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Dissociation in Patients with Non-Psychotic Mental Disorders

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Background. Dissociation is a generally recognized phenomenon in psychology and psychiatry; however, questions are still not fully resolved about the difference between pathological and normal dissociation, as well as the role of dissociation, depending on its aetiology, in the formation of clinical manifestations of mental disorders.

Objective. To complement the existing data about the significance of dissociation in non-psychotic mental disorders.

Design. Using the Dissociative Experience Scale (DES), we screened 62 patients (13 male and 49 female) from the Non-Psychotic Conditions Inpatient Department of the Udmurt Republican Clinical Psychiatric Hospital (Izhevsk, Russia). Nineteen of the patients had mental disorders of organic aetiology and 43 patients had mental disorders of psychogenic aetiology.

Results. Dissociation at the pathological level was detected in 12.9% of the patients, all of them female. Among patients with psychogenic disorders, the proportion of patients with pathological dissociation was more than three times that of patients with organic disorders. Among the particular dissociative phenomena, absorption had the highest average severity, both in the general sample and in each aetiological group of patients, while dissociative amnesia had the lowest average severity. The highest levels of dissociation were found in young female patients who had never been married. In patients with psychogenic disorders, the average dissociation severity was significantly higher than in the general population, while in patients with organic disorders it was significantly lower.

Conclusion. The dissociation phenomenon may play a significant symptom-forming role in young women suffering from non-psychotic mental disorders of psychogenic aetiology. In the case of organic mental disorders, the severity of dissociative manifestations decreases even below the conditionally normal level, which may indirectly indicate the destruction of dissociative physiological mechanisms by an organic brain process.

Keywords: dissociation; dissociative phenomena; dissociative disorders; non-psychotic mental disorders; dissociation scale

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Introduction

Dissociation is a psychic phenomenon consisting in the detachment of certain experiences (usually painful ones) from a person's consciousness. In a particular individual, this phenomenon may be manifest as the alienation of his own psychic acts or even his own "self", the alienation of psychotraumatic events experienced by him, or the disintegration of memories of these events (McWilliams, 2011; Tarabrina, 2001). The term "dissociation" was introduced into practice in this specified meaning by the eminent French psychologist and psychiatrist P. Janet in the late 19th century (Janet, 2009). Dissociation is a common term in psychology and psychiatry, and it is considered an important mechanism in the formation of psychopathological symptoms. The role of dissociation in this process is recognized, in particular, by its inclusion in the "Dissociative disorders" block of modern psychiatric classifications, including the classification of mental and behavioral disorders in the current 10th revision of International Classification of Diseases (ICD-10). In the ICD-10 there are such forms of pathological dissociative disorders as dissociative amnesia, dissociative fugue, dissociative stupor, dissociative trance and possession disorder, dissociative motor disorder, dissociative convulsions, dissociative anaesthesia, Ganser syndrome (which is understood mainly as dissociative pseudodementia), and multiple personality disorder.

The predominant concept of the origin of dissociative disorders in the world today is the so-called traumatic concept, which considers these disorders a result of childhood mental trauma (Loewenstein, 2018; Reddy, Patil, Nayak, Chate, & Ansari, 2018). In this concept, great importance is attached to different types of child abuse — physical, emotional, or sexual (Dalenberg & Palesh, 2004; Dar & Hasan, 2018; Ross et al., 2008). Some authors even try to estimate the quantitative relationships between the intensity of childhood abuse and the risk of subsequent dissociative disorders (Granieri, Guglielmucci, Costanzo, Caretti, & Schimmenti, 2018; Schalinski et al., 2016). However, not all researchers view mental trauma as the main cause of dissociative disorders, and the nature of these disorders remains disputed (Canan & North, 2019). Moreover, there is a separate diagnostic category in the ICD-10, "Organic dissociative disorder", which assumes the existence of a purely organic mechanism of the formation of dissociative disorders, unrelated to mental trauma. Finally, there are reports of an effect of dissociation on the course of a number of other neurotic and affective disorders, which may indirectly suggest involvement of the dissociation in the clinical manifestations of these disorders (Choi et al., 2017; Prasko et al., 2016).

Several authors note the existence of normal dissociation, which is part of a healthy psyche and is a mechanism of psychological defense, along with other similar mechanisms (Bokhan, Ovchinnikov, & Sultanova, 2017; McWilliams, 2011; Stepanova & Tokareva, 2017). The difference between normal dissociation and dissociation underlying mental disorders is understood in different ways by different researchers. Some view these two types of dissociation as qualitatively different phenomena, possibly even of different origins (Alayarian, 2019; Waller, Putnam, & Carlson, 1996). Others consider the differences between them to be purely quantitative, determined

by the degree of adaptivity of dissociative manifestations at a certain level in a specific situation (Dell, 2002). Considering dissociation in this context and drawing data from Western researchers, Russian psychologist N.V. Tarabrina (2001) identified several particular dissociative phenomena that are components of a general dissociative continuum, extending along the norm–pathology axis. According to her study, the specified phenomena include: *absorption* — an affective absorbing of attention by a bright external object, up to complete mental fusion with it; *distraction* — uncontrolled shifting of attention from surrounding reality to internal experiences ("empty sight", "waking dreams"); *depersonalization* — a feeling of one's emotional change or loss of a sense of reality; *dissociative identity violation* — a transient or persistent experience of splitting or alienation of one's "self"; and *dissociative amnesia* — obscurity or total loss of memories about psycho-traumatic events.

Several scales have been developed to assess the severity of dissociative manifestations, including scales for large-scale epidemiological studies (Bernstein & Putnam, 1986; Carlson et al., 1993; Dalenