Their aim was to measure contemporary “modern” myths of sexual aggression and to use more subtle wording than traditional RMA scales, thus eliminating the problem of skewed distributions and reflecting respondents’ current beliefs more accurately than the classic scales do. The new instrument was named the Acceptance of Modern Myths about Sexual Aggression (AMMSA) Scale.

Its contents include the following categories: 1) denial of the scope of the problem (e.g., “Many women tend to misinterpret a well-meant gesture as a ‘sexual assault’”); 2) antagonism toward victims’ demands (e.g., “Although the victims of armed robbery have to fear for their lives, they receive far less psychological support than do rape victims”); 3) lack of support for policies designed to help alleviate the effects of sexual violence (e.g., “Nowadays, the victims of sexual violence receive sufficient help in the form of women’s shelters, therapy offers, and support groups”); 4) beliefs that male coercion forms a natural part of sexual relationships (e.g., “When a woman starts a relationship with a man, she must be aware that the man will assert his right to have sex”); and 5) beliefs that exonerate male perpetrators by blaming the victim or the circumstances (e.g., “Alcohol is often the culprit when a man rapes a woman”).

The AMMSA scale comprises 30 items. In a host of studies, it has been shown to be essentially unidimensional and to yield symmetrical, close-to-normal distributions; it has also proved to be highly reliable (Cronbach’s alphas ranged from .90 to .95) and to have construct validity (e.g., Eyssel & Bohner, 2011; Gerger et al., 2007; Milesi, Süssenbach, Bohner, & Megías, 2020; Süssenbach et al., 2012). For example, AMMSA correlated not only with similar constructs, such as hostile sexism (HS) and benevolent sexism (BS) (Glick & Fiske, 1996), but also with a traditional RMA scale (Payne et al., 1999). AMMSA scores also correlate with the “belief in a just world” (Lerner, 1980); lack of empathy (Bohner, 1998; Schmitt, 1982); right-wing authoritarianism (Altemeyer, 1988; Canto, Perles, & San Martín, 2014); and social dominance orientation (Pratto, Sidanius, Stallworth, & Malle, 1994). The scale was originally developed in parallel in German and English; later, Spanish (Megías et al., 2007), Colombian (Romero-Sánchez, Megías, Carretero-Dios, & Rincón Neira, 2013), French (Helmke, Kobusch, Rees, Meyer, & Bohner, 2014), Greek (Hantzi, Lampridis, Tsantila, & Bohner, 2016), Chilean (Camplá, Novo, Sanmarco, & Arce, 2019), and Italian versions (Milesi et al., 2020) were developed and validated.

Objective

Validation of the Russian AMMSA Scale

There are no comparable scales available in Russian to date. Therefore, the validation of a Russian version of the AMMSA scale is an important first step for studying beliefs about sexual aggression in Russian society. The main aim of this study was to validate a 16-item short version of the AMMSA scale in the Russian language. To do so, we assessed the Russian scale's reliability, and convergent and discriminant validity in comparison with a German short version, by studying parallel samples of Russian and German students.

As external validation criteria we used the Ambivalent Sexism Inventory (ASI) with its subscales of hostile sexism and benevolent sexism (Glick & Fiske, 1996; German version: Eckes & Six-Materna, 1999); the Gender Role Preference (GRP) scale (Becker & Wagner, 2009); and the Impression Management (IM) scale of the "Balanced Inventory of Desirable Responding" (Paulhus, 1998; German version by Musch, Brockhaus, & Bröder, 2002).

Hostile and benevolent sexism are two separate but interrelated components of ambivalent sexism (see Glick et al., 2000). Whereas hostile sexism reflects the typical antipathy toward women that fits classical definitions of prejudice, benevolent sexism comprises sexist beliefs that are subjectively positive and affectionate toward women (Glick & Fiske, 1996). Significant correlations of hostile sexism and classic RMA scales have been demonstrated (Chapleau, Oswald, & Russell, 2007; Glick & Fiske, 1996); for the AMMSA scale, significant associations with both hostile and benevolent sexism were found (Gerger et al., 2007; Hantzi et al., 2016; Megías et al., 2007), with the former being stronger than the latter.

The GRP measures women's tendencies to share specific gender-in-group values that may be either progressive or traditional (Becker & Wagner, 2009). It was shown that women who were highly identified with more traditional gender roles endorsed sexist beliefs, whereas women who were highly identified with progressive gender roles did not. Thus, we predicted that AMMSA scores would be positively correlated with the GRP traditional values scale.

The IM scale indicates to what extent a person tries to make a good impression on others. IM was demonstrated to be uncorrelated with the AMMSA measurements in previous research (Gerger et al., 2007), and a correlation close to zero would also reflect discriminant validity of the Russian version.

Summary of Research Aims and Hypotheses

The main aim of this study was to validate the Russian version of the AMMSA scale, assessing its psychometric properties in comparison with a German version of AMMSA. In line with previous research (Gerger et al., 2007; Hantzi et al., 2016), we expected to find: 1) a one-factor solution and high internal consistency of the AMMSA scale; 2) a symmetrical and fairly normal distribution of AMMSA scores; 3) a strong positive correlation of AMMSA measurements with HS, which is a conceptually similar construct; 4) moderately positive correlations of AMMSA scores with BS and GRP, which are both related to the AMMSA construct, but more distinct from it conceptually; and 5) AMMSA to be uncorrelated with IM. These correlation patterns were expected to be the same for the Russian and German versions of the AMMSA scale.

Method

Participants

Recruitment was restricted to female participants, because we also tested several experimental hypotheses regarding AMMSA: specifically, the effects of exposure to rape-related information moderated by RMA in women coming from different cultures, and the role of GRP in the self-esteem – related function of RMA. We also wanted to identify subgroups of women according to their RMA and to test this difference by considering such aspects as culture and GRP. These issues will not be further addressed in the present paper.

Table 1

Final Sample Characteristics

	German students	Russian students	Russian non-students
N total	131	120	150
Mean age	22.93	25.79	31.14
SD of age	3.73	6.05	6.55
Obtained Educational level (in %)	Secondary high school (Realschule) (.8%)	Secondary high school (35.5%)	Secondary high school (1.3%)
	Advanced technical college (Fachhochschule) (6.9%)	Specialized secondary education (.8%)	Specialized secondary education (.7%)
	General qualification for university entrance (Abitur) (61.8%)		
	Bachelor (27.5%)	Bachelor (8.5%)	Bachelor (13.3%)
	Master's degree (2.3%)	Master's degree (12.4%)	Master's degree (17.3%)
		Diploma (37.3%)	Diploma (58.0%)
		PhD (3.3%)	PhD (8%)
	Other (.7%)	Other (.5%)	Other (1.4%)
		Missing (1.7%)	
	Relationship status (in %)	Single (47.3 %)	Single (30.8%)
Live together with a partner (31.3%)		Live together with a partner (20.0%)	Live together with a partner (22.7%)
Married (3.8%)		Married (22.5%)	Married (38.0%)
Divorced (.0%)		Divorced (8.3%)	Divorced (7.3%)
Other (17.6%)		Other (18.3%)	Other (10.7%)

Our choice of participants seemed to be appropriate for the AMMSA scale validation as well, insofar as the German-speaking and Russian-speaking samples would be comparable in terms of education and socioeconomic background. Also, although gender might be an important factor to include in future studies, and previous research suggests that there are specific gender differences in regard to victim perception (Hockett, Smith, Klausing & Saucier, 2016) and even in RMA itself (Lonsway & Fitzgerald, 1994), these studies usually refer to more traditional RMA scales, which use stronger language than the less blatant AMMSA wording. Regarding the instrument used in this study (AMMSA), a study with a representative sample of Germans had revealed no gender differences in RMA perception when using a nine-item version of AMMSA (Süssenbach & Bohner, 2011).

Participants were recruited online through solicitations targeting different German and Russian Facebook student groups, e-mail lists from different universities, and open female blogs. In order to stimulate participation, the participants were entered in a cash lottery. The research followed applicable ethical guidelines: Participants gave their informed consent, and were informed about their right to withdraw at any time; upon completion of the questionnaire, participants were given a final opportunity to withdraw their data by clicking a corresponding response button. The study was approved by the Ethics Committee of Bielefeld University (Statement EUB 2015-117).

In total, 383 people completed the Russian survey, and 173 people completed the German survey. After exclusion of those who had completed less than 60% of the items, had not read the text vignettes used in the experimental part of the study (not reported here), or were not heterosexual (this was important for some of the ASI and GRP items to be meaningful), we formed three subsamples for the validation study: a sample of 120 Russian students (15 of them were psychology students), a comparable sample of 131 German students (41 psychology students), and a sample of 150 Russian non-students. The characteristics of the three subsamples are presented in *Table 1*.

Procedure

We used a short version of the AMMSA scale (Gerger et al., 2007) in order to generate a brief and economic instrument (see *Appendix 2* for an English version). This particular 16-item version of AMMSA had been repeatedly used in previous studies with German samples (Bohner & Schapansky, 2018; Eyssel & Bohner, 2011; Eyssel, Bohner, & Siebler, 2006). In those studies, its reliability was almost as good as that of the full 30-item scale, reaching Cronbach's alphas well above .80. Also, the 16-item scale is essentially unidimensional, and its items have a higher average item-to-total correlation (.533) than those of the full AMMSA scale (.508; values based on Gerger et al., 2007, Table A1).

The short version of the scale consists of 16 items (Eyssel & Bohner, 2011); e.g.: "In order to get custody for their children, women often falsely accuse their ex-husbands of tendency toward sexual violence;" "When a man urges his female partner to have sex, this cannot be called rape." Participants were asked to indicate

how much they agreed with each item on a 7-point scale ranging from 1 (*totally disagree*) to 7 (*totally agree*). All the items were carefully translated from German into Russian by one bilingual person, and then back-translated into German by another bilingual person. There were few disagreements with regard to meaning in the two versions. These disagreements were discussed, and all necessary changes were included in the final Russian version that was used in the study. The German and Russian wordings of the items, item-to-total correlations, and item means are presented in *Appendix 1*.

In order to test the convergent and discriminant validity of AMMSA, we additionally administered the Ambivalent Sexism Inventory (ASI) (Glick & Fiske, 1996; German version: Eckes & Six-Materna, 1999), which consists of the subscales hostile sexism (HS – 11 items) and benevolent sexism (BS – 11 items); the Gender Role Preference scale (GRP– eight items where high scores indicate a preference for traditional gender roles and low scores indicate a preference for progressive gender roles) (Becker & Wagner, 2009); and the German Impression Management Scale (IM – 10 items) (Musch et al., 2002) from the Balanced Inventory of Desirable Responding (Paulhus, 1998). For the Russian versions we used our own Russian adaptations of these scales.

Item examples of the validation scales, along with coefficients of internal consistency, are provided in *Table 2*. Cronbach's alpha was satisfactory for all scales, so scoring was done for each scale by averaging across all of its items, after reverse-scoring where appropriate.

Table 2

Means, Standard Deviations, Content and Reliability of Scales Used for Convergent and Discriminant Validation

Scale (No. of items)	Item Example	German students			Russian students			Russian non-students		
		Cron- bach's alpha	M	SD	Cron- bach's alpha	M	SD	Cron- bach's alpha	M	SD
HS (11)	Many women are actually seeking special favors, such as hiring policies that favor them over men, under the guise of asking for "equality".	.92	3.43	1.22	.89	3.54	1.25	.91	3.08	1.24
BS (11)	Many women have a quality of purity that few men possess.	.88	3.71	1.09	.80	3.70	1.02	.83	3.40	1.02
GRP (8)	When I date a man, I would feel unpleasant if I had to pay.	.63	2.51	.79	.77	3.12	1.14	.81	2.74	1.12
IM (10)	I sometimes tell lies if I have to.	.59	4.34	.62	.62	4.50	.85	.62	3.27	.82

Note: HS = hostile sexism; BS = benevolent sexism; GRP = gender role preferences; IM = impression management

Results

Exploratory Factor analysis

As previous research had suggested a one-factor solution for the AMMSA scale, we conducted an exploratory factor analysis to examine if the scale's dimensionality could be replicated in the different cultural context represented by the Russian participants. For the factor analysis we used the answers of the Russian students and nonstudent samples combined ($N = 270$). The KMO measure of sampling adequacy ($KMO = .92$) and Bartlett's test of sphericity ($c^2(120) = 2101.26, p < .001$) both indicated that it was appropriate to apply factor analysis to this set of data.

Maximum-likelihood extraction and promax rotation were used in this analysis. The analysis yielded three factors with eigenvalues greater than one, explaining 60.97 % of the variance. The eigenvalues of these factors were: 6.96, 1.78, and 1.01. The eigenvalues showed a sharp decline after the first component. Thus we could adopt a one-factor solution for the Russian AMMSA scale, which was very similar to those of previous AMMSA versions in English, German, Spanish, and Greek (Gerger et al., 2007; Megías et al., 2007; Hantzi et al., 2016). Cronbach's alpha for the Russian adaptation of the AMMSA scale was .86 (.90 for the students and .89 for the non-student samples) and thus quite satisfactory.

We also conducted a factor analysis for the German sample in order to compare the results ($KMO = .83$, Bartlett's test of sphericity: $c^2(120) = 585.07, p < .001$). This yielded four factors with the following eigenvalues: 5.26, 1.34, 1.20, and 1.16. Again, the sharp decline of eigenvalues after the first factor suggests a one-factor model for the German AMMSA scale, which replicates previous research (Gerger et al., 2007).

Confirmatory Factor analysis

Confirmatory factor analysis (CFT) was performed to test a one-factor model (SPSS AMOS 21.0). The CFT was based on an asymptotic covariance matrix. Next, to evaluate the model's goodness of fit, multiple approximations were used. The following indices were evaluated: the root mean square error of approximation (RMSEA); the adjusted goodness of fit index (AGFI); and the non-normal fit index (NNFI) (Browne & Cudeck, 1993). For the Russian sample these measures indicated that the one-factor model had a good fit ($\chi^2(104) = 351.396, p < .001$, $RMSEA = .09$, $AGFI = .91$, $NNFI = .94$).

Means

Comparisons of the AMMSA means between the subsamples showed that Russian students ($M = 3.41, SD = 1.10$) scored higher than both Russian non-students ($M = 3.05, SD = 0.99$), $F(1, 268) = 8.72, p = .002$, and German students ($M = 3.09, SD = 0.86$), $F(1, 249) = 6.88, p = .009$. The latter two groups did not differ from each other, $F(1, 279) = 0.109, p = .742$.

Distributions

Sample distributions for the German sample and the combined Russian sample are displayed in *Figure 1*. We can see that the AMMSA scale distribution looks close to

a normal distribution for both language versions. This was confirmed by the non-significant results of Shapiro-Wilks tests. Both German and Russian AMMSA distributions had a slightly positive skewness of 0.17 (SE = 0.21) for the German version, and of 0.29 (SE = 0.20) for the Russian version; and a kurtosis of -0.45 (SE = 0.42) and of -0.47 (SE = 0.39) for German and Russian versions, respectively. These results indicate that the distributions are fairly symmetrical and not too wide.

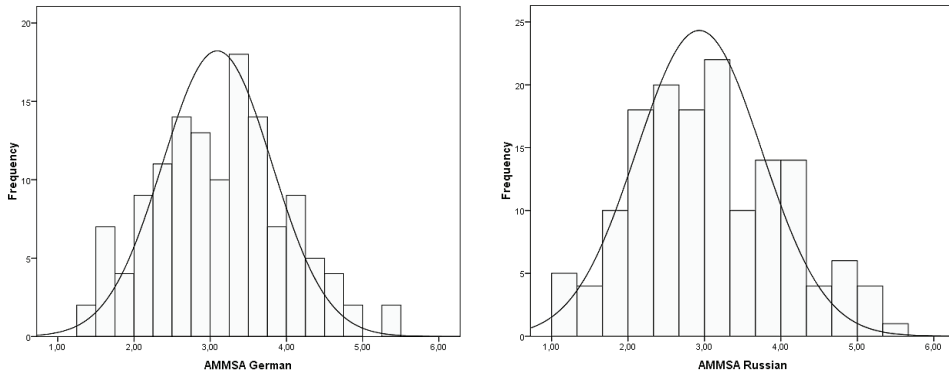


Figure 1. Distributions of the German and Russian versions of the Acceptance of Modern Myths About Sexual Aggression (AMMSA) scale.

Convergent and discriminant validity

The correlations of AMMSA and other measures used for convergent and discriminant validation are reported in Table 3.

Table 3
Correlations of AMMSA With Related and Unrelated Constructs

	German version		Russian version	
	Students		Students	Non-Students
HS	.77		.83	.84
N	131		120	150
BS	.46		.44	.42
N	131		120	150
GRP	.40		.62	.61
N	131		120	150
IM	.09 ^{ns}		.03 ^{ns}	.01 ^{ns}
N	131		120	150

Note. HS = hostile sexism; BS = benevolent sexism; GRP = gender role preferences; IM = impression management ns not significant. All other correlations displayed are significant at $p < .01$.

As predicted, the Russian AMMSA scores were highly correlated with HS for both the student ($r = .83, p < .01$) and non-student samples ($r = .84, p < .01$),

which indicates the scale's convergent validity. We had also predicted that AMMSA scores would show moderately high correlations with BS and traditional GRP, and the analyses confirmed this. For the student sample, the correlations were: $r = .44$ ($p < .01$) with BS and $r = .62$ ($p < .01$) with GRP. For the non-student sample, the correlations between AMMSA and these scales were: $r = .42$ ($p < .01$) with BS and $r = .61$ ($p < .01$) with GRP. Finally, AMMSA scores were uncorrelated with impression management scores for both Russian samples: $r = .03$ for the student participants, and $r = -.01$ for the non-student participants (all *n.s.*).

We also tested the same relationships for the German version. As can be seen in *Table 3*, the correlation patterns between all measures and AMMSA results in the German and the Russian samples are highly similar: a strong positive correlation between AMMSA and HS; a moderately high correlation between AMMSA and BS as well as AMMSA and GRP; and a correlation close to zero with IM.

Discussion

The main aim of our study was to validate the Russian version of the 16-item AMMSA scale. As predicted, the 16-item Russian AMMSA scale has a one-factor solution, shows a symmetrical close-to-normal distribution, and has both a strong internal consistency and good convergent and discriminant validity. Convergent validity was established via a high correlation with hostile sexism, which is a conceptually similar construct, and moderately positive correlations with related, but more distinct constructs – benevolent sexism and traditional gender role preferences. The finding about AMMSA scores being uncorrelated with impression management provides evidence for the AMMSA scale's discriminant validity.

When looking at the scale's means, we found meaningful differences between the Russian students, who showed the highest scores, and the two other subsamples, which did not differ from one another. The finding that Russian students score higher than German students might be explained by the fact that Russian society, generally, may be more traditional and conservative regarding gender issues than German society. Indeed, the United Nations' gender inequality index is much higher in Russia (.271) than in Germany (.066) (United Nations Development Programme, 2016).

Interestingly, however, the Russian nonstudent sample had lower scores than the Russian student sample, and almost identical scores as the German student sample, although being about nine years older. These results are somewhat similar to findings by Süssenbach and Bohner (2011), who found a negative relationship between AMMSA scores and age ($r = -.47$) among younger German participants (up to 30 years of age), although the overall relationship between age and AMMSA in their representative sample was U-shaped. Thus, there might be interesting generational differences in the endorsement of modern sexual aggression myths within Russian society as well. It would be highly useful to test different age groups more systematically in follow-up research.

When it comes to the correlation patterns, hardly any differences were observed between the Russian and German samples. If anything, there was a higher correlation between the AMMSA and GRP results in the Russian samples. A plausible reason for this might lie in the rather blatant wording of the GRP scale. German

women might be more aware of the sexism implied by these statements, given the societal differences in gender equality mentioned above.

Conclusion

All of our hypotheses were clearly supported, suggesting that the Russian AMMSA scale is a reliable and valid instrument for measuring modern myths about sexual aggression. Thus, it can be useful for both basic and applied research.

Limitations

A possible limitation of our study lies in the fact that we did not include male participants. Although no strong gender differences were found in previous research on AMMSA (Gerger et al., 2007; Süssenbach & Bohner, 2011), it may be the case that such differences would emerge in Russian society. Thus, we recommend that future studies test whether the Russian AMMSA scale is valid for male respondents as well, and whether there are gender differences in the Russian population.

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Original manuscript received September 05, 2019

Revised manuscript accepted April 24, 2020

First published online June 25, 2020

To cite this article: Khokhlova, O., Bohner, G. (2020). A Russian Version of the Acceptance of Modern Myths about Sexual Aggression Scale: Validation with a Female Online Sample. *Psychology in Russia: State of the Art*, 13(2), 121–139. DOI: 10.11621/pir.2020.0209

Appendix 1. (Russian and German AMMSA scales)

Items of the AMMSA Scale (German/ Russian)	German students			Russian students			Russian non-students		
	Item-Total-Correlations	M	SD	Item-Total-Correlations	M	SD	Item-Total-Correlations	M	SD
1. Um das Sorgerecht für die Kinder zu bekommen, unterstellen Frauen ihrem Ex-Ehemann gerne zu Unrecht einen Hang zu sexueller Gewalt / Для того, чтобы получить родительскую опеку над детьми, женщины часто ложно обвиняют бывших мужей в том, что они имели склонность к сексуальному насилию.	.26	2.84	1.44	.44	2.99	1.70	.55	2.60	1.55
2. Nach einer Vergewaltigung erhalten Frauen heutzutage Unterstützung von allen Seiten / После изнасилования женщины в наше время получают значительную поддержку.	.32	4.00	1.43	.65	2.47	1.47	.62	1.81	1.07
3. Ein Großteil der Vergewaltigungen wird heutzutage durch die Darstellung von Sexualität in den Medien mitverursacht, da diese den Sexualtrieb potentieller Täter weckt / В настоящее время большая часть изнасилований частично обусловлена использованием сексуальности в медиа, так как это повышает сексуальное влечение потенциальных преступников.	.37	3.57	1.62	.11	3.89	1.84	.28	3.74	1.84
4. Wenn eine Frau mit einem Mann eine Beziehung eingeht, muss sie sich darüber im Klaren sein, dass der Mann sein Recht auf Sex einfordern wird / Когда женщина начинает отношения с мужчиной, она должна осознавать, что мужчина будет предъявлять свои права на сексуальные отношения.	.55	2.04	1.56	.73	4.12	2.10	.49	3.78	1.89
5. Die meisten Frauen möchten lieber für ihr Aussehen gelobt werden als für ihre Intelligenz / Большинство женщин предпочитают, чтобы их хвалили за внешность, а не за их интеллект.	.38	3.15	1.66	.28	3.44	1.73	.39	3.79	1.65

(continued on next page)

Items of the AMMSA Scale (continued)	German students			Russian students			Russian non-students		
	Item-Total-Correlations	M	SD	Item-Total-Correlations	M	SD	Item-Total-Correlations	M	SD
6. Weil Sex an sich eine unverhältnismäßig große Faszination ausübt, ist unsere Gesellschaft für Straftaten in diesem Bereich auch unverhältnismäßig sensibel / Из-за непропорционально высокого интереса к сексу чувствительность нашего общества к преступлениям в этой сфере также непропорционально высока.	.46	3.44	1.58	.26	4.40	1.65	.28	4.42	1.64
7. Frauen zieren sich gerne. Das bedeutet nicht, dass sie keinen Sex wollen / Женщинам нравится казаться невозмутимыми. Это не значит, что они на самом деле не хотят секса.	.54	3.74	1.95	.65	4.59	1.94	.55	3.83	1.88
8. Viele Frauen neigen dazu, das Problem der Männergewalt zu übertreiben / Многие женщины имеют тенденцию преувеличивать проблему мужского насилия.	.62	2.89	1.56	.74	3.01	1.74	.73	2.37	1.59
9. Wenn ein Mann seine Partnerin zum Sex drängt, kann man das nicht Vergewaltigung nennen / Когда мужчина склоняет свою партнершу заняться с ним сексом, это нельзя назвать изнасилованием.	.56	2.08	1.39	.77	3.57	2.01	.71	2.91	1.78
10. Frauen bezichtigen ihre Männer häufig einer Vergewaltigung in der Ehe, um sich für eine gescheiterte Beziehung zu rächen / Женщины часто обвиняют своих мужчин в супружеском насилии, чтобы отомстить им за неудачные отношения.	.66	2.65	1.40	.74	3.15	1.77	.72	2.48	1.48
10. Frauen bezichtigen ihre Männer häufig einer Vergewaltigung in der Ehe, um sich für eine gescheiterte Beziehung zu rächen / Женщины часто обвиняют своих мужчин в супружеском насилии, чтобы отомстить им за неудачные отношения.	.66	2.65	1.40	.74	3.15	1.77	.72	2.48	1.48

(continued on next page)

Items of the AMMSA Scale (continued)	German students			Russian students			Russian non-students		
	Item-Total-Correlations	M	SD	Item-Total-Correlations	M	SD	Item-Total-Correlations	M	SD
11. Die Diskussion über sexuelle Belästigung am Arbeitsplatz hat vor allem dazu geführt, dass manches harmlose Verhalten jetzt als Belästigung missverstanden wird / Дискуссия по поводу сексуальных домогательств на работе в основном привела к тому, что безобидное поведение стало неправильно восприниматься как домогательство.	.72	3.61	1.75	.67	2.74	1.65	.76	2.36	1.48
12. Beim Kennenlernen entspricht es der allgemeinen Erwartung, dass die Frau "bremst" und der Mann "Gas gibt" / На свиданиях в целом ожидается, что женщина «жмет на тормоза», а мужчина «жмет на газ».	.51	3.19	1.69	.27	3.65	1.63	.34	3.99	1.66
13. Obwohl die Opfer bewaffneter Raubüberfälle um ihr Leben fürchten müssen, erhalten sie wesentlich weniger psychologische Unterstützung als Vergewaltigungsopfer / Хотя жертвы вооруженного ограбления должны испытывать страх за свою жизнь, они получают значительно меньше психологической поддержки, чем жертвы изнасилований.	.42	3.87	1.30	.72	3.61	1.70	.59	3.01	1.64
14. Wenn Männer vergewaltigen, ist oft der Alkohol schuld / Когда мужчины совершают изнасилования, виновником часто оказывается алкоголь.	.32	2.49	1.44	.51	3.41	1.91	.57	2.75	1.69
15. Viele Frauen neigen dazu, eine nett gemeinte Geste zum "sexuellen Übergriff" hochzuspielen / Многие женщины имеют склонность неправильно интерпретировать жесты, сделанные из лучших побуждений как посягательства сексуального характера.	.54	2.99	1.52	.82	3.23	1.69	.76	2.63	1.52
16. Für die Opfer sexueller Gewalt wird heutzutage durch Frauenhäuser, Therapieangebote und Selbsthilfegruppen schon genug getan / На сегодняшний день жертвы сексуального насилия получают достаточно помощи в форме убежищ для женщин, терапии и групп поддержки.	.45	2.86	1.27	.64	2.65	1.58	.66	2.07	1.30

Appendix 2
(AMMSA scale English version)

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- 1 To get custody for their children, women often falsely accuse their ex-husbands of a tendency towards sexual violence.
 - 2 After a rape, women nowadays receive ample support.
 - 3 Nowadays, a large proportion of rapes is partially caused by the depiction of sexuality in the media as this raises the sex drive of potential perpetrators.
 - 4 When a woman starts a relationship with a man, she must be aware that the man will assert his right to have sex.
 - 5 Most women prefer to be praised for their looks rather than their intelligence.
 - 6 Because the fascination caused by sex is disproportionately large, our society's sensitivity to crimes in this area is disproportionate as well.
 - 7 Women like to play coy. This does not mean that they do not want sex.
 - 8 Many women tend to exaggerate the problem of male violence.
 - 9 When a man urges his female partner to have sex, this cannot be called rape.
 - 10 Women often accuse their husbands of marital rape just to retaliate for a failed relationship.
 - 11 The discussion about sexual harassment on the job has mainly resulted in many a harmless behavior being misinterpreted as harassment.
 - 12 In dating situations, the general expectation is that the woman "hits the brakes" and the man "pushes ahead."
 - 13 Although the victims of armed robbery have to fear for their lives, they receive far less psychological support than do rape victims.
 - 14 Alcohol is often the culprit when a man rapes a woman.
 - 15 Many women tend to misinterpret a well-meant gesture as a "sexual assault."
 - 16 Nowadays, the victims of sexual violence receive sufficient help in the form of women's shelters, therapy offers, and support groups.
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PERSONALITY PSYCHOLOGY

An Existential Criterion for the Normal and Abnormal Personality in the Works of Viktor Frankl. **Summary**

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Background. This is the last in a series of four articles scheduled for publication in this journal. In the first article (Kapustin, 2015a), I proposed a new “existential criterion” for the normal and abnormal personality that is implicitly present in the works of Erich Fromm. According to this criterion, normal and abnormal personalities are determined, first, by their position regarding existential dichotomies, and, second, by particular aspects of the formation of this position. Such dichotomies, entitatively existent in human life, are inherent, two-alternative contradictions. In the other articles (Kapustin, 2015b, 2016a), I showed that this criterion is also implicitly present in the four famous personality theories of Freud, Adler, Jung, and Rogers.

Objectives. To provide evidence that this criterion is present in the personality theory of Viktor Frankl and to present a comparative analysis of all six theories of personality.

Results. The existential criterion for the normal and abnormal personality based on the works of Fromm is also implicitly present in theoretical conceptualizations of personality, predisposed and non-predisposed to developing various psychological problems and to mental disorders, by Freud, Adler, Jung, Rogers, and Frankl, although in more particular forms, related to more specific existential dichotomies, characterizing the nature of human life.

Conclusion. The fact that the existential criterion is present in these six theories of personality, developed within totally different approaches to psychology and psychotherapy, is evidence of a high degree of its theoretical justification and of the possibility of their integration.

Keywords:
human nature, human essence, existential dichotomy, normal personality, abnormal personality

Introduction

In the first article in this series (Kapustin, 2015a), I described an “existential criterion” for the normal and abnormal personality implicitly present in the works of Erich Fromm (1942, 1947, 1964, 1977, 1991).

Fromm developed his theoretical understanding of personality based on the philosophical branch of objective humanistic ethics, which proposes a certain view of how a human being should live. The ultimate moral imperative of a person who is following what should be considered as a standard of life, involves the self-determination of values that facilitate living in accordance with human nature.

Based on this school of thought, Fromm proposed his own theoretical concept of human nature, which has two characteristics that Fromm considered essential. The first is that in human life there are so-called existential dichotomies, which are inherent, two-alternative contradictions, which appear to a person as problems requiring solution. The second characteristic is that a human being is capable of self-determination.

The most important concepts in Fromm’s works are those of the productive and the nonproductive personality, which are characterized by particular features of the content and the formation of the personality in relation to these two characteristics. Fromm defined this position as a scheme of orientation and worship. If the position of a personality (scheme of orientation and worship) in its content and in the way it is formed facilitates implementation of these two characteristics, such a personality was defined by Fromm as productive; if not, it is nonproductive. From the point of view of objective humanistic ethics, the way of life of a productive personality is a norm of human life, because it corresponds to human nature. Thus a productive personality can be considered a normal personality; a nonproductive personality deviates from this norm and is abnormal.

In my view, because Fromm considers the essence of human life to be characterized by existential dichotomies and self-determination, the position of a productive (normal) personality is compromising in its content, matching the contradictory structure of human life in the form of existential dichotomies, and it is created by oneself, based on one’s life experience and reason—that is, on a rational basis. On the contrary, the nonproductive (abnormal) personality denies the contradictory structure of human life in the form of existential dichotomies, and is oriented toward a consistent, noncompetitive and, as a consequence, one-sided way of life. A specific feature of this position is that it is imposed by others and based on a person’s wishes and feelings about them—that is, on an irrational basis. From the point of view of Fromm, the abnormality of a personality interpreted like that is one of the most important factors influencing the development of various psychological problems and other mental disorders—primarily, neurosis.

Given that the criterion for differentiating between normal and abnormal personalities involves specific features of their position toward existential dichotomies, I identify this criterion as existential: Normality and abnormality are determined first by special features of content and second by particular aspects of the formation of a position toward existential dichotomies, which are entitatively existent in human life and are inherent, two-alternative contradictions that appear to a person as problems requiring solution.

The essential attribute of a normal personality is orientation toward the contradictory predetermination of life in the form of existential dichotomies and the need to search for compromise in their resolution. A distinct feature of the formation of this position is that it develops on a rational basis with the active participation of the person—that is, on the basis of knowledge, the source of which is the person's own experience and reason. The position of an abnormal personality subjectively denies the contradictory predetermination of life in the form of existential dichotomies and is oriented toward a consistent, noncompetitive, and, as a consequence, one-sided way of life that doesn't include self-determination. Such a position is imposed by other people on an irrational basis: that of wishes for and feelings toward them.

The objectives of my articles were to show that the existential criterion is contained in a number of well-known theories of personality developed in different traditions of psychology and psychotherapy and regarded as incompatible with each other. In the second article in this series (Kapustin, 2015b), I showed that this criterion is implicitly present in the personality theory of Sigmund Freud (1963a, 1963b, 1964), toward the *existential dichotomy of nature–culture*, and in the personality theory of Alfred Adler (2007, 2011) toward the *existential dichotomy of superiority–community*. In the third article (Kapustin, 2016a), I showed that this criterion is also implicitly present in the personality theory of Carl Jung (1914, 1969, 1971, 1972), toward the *existential dichotomy of opposites*, and in the personality theory of Carl Rogers (1959, 1965, 1995), toward the *existential dichotomy of self-actualization–conditional values*.

Objectives

The objectives of this article are to show that the new existential criterion of normal and abnormal personality based on the works of Fromm is implicitly present in the theories of personality of Viktor Frankl, although in a rather special way, and to present a comparative analysis of all six theories of personality.

The Existential Criterion in Frankl's Theory of Personality

I begin discussing Frankl's theory (1967, 1986, 1990, 2014) with an analysis of his general views on human nature, which he views as characterized by a pluralism of diverse forms of existence that coexist in life as an indestructible unity:

The distinguishing characteristic of human existence is the coexistence between anthropological unity and ontological differences, between the unified human manner of being and the diverse constitutive elements of being of which it is a part. (Frankl, 1990, p. 48)

Frankl explains this view with a geometrical analogy. Pluralism of diverse forms of human existence can be compared to an integral dimensional figure, presented on a chart as three projections in orthogonal dimensions. Each of these projections, taken separately, characterizes some essential feature of this geometrical figure, but only one-sidedly, because a dimensional figure cannot be identified as only one of its projections. Adequate and full representation of the form exists only in the unity of its diverse projections.

According to Frankl, the main different forms of human existence, equivalent to three orthogonal dimensions in geometry, are the biological, social, and spiritual. Each of these forms is characterized by its specific features.

The *biological* form of human existence characterizes human life as a living organism. In Frankl's view, this is a subject of research mostly in two sciences: biology and psychology. The *social* form of human existence characterizes life in society and is studied in the field of sociology. Frankl considers these three sciences, which study human life in two important dimensions, as bearing a certain resemblance: All three of them study people from the perspective of the natural sciences, regarding them as creatures whose lives are fully conditioned and predetermined. For example, in biology there are attempts to explain human behavior with the help of innate predisposition. According to Frankl, examples of this approach are the theory of Freud, in which human behavior is explained by sexual drives, and that of Adler, which explains human behavior by the person's character. Sociologists often regard social conditions of various kinds as the most important determinants of human life.

In Frankl's view, such positions cannot be appropriate due to their one-sidedness. Natural scientists' approach misses the most important human dimension, the most important characteristics that compose mankind's essence: spirituality, freedom, and responsibility:

Spirituality, freedom, and responsibility are the three constituents of human existence. They do not only characterize human existence as the existence of a person in particular; rather they constitute it as such. In this sense, human spirituality is not a characteristic, but a constitutive feature: The spiritual is not just inherent to human beings as physical and mental, qualities which are inherent to animals as well. The spiritual is a distinctive feature of the human being, which is inherent to him and only to him. Naturally, an airplane does not cease to be an airplane if it moves only on the ground. It can, and indeed must, move on the ground over and over again, but that it really is an airplane only becomes evident when it lifts off into the sky. (Frankl, 1990, p. 93)

Let's discuss these three characteristics in further detail.

In Frankl's view, there are phenomena of so-called facultative noö-psychic antagonism (phenomena of the obstinacy of the human spirit), which testify to a specific spiritual origin. They consist of the ability to withstand one's own natural predetermination by taking a certain position toward one's life and to act in accordance with this position, despite the pressure of social circumstances, drives, heredity, and other such natural determinants. Explaining his vision of the existence of a spiritual origin in a person, Frankl writes:

Human existence is conditioned. Though it becomes human only then and because, when and because it goes beyond its own conditioning, overcoming it, "transcending" it. Thus a person is a person only then and because, when and because he goes beyond the limits of his physical and mental existence as a spiritual creature.... Nevertheless we want to emphasize the fact that man as a spiritual creature not only withstands the world (external as well as inner), but also takes a position toward it. A person may always somehow "have an attitude toward", "behave" in relation to the world. At every

moment of his life, a person takes a certain position in relation to his natural and social environment, to the external world as well as to the vital psychophysical inner world, inner environment. And that which is able to withstand the social, physical and even mental in man, is what we call spiritual in him. (Frankl, 1990, pp. 111–112)

As a psychiatrist, Frankl states that facultative noö-psychic antagonism has crucial significance in the human struggle for recovery from mental illness. In his view, mental illness often has a psychophysical nature, but that doesn't mean that a person cannot withstand it. On the contrary, "in order to cure himself, the patient needs to somehow distance himself internally from his disease, his 'madness'" (Frankl, 1990, p. 113). He sees one of the most important tasks of a therapist in:

facilitating development of a healthy distance, which allows the patient as a spiritual personality due to facultative noö-psychic antagonism to take a position with regard to psychophysical disease, a very important position from the therapeutic perspective! Because this inner distance, taken by the spiritual in relation to the psychophysical, which is the foundation of the noö-psychic antagonism, seems to us very fruitful in relation to therapy. Eventually, any psychotherapy should be based on noö-psychic antagonism. (Frankl, 1990, pp. 113–114)

Man as a spiritual creature has freedom, which makes him capable of self-determination. Explaining his vision of this second specifically human characteristic, Frankl points at the two aspects of human freedom—negative and positive—which he calls "freedom from" and "freedom to" (Frankl, 1986, p. 52).

The negative aspect characterizes man as someone relatively independent from his natural predetermination. This means that his life journey cannot be fully determined by biological, psychological, and social determinants; he can actively participate in the determination of his life. At the same time, Frankl emphasizes that human independence is quite relative and should not be seen as omnipotence. Independence is possible only within a certain range, which is limited by the objective conditions of human life. In one of his works, Frankl points at this relatively negative human freedom, saying that

there is little point in opposing the "power of spirit" to the "power of nature". We have already indicated that both are contingent upon one another in his existence. For man is a citizen of more than one realm; he stands in life in a state of permanent tension, in a bipolar field of force. If we attempted to pit the two powers against one another, to test the power of one against the power of the other, the result would probably be a "dead hit". As is well known, a dead hit is the liveliest kind of race. The eternal combat between man's spiritual freedom and his inward and outward destiny is what intrinsically makes up his life. (Frankl, 1986, p. 82)

The positive aspect of human freedom is, according to Frankl, closely connected to the third essential human characteristic: responsibility. Frankl gives a substantial description of this characteristic in the form of answers to the questions that he poses to himself: 1) What does a person take responsibility for? 2)

Before what does a person take responsibility? 3) Before whom does a person take responsibility?

Answering the first question, Frankl emphasizes that human spiritual existence is always a conscious existence, and human responsibility consists of finding the sense of one's life, as a whole as well as in the particular circumstances. Meaning is given to life by values. A person must find these values by himself, and then his positive freedom lies in the freedom of choice of these values.

Before what does a person take responsibility? Before his conscience, which is closely related to the success in fulfilling his main moral duty. In Frankl's view, this duty is to be human, which means to be spiritual, free, and responsible—i.e., self-determinant in the values of one's own life and their implementation. Frankl believes that human nature is made so that man's conscience is able to indicate his advance or failure in fulfilling his main moral duty.

Answering the question, before whom does a person take responsibility, Frankl, being a believer, points at God as the Creator of man. It cannot be otherwise for a true believer, because if man is created by God, in the image and likeness of God, he is responsible for his specifically human existence, which, when all is said and done, passes before the face of God.

Thus, in general the specific character of human spiritual existence can be determined as a constantly conscious existence, which is a result of human self-determination on the questions of the values of his own life, for which he is responsible before his conscience and his Creator.

The existential criterion for normal and abnormal personality is implicitly present in the works of Frankl in his theoretical conceptualization of personality, non-predisposed and predisposed, respectively, to developing various psychological problems and mental disorders. Normality and abnormality (non-predisposition and predisposition to developing psychological problems of different kinds and to mental disorders) of a personality in Frankl's theory are determined by the particular features of the position a person takes toward his life.

Frankl defines the position of abnormal personality as fatalistic, because it orients the person's attitude to himself as to a naturally predetermined creature, which lacks a specifically human spiritual dimension. A person with such a position does not regard himself as responsible for the self-determination of his values, and, as a consequence, doesn't see himself as an active participant and allows various natural, psychological, and social determinants to decide his life journey.

According to Frankl, the most common consequence of human life following this fatalistic position is the development of a particular state, which he calls an existential vacuum. This vacuum is characterized by the experience of emptiness in life, boredom, loss of the meaning of life, lack of interest in life. According to a survey he conducted at the Medical University, Vienna, where he worked, symptoms of this state were found in 40% of Austrian, West German, and Swiss students, and in 80% American students. Frankl regards the existential vacuum as a prerequisite of various mental and behavioral disorders.

The position of a normal personality above all orients the person toward his spiritual existence, which implies awareness of responsibility for the meaningful-

ness of one's life. A person with a normal personality brings into effect the meanings of life, which he finds by himself, thus becoming an active participant in forming the direction of his own life. At the same time, a normal personality is also conscious of being conditioned by various biological, psychological, and social factors, which predetermine a human life, regardless of the person's own will. Due to this position of the normal personality, there is a reasonable compromise between naturally predetermined biological and social human existence, and free and reliable spiritual existence.

Frankl repeatedly emphasized the need for such compromise. For instance, he uses an illustrative comparison:

An individual's destiny belongs to him in much the same way as the ground, which fetters him by its gravity, but without which walking would be impossible. We must accept our destiny as we accept the ground on which we stand—a ground which is the springboard for our freedom. Freedom without destiny is impossible; freedom can only be freedom in the face of a destiny, a free stand toward destiny. Certainly man is free, but he is not floating freely in airless space. He is always surrounded by a host of restrictions. These restrictions, however, are the jumping-off points for his freedom. Freedom presupposes restrictions, is contingent upon restrictions. (Frankl, 1986, p. 75)

In Frankl's view, the conscious position of a normal personality toward life should be formed fully independently, and this idea is accentuated in his characterization of the main goal and process of existential psychotherapy:

Existential analysis, along with all forms of medical ministry, is content and must be content with leading the patient to the experience in depth of his own responsibility. Continuation of the treatment beyond that point, so that it intrudes into the personal sphere of particular decisions, must be termed impermissible. The physician should never be allowed to take over the patient's responsibility; he must never permit that responsibility to be shifted to himself; he must never anticipate decisions or impose them upon the patient. His job is to make it possible for the patient to reach decisions; he must endow the patient with the capacity for deciding. (Frankl, 1986, pp. 276–277)

Comparing the theories of personality of Frankl and Fromm, we conclude that they have two similar provisions.

First, one of the most important statements in Frankl's theory is his assertion of a contradiction between different forms of human existence: On one side, a person should live according to his biological and social nature, as a naturally predetermined creature, and follow natural, psychological, and social influences of different kinds. On the other side, man, as a creature responsible for the self-determination of life's meanings, should live in accordance with his spiritual nature. Due to the fact that such contradictions are inevitable from the very nature of human life, we may regard it as an existential dichotomy in Fromm's terms and define it as *a dichotomy of determinism–self-determination*.

Second, the existential criterion for the normal and abnormal personality is implicitly present in Frankl's theoretical concept of personality, non-predisposed and predisposed, respectively, to developing psychological problems and mental illnesses, and is characterized by the same particular features of content and formation of the position of the individual, as in Fromm's theory of personality, but in relation to this more specific existential dichotomy.

The normal personality orients the person toward the contradictory pre-determination of life in the form of an existential dichotomy of determinism–self-determination. A person with such a position is conscious of the unity of the diverse forms of his existence and admits the necessity of his simultaneous existence in all these forms. As a result, his position is one of reasonable compromise. Such a person admits that he is responsible for self-determination of the meanings of his own life, taking into account his real abilities, dictated by the biological and social conditions of his life. The position of the normal personality is developed on a rational basis, with the active participation of the person himself. It is done in the process of self-cognition, first of all of cognition of his own spiritual existence.

The position of the abnormal personality, called fatalistic, in its content orients a person toward a one-sided attitude toward himself, as if to a naturally predetermined creature who should obediently accept his fate and refuse responsibility for self-determination of the meanings of his own life. Frankl doesn't elaborate on the specific features of the formation of such a fatalistic position. Nevertheless, proceeding from its substantial characteristic, which fully corresponds to its name, we may conclude that it is not a result of self-determination, because it radically denies such a possibility.

Thus, the existential criterion for the normal and abnormal personality based on the works of Fromm is also implicitly present in Frankl's theory of personality as being non-predisposed and predisposed, respectively, to developing various psychological problems and other mental disorders. Frankl's theory, however, is based on the special case of *an existential dichotomy of determinism–self-determination*.

Summary: Comparative Study of Criteria for the Normal and Abnormal Personality in the Works of Fromm, Freud, Adler, Jung, Rogers, and Frankl

The results of the theoretical study discussed here and in the previous works (Kapustin, 2015a, 2015b, 2016a) allow the following conclusions.

1. Based on the works of Fromm, we propose a new “existential criterion” for the normal and abnormal personality, implicitly present in his works. According to this criterion, these two types of personality are determined by the particular content and the formation of a person's position toward existential dichotomies. Such dichotomies, entitatively existent in one's life, are inherent two-alternative contradictions between its different sides. They appear to the individual as problems requiring solution. This criterion is shown in the *Table 1* as the three main differences.

Table 1

Existential criterion for the normal and abnormal personality

Characteristics of the position taken by a person toward existential dichotomies		
	Normal personality	Abnormal personality
Content of the position	Compromising: orients toward a contradictory pre-determination of life in the form of existential dichotomies and the necessity of searching for compromise in resolving them	One-sided: orients toward a consistent, non-competitive and, as a consequence, one-sided way of life, denying the contradictory predetermination of human life in the form of existential dichotomies
Formation of the position	On one's own: result of self-determination Rational: based on one's own experience and reason	Imposed: formed by others Irrational: based on wishes and feelings

2. This criterion is also implicitly present in the theoretical conceptualizations of personality, predisposed and non-predisposed to developing various life problems and to mental disorders, by Freud, Adler, Jung, Rogers, and Frankl, though, in more particular forms, related to more specific existential dichotomies characterizing human life. These dichotomies are listed in *Table 2*.

Table 2

Existential dichotomies in different theories of personality

Author	Characteristics of human life
Erich Fromm	Existential dichotomies
Sigmund Freud	An existential dichotomy of nature–culture
Alfred Adler	An existential dichotomy of superiority–community
Carl Jung	Existential dichotomies of opposites
Carl Rogers	An existential dichotomy of self-actualization–conditioned values
Viktor Frankl	An existential dichotomy of determinism–self-determination

As shown in *Table 3*, the position of a normal personality orients the person toward contradictory predetermination of his life in the form of existential dichotomies and the necessity of searching for compromise in their resolution. The position of an abnormal personality orients the individual one-sidedly toward implementation of only one side of this dichotomy in his life, denying the need for implementation of another and, by doing so, directs the person to a non-confrontational and non-competitive way of life.

As shown in *Table 4*, in all these theories the position of a normal personality develops with the active participation of the person on a rational basis. At the same

time, these theories emphasize an important role of self-cognition in forming such a position and accentuate the specific features of self-cognition. We have not found any direct information about the formation of a position of the abnormal personality in the theories of Jung and Frankl. But in the other theories, where such information is present, it is stated that such a position is imposed on a person in early childhood, on an irrational basis, by internal or external sources, and the content of such an irrational basis is discussed in detail.

Table 3

Criteria for normal and abnormal personalities in different theories of personality, based on the content of the position taken by the individual toward existential dichotomies

Author	Content of the position	
	Normal personality	Abnormal personality
Erich Fromm	Orients toward a contradictory pre-determination of life in the form of existential dichotomies and the necessity of searching for compromise in resolving them	Orients toward a consistent, non-competitive, and, as a consequence, one-sided way of life, denying its contradictory pre-determination in the form of existential dichotomies
Sigmund Freud	Orients toward a contradictory pre-determination of life in the form of a dichotomy of nature-culture and the search for compromise in resolving it	Orients one-sidedly toward following cultural taboos on certain objects of natural (sexual) drives and ways of satisfying them, denying the existence of these prohibited drives in oneself
Alfred Adler	Orients toward a contradictory pre-determination of life in the form of a dichotomy of superiority-community and the search for compromise in resolving it	Orients one-sidedly toward gaining superiority over other people and denying the realization of a feeling of community
Carl Jung	Orients toward a contradictory pre-determination of life in the form of existential dichotomies of opposites and the search for compromise in resolving them	Orients one-sidedly toward the realization of conscious attitudes, denying the need for realization of their unconscious opposites
Carl Rogers	Orients toward a contradictory pre-determination of life in the form of an existential dichotomy of self-actualization-conditional values and the search for compromise in resolving it	Orients one-sidedly toward aligning one's personal qualities with conditional values, denying the need for self-actualization
Viktor Frankl	Orients toward a contradictory pre-determination of life in the form of a dichotomy of determinism-self-determination and the search for compromise in resolving it	Orients one-sidedly toward obedience to fate, denying responsibility for self-determination of the meanings of one's own life

Table 4

Criteria of the normal and abnormal personality in different theories of personality, based on formation of the position taken by the individual toward existential dichotomies

Author	Formation of the position	
	Normal personality	Abnormal personality
Erich Fromm	Developed with the active participation of the person himself on a rational basis – on knowledge, the source of which is his own experience and reason	Imposed by other people on an irrational basis – on the wishes and feelings that he experiences toward them
Sigmund Freud	Developed with the active participation of the person himself on a rational basis – in the process of self-cognition, first of all, of cognition of one's unconscious	Imposed by other people in one's childhood on an irrational basis, using one's vital and psychological dependence on them
Alfred Adler	Developed with the active participation of the person himself on a rational basis – in the process of self-cognition, first of all, of cognition of one's leading motivation and individual style of life	Imposed in childhood on an irrational basis, under the influence of an exaggerated feeling of inferiority
Carl Jung	Developed with the active participation of the person himself on a rational basis – in the process of self-cognition, first of all, of cognition of one's personal and collective unconscious	No direct evidence
Carl Rogers	Developed with the active participation of the person himself on a rational basis – in the process of self-cognition, first of all, of cognition of one's distorted conscious and unconscious experience	Imposed in childhood by other people on an irrational basis – on the basis of the person's need for positive regard from others and for positive self-regard
Viktor Frankl	Developed with the active participation of the person himself – on a rational basis, in the process of self-cognition, first of all, of cognition of one's own spiritual existence	No direct evidence

Conclusion

1. The fact that an existential criterion for the normal and abnormal personality is present in six classical theories of personality, developed within totally different approaches to psychology and psychotherapy, is evidence of a relatively high degree of its theoretical justification. If we also take into account that all these theories were based on analysis of clinical cases from the psychotherapeutic practice of their authors, this criterion can be considered as having a relatively high degree of empirical justification.

2. The general provisions found in all these theories of personality indicate the possibility of their integration, although they were developed in different approaches to psychology and psychotherapy that are traditionally regarded as incompatible.
3. These results allow us to draw the general conclusion that the existential criterion can be successfully used to assess the abnormality of a personality as one of the most important indicators of its predisposition to developing various life problems and mental disorders, as well as in the practice of psychotherapy, in the correction and education of the personality, as one of the most valuable reference points for its normal development.

Application of the Results

I have shown in a number of empirical studies (Kapustin, 2014, 2015c, 2015d, 2015e, 2016d) that the key factor leading to child-parent problems in the families of clients in psychological consultation is the abnormality of the parents' personalities, identified through an "existential criterion" that is displayed in their parenting styles. These parenting styles contribute to the development of children with abnormal personality types, also identified through existential criteria, that are designated as "oriented toward external help", "oriented toward compliance of one's own behavior with other people's requirements", and "oriented toward protest against compliance of one's own behavior with other people's requirements".

Children with such personality types are faced with requirements from their closest social environment that are appropriate for children with normal personalities, but not for those with abnormal personal abilities, and so they start having problems. As these problems are connected with difficulty adjusting to requirements of the social environment, they can be classified as problems of social adaptation.

I have identified a similarity between the personality type "oriented toward compliance of one's own behavior with other people's requirements" and theoretical concepts in the work of Fromm, Freud, Adler, Jung, Rogers, and Frankl about the predisposition of people with an abnormal personality to various psychological problems and mental disorders. These similarities suggest that a personality of this type can be regarded as a classic type that all these authors faced in their psychotherapeutic practices. It was shown that abnormal personality types, formed in childhood, influenced the formation of a large proportion of personal and marital problems in adulthood (Kapustin, 2016b, 2016c).

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Original manuscript received April 02, 2018

Revised manuscript accepted September 24, 2019

First published online June 25, 2020

To cite this article: Kapustin, S.A. (2020). An Existential Criterion for the Normal and Abnormal Personality in the Works of Viktor Frankl. Summary. *Psychology in Russia: State of the Art*, 13(2), 140–153. DOI: 10.11621/pir.2020.0210

Ethical Challenges in the Teaching of Improvisation for Psychologists' Communication

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Background. In the last few decades, the ethical issues in psychological research have gained considerable attention. In our study we discuss training of psychologists from the ethical point of view.

Objective. 1) To develop communication skills with the help of improvisation in a specially designed training program. 2) To uncover the role of ethical questions about the morality of risk–benefit assessment and justification for the conduct of research, selection of a suitable target population, informed consent, and evaluation of our results.

Design. Psychology students are required to develop communication skills that they will need in their future profession. The participants (70 psychology students) were asked to improvise following the three-stage procedure we designed. We describe all the stages of our training program and how the ethical norms contribute to our work. We discuss the ethical norms and rules in the first and third stages of our training session.

Results. We faced several ethical issues with risk–benefit assessment and justification of the conduct of the research. On the one hand, training causes anxiety, putting participants in uncomfortable situations; on the other, this corresponds precisely to the objectives of our work, posing an ethical dilemma. We looked for ways to create more comfortable conditions without jeopardizing the objectives of our study. We introduced concerns about the interpretation of an improviser's work. The improvisers told stories that did not always correspond to reality, which confused the other participants. Discussing this point from an ethical position led us to a deeper understanding of improvisation and led to certain modification in our design of the training program.

Conclusion. We consider improvisation a creative process which helps one to adapt to new, uncomfortable situations. Here we show that based on ethical standards and rules, we could properly organize our training and comprehensively review the learning and improvisation process.

Keywords: improvisation, communication, educational training, ethical dilemmas, ethical standards

Introduction

Huge advances in technology, novel challenges, and more and more complicated research have brought ethics to prominence in scientific psychology. Ethics is defined as a moral philosophy or code of morals practiced by a person or group of people (yourdictionary.com). In other words, ethics verbalizes what is considered good or bad, moral or immoral in a society at a given period of time. Although ethics in the narrow sense has been discussed and applied in medicine and biomedical research for centuries, ethics in the general sense and as applied to psychology is a concept of the 20th century (Dilman, 2005; Luegenbiehl & Clancy, 2017; Mason et al., 2019; Spencer-Oatey & Xing, 2019).

Although seemingly clear-cut, it still has certain areas requiring further conceptualization and rigorous research, with a particular focus on applied issues of psychology studies today. The basic principles of research ethics are three: (a) minimizing the risk of harm; (b) obtaining informed consent; and (c) protecting anonymity and confidentiality (Laerd Dissertation, n.d.; Artal and Rubinfeld, 2017; Grech, 2018).

The importance of ethics is supported by numerous articles dealing with medical practice or interaction with special groups of respondents. Thus, articles on cancer patients, newborns, and experimental studies of humans and animals emphasize the necessity to rely on ethical norms and rules, each time checking our actions in terms of the balance between benefits and harm, observing the boundaries of autonomy, and providing the requested information to all the participants in full (Harper et al., 2018; Buzdar and Hoover, 2017; Houdayer et al., 2019). The research tradition both abroad and here in Russia rests on already established milestones in medical studies and biological research.

The legacy of World War II triggered broad research on war veterans and other civilians finally leading to understanding of the need for guiding principles for investigating the human (Schuler, 2013). The first document designed to regulate the professional behavior of psychologists was the Code of Ethics of the American Psychological Association, which was adopted in 1953 (American Psychological Association, n.d.).

In Russia, psychological research has long followed the principles formulated by bioethics committees and the common sense intrinsic to the Russian school of psychology. Some issues were already formulated by B.S. Bratus' (1998). However it was not until the 21st century that special attention was paid to ethics in psychology as a separate area (Bratus, 2019; Shabolta, n.d.).

The Code of Ethics of the Russian Psychological Society was adopted in 2012 at the Fifth Congress of the Russian Psychological Society (Russian Psychological Society, 2012). It is based on the Constitution of the Russian Federation and reflects a wide palette of a psychologist's work. Yet, at the legislative level, this document has little power; it serves for self-regulation within the community rather than for protecting psychologists and their patients.

At the First International Conference on Ethics in Psychological Counseling and Psychotherapy in 2017, in Moscow, various aspects of ethical issues faced by counseling psychologists and psychotherapists were discussed, and a book of reports and articles from the conference was published (Kiselnikova et al., 2019).

The field of psychological research in Russia is regulated, yet quite a number of questions still arise and require a balanced approach. Multidisciplinary approaches, with philosophy serving as the foundation, could be useful in this field. One of the seminal works is the book *Would you kill the fat man?* (Edmonds, 2015), where David Edmonds outlines ethical problems, providing a comprehensive view of the classic “trolley problem” in ethics, while analyzing many ethical theories and how each would respond to it. The book *Justice: What’s the right thing to do?*, by Michael Sandel (Sandel, 2010) argues that justice is more important than being autonomous. Sandel quotes Alasdair MacIntyre and his characterization of humans as “storytelling beings” who live their lives with narrative quests. MacIntyre’s best-known book, *After virtue* (MacIntyre, 2016) is the product of a long-term ethical project. It diagnoses contemporary society as a “culture of emotivism”, where moral language is used pragmatically to manipulate attitudes, choices, and decisions, so that contemporary moral culture is a theater of illusions with objective moral rhetoric masking arbitrary choices. MacIntyre followed his seminal work with two books examining the role that traditions play in judgments about truth and falsity, *Whose justice? Which rationality?* (MacIntyre, 2017) and *Three rival versions of moral enquiry* (MacIntyre, 2006). MacIntyre’s next major work, *Dependent rational animals: Why human beings need the virtues*, investigates the social needs and social debts of human agents, and the role that a community plays in the formation of an independent practical reason (MacIntyre, 2006).

However, the philosophical constructions, notwithstanding their profound insights and practical validity, are still abstract models, lacking the scope for numerous minor cases loaded with emotion and unresolved tensions.

In modern fiction writing, over the past decade quite a few books have addressed important ethical issues within the framework of the putative challenges of the 21 century. Kazuo Ishiguro’s novels frequently grapple with the importance of the individual within the confines of society. Over the years returning to his novel *Never let me go* (Ishiguro, 2006) makes one think about the possible ethical limits for a man desiring to change nature, the existence of the soul, and whether all means are good for solving global human problems.

The ethical issues are a topic for many publications and in each new decade new questions are debated (Asmolov, 2016; Koonrunsesomboon et al., 2016; Kostis et al., 2018; Leontiev, 2013).

In our study we focus on the major ethical issues arising in purely scholarly research dealing with normal people in the educational context, when no ethical problems would be expected to arise at all. Still, quite a few issues appear upon closer inspection. In the following sections we address risk–benefit assessment and justification of the conduct of research, selection of a suitable target population, and informed consent in the context of our work.

Methods

Setting the goals for developing improvisation skills, we need both to use existing training exercises and to create new ones. Guided by the Code of Ethics of the Russian Psychological Society (Russian Psychological Society, 2012), we are aware that we must:

1. Recognize the value and dignity of students and respect their individual, cultural, and role differences, including origin, social status, gender, age, sexual orientation, and physical disability. The participants should also be aware of their prejudices and stereotypes of perception and especially carefully monitor how these can affect the learning process.
2. Promote self-development and self-awareness of students so that they learn how to integrate personal discoveries and practice.
3. Be responsible for respecting the existing personal boundaries.
4. Recognize the personal life experience and personality of students.
5. Follow the progress of students' work and be ready to report to students and colleagues about what the researchers/teachers are doing and why.
6. Comply with the rules on confidentiality, which stipulate the responsibility of both the trainer and the students.
7. Provide students with the opportunity to discuss and evaluate the experience gained during the training individually and/or in groups, at least once during the training program.

Keeping these rules in mind, we further discuss the organization of research on improvisation within the educational setting and the difficulties we faced designing the experiment, which had not only a scientific but also a training purpose. Since we had to videotape our training sessions to be able to further apply qualitative research methods, we requested the written consent of the participants.

Conducting the training sessions requires the mentors to create an atmosphere that includes all participants, to develop an action plan, and most importantly, to observe the personal boundaries of the participants, creating a safe working environment. In other words, to create an ethically balanced environment.

During our training session we created an unexpected communicative situation to develop communicative skills and to single out and study the significant skills encouraging improvisation. We examined the improvisational behavior of students through training sessions that included three stages: the preparatory stage, the main stage, and the analysis.

Participants

Our training is educational; its participants are 70 students from 19 to 22 years old. It was conducted at the Department of Psychology at Lomonosov Moscow State University, during a course on "Social Psychology of Negotiation", and at the Psychology Department of the Academy of Public Administration within the framework of "Communication Psychology".

Procedure

The training session comprised two lessons; it was technically complicated and demanded close attention to organizational details.

Much attention is paid to the preparatory phase, which accounts for a third of all the time, and preparation is also expected outside the classroom, which usually takes approximately one week until the next lesson.

During the first stage, we present the full picture and the rules of behavior. We talk about the improvisation process from different angles, so that the participants get acquainted with this phenomenon from the theoretical point of view. We single out that we will work with developing communication skills. During the next lesson, we write down the rules according to which we plan to work during the main stage of the training and point out the following principles: voluntary participation, activity, confidentiality, respect for each other, actual communication (here and now), and competent feedback. We discuss these rules and add some if the students consider them necessary.

The procedure was approved by the Board of Ethics, Department of Psychology, Lomonosov Moscow State University.

Then the participants were shown *Emilia Muller*, a short film directed by Yvon Marciano shot in 1993. The plot is based on the improvising game of an actress. She came in for an audition and after a few general questions, they asked her to speak about the contents of her handbag. The intrigue was revealed at the end of the video, when it became clear that the actress was actually talking about the handbag belonging to the studio worker, not to herself. Thus, she managed to improvise in a highly unexpected situation. We asked them to prepare for the next class, as we were planning to role-play a similar story. We asked the participants to prepare their own bags, including small handbags, backpacks and others for the experiment beforehand: As the content of the bags will be displayed in front of all the participants, it should include only objects the participants are prepared to disclose before the audience. We asked their consent to videotape the improviser's work, which was to speak about the objects in the bag as if they belonged to him/her. The task of the analysts – the other members of the student team – was expert estimation of the videos.

For any research to be ethical, the researcher must have informed consent from the participants. The “informed” part of this ethical principle is the most important part. We warn the participants that their improvisation will be recorded, which implies a written consent.

The main stage was the training and the improvisation event. It comprises a warm-up exercise and the main stage. Let us briefly describe it here. Our participants gave their bags to us to attach a number to each of them. With the first exercise, we divided the participants into four groups. They chose one improviser within each group, while the others became expert analysts. The improviser picked a number and was given the corresponding bag, started taking objects out of it and speaking about them as if they belonged to him/her. Representatives of all groups played the role of an improviser. The exercise culminated in a feedback session in which the participants shared their impressions, thoughts, feelings, and comments. This feedback has a number of purposes. First, it aims to ensure that none of the participants have been harmed or made to feel uncomfortable in any way by the study. Second, it aims to make sure that the researchers have informed consent. Third, it allows the participants an opportunity to remove their results from the study if they felt insecure. Finally, it allows the participants to ask any questions about the study to make sure they fully understand its content and the purpose.

Results

Analyzing the results of the training, we had the following difficulties. For heuristic purposes, we could divide them into those connected with the form and those connected with the content of the procedure. We will discuss the organization questions first.

How could the training be organized more effectively, observing personal autonomy and boundaries? The role-play required the participants to act in an unexpected situation, improvising while demonstrating their communication skills. From this point of view, the result was positive. But from the point of view of organizing the training, we had the following questions or ethical dilemmas. Could we achieve better results in the training of improvisation skills if we did not warn participants about the upcoming exercises and ask them to prepare? In particular, to prepare their bags? They put into their bags only things they were prepared to display to the large audience. However, we expected that the result of the training would have been better if we had not asked them to do so. It would have created a tense atmosphere, yet it would have stimulated improvisation even more and thus forced the development of communicative skills. Therefore, the outcome would have been better, while the experience would have been more stressful. Still, one cannot neglect the ethical questions in this respect. By improving one aspect, we would violate the ethical norms and we cannot rule out the possibility of harming some people. The following questions arise: How much can we violate personal boundaries by tightening up on the rules of training and achieving better results in improving the students' skills? For growth and personal development, the discomfort situation must be optimal so that there is a zone of proximal development, as this is an opportunity to learn new things with the help of a teacher and not to be overwhelmingly stressed.

Having conducted a series of such training programs, we would like to remove the task of preparing the bags for the next lesson done by the participants themselves. We intend to use tote bags thanks to their simplicity, spaciousness, and rectangular shape. These bags are convenient for many tasks, they are often distributed to participants at scientific conferences, and there are plenty of them ready at hand. Each participant would be supplied with a certain number of items, placing everyone on an equal footing. The main finding is that the improvisation process is at the right balance between the optimal level of anxiety and a good level of communication skills.

Discussion

Overall, we conducted our classes in accordance with the norms of the Code of Ethics of the Russian Psychological Society. All the participants included in our study discussed and agreed to the rules we devised. Discussing on a case by case basis, rather than presenting the already established rules, is critical for organizing the training session. Training, even when clearly structured and subordinated to a rigid plan, is a creative process, possible only if the interaction is open. Then creativity will become joint, and the synergy effect will be powerful. The presenter needs to solicit a joint discussion of the principles and values of the participants at the preliminary meeting.

We used a set of exercises we had developed to teach communication skills, to be further explored in improvisation. Using non-standard formats makes it possible to create a qualitatively different level for development. This atmosphere also markedly enhances emotional involvement in the process.

However, the level of the students needs to be taken into account. If the format is too unexpected for the level of preparation of the participants, the training may have the exact opposite effect, turning people off. It is important to choose the right target audience and balance the stress and outcome.

The participants in our training were psychology students who have many practical classes and workshops during their education. The students are required to develop communication skills that they will all need in their future profession. Thus, they represent a good group for the training program, both to practice communication through improvisation and to study these processes. We faced several ethical issues with risk–benefit assessment and justification of the conduct of the research. We intentionally placed subjects in an unexpected communicative situation to create the conditions for improvisation. On the one hand, this causes anxiety, putting participants in an uncomfortable situation; on the other, it corresponds precisely to the goals of our work, presenting an ethical dilemma. Improvisation in communication means acting in unexpected conditions. It was important for us to ensure that the unexpected situation we created was experienced by the participants as an optimal one for training.

In the future, we plan to change the training at the preparation stage, in order to create more comfortable conditions for the participants, without jeopardizing the objectives of our study. We believe that irrespective of the training needs, goals, and efficiency, the participants' comfort and respect for personal boundaries remain of utmost importance for planning and designing any kind of training session or master class.

Some studies require that the participants be deceived in some way to achieve the study's goals and have reliable results. Deception includes: misleading the participants in any way and the use of stooges or confederates. But this is against the ethical standards set by the Russian Psychological Society. Deception is also unfavorable and sometimes even impossible in a training session, as it would impede the development of the necessary skills and destroy the comfortable atmosphere.

This is an important point, directly related to the ethical challenges in psychological practice. It is particularly the interpretation of results in terms of ethical standards and values that is difficult and calls for greater consideration and accuracy in contemporary settings.

Further questions arise about interpreting the results. It turned out that the simple process of evaluating the videos raised a number of ethical problems. These were discussed after the improvisation. An overview of the most frequent and pressing questions is presented below. This discussion was an important outcome of our training as it provided valuable feedback initiated by the participants, that has to be discussed.

Many of our participants, playing the role of the observers, wondered if it wouldn't turn out that a good, natural liar gives a better impression of himself by completing the task better than others.

Where is the line between lies and fantasy?

What are limits of fantasy?

How to treat modern Munchausens?

Munchausen (Raspe et al., 2012) was a trickster of the Enlightenment, and like any trickster, he was highly ambivalent, negative and positive at the same time. As a rule, the trickster sets the task of changing the game, the situation and life, and does not act with malicious intent. It is not the game of life itself, but the process that is important for the trickster. On the one hand, he would seem to reject rationality by telling fables. He takes pleasure in penetrating the fabric of reality, opening up a rich palette of ways to interpret it. On the other hand, all of his fables have a clear rational or, more often, quasi-rational explanation.

In world literature, an example is a character created by the Swedish writer Astrid Lindgren, the world-famous Karlsson (Lindgren, 2008). Karlsson creates his own world, the world of a game, construes the reality that would help the boy grow, develop, and become an adult. Another character, sometimes irritating, sometimes arousing admiration, is Ostap Bender (Il'f & Petrov, 2011). He is one of the most popular heroes of the picaresque novel in Russian literature, bringing together two worlds: reality and fantasy.

According to a definition of lies by Aldert Vrij (Vrij, 2008), "A lie is a successful or unsuccessful deliberate attempt, made without warning, to form another person's belief that the communicator considers incorrect". In his scientific articles, the author and colleagues consider various aspects of lies in verbal and non-verbal contexts (Leal et al., 2018).

According to recent studies, a false statement is usually filled with many details, in contrast to truthfully presented information. Expressions such as "sweet-talking" or "honey-tongued" imply a certain self-interest. A ridiculous story written in 1960 for children, "Fantazery", is an interesting illustration of this difference. It is about two boys who told each other all sorts of tales, competing over who would be better at lying (Nosov, 2010). A third boy sat on the bench facing them. He told how he had really deceived his mother by eating half a can of jam and blaming his sister for it. In the example, N.N. Nosov introduced the idea that the main thing in all the fantasies of the two boys does not relate to a person as a means, a tool to achieve personal goals, or as an object, whereas the third boy used his lies to harm his sister and to escape punishment.

Following Kant, we turn to moral law, the "categorical imperative": "So act that you use humanity, in your own person as well as in the person of any other, always at the same time as an end, never merely as a means" (Dimmock, 2017).

If we perceive fantasy in art, music, dance, and theater as leading to the creation of an artistic image, as the ability to combine emotional and rational components, in communication the fantasy may lead to problems. This is because it is a complex process that includes at least three different processes: communication (exchange of information), interaction (exchange of actions), and social perception (perception and understanding of the partner), which directly depend on social trust (Psychology Wiki, n.d.).

After all these profound discussions, we have come to the idea that the improvisation process has to be evaluated, including its general effect. In the final stage, the expert analysts, having watched the videos of students, were to evaluate the stress resistance, communicative skills, and spontaneity of the improviser and the general effect, with a 5-point expert estimation protocol. A high assessment of the overall impression of the improvisation of colleagues depended in many respects on the inherent coherence and congruence of the situation, rather than on the presumed success of the improviser.

Our task is to show that improvisation in communication is a creative process aiming at creating images and organizing them into a meaningful whole.

With the help of imagination, the real world is mastered creatively; the images created are determined not by credibility, but by the logic of what is happening. The imbalance between reality and fantasy in creativity leads either to copying the real world or to fantasy, and creating images is much more important than fitting them into reality. The rules guiding their creation belong to the domain of art and fiction and not to the domain of real world and linear logic. This should be also considered when exploring such complex processes as improvisation and communication.

Conclusion

In our study we explored the improvisation process and its relationship to communication. Improvisation involves freedom expression, which determines the openness of instructions for participants, and the inclusion of all participants. In order to achieve this, one must choose a form of performance that inspires the confidence of the audience and does not turn it off. But this in turn requires a clear definition of the goals of the work shared by each participant in the training program. Otherwise, we lose the structure and encounter difficulty in interpreting the results. We arrive at the conclusion that improvisation is a creative process which helps to adapt to a new situation.

When choosing the profession of a psychologist working in research, counseling, or therapy, we are faced with many ethical choices. Ethical rules and norms enter our lives, first through acquaintance with them, then via personal experience, and finally from analysis of situations. It seems to us that this process is endless. Based on international practice and our experience, we have proposed seven rules for conducting the training sessions. The ethical principles that underlie our current regulatory framework must be carefully considered and reflected in several regulatory documents.

A teacher's work requires looking for new methods of work with various kinds of audiences. Seminars and workshops are supposed to be highly interactive, which requires a constant search for new types of group work. In this search, we need to be able to embrace all the difficulties of this work in the context of ethical norms and rules. We believe these rules need to be adapted for each group. Any uncomfortable situation may impede the improvisation process; therefore, developing improvisation skills is a highly delicate task pertaining to personal boundaries that must be carefully observed.

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Original manuscript received November 11, 2019

Revised manuscript accepted May 12, 2019

First published online June 25, 2020

To cite this article: Temezhnikova, O.B., Bazarov, T.Yu. (2020). Ethical Challenges in the Teaching of Improvisation for Psychologists' Communication. *Psychology in Russia: State of the Art*, 13(2), 154–164. DOI: 10.11621/pir.2020.0211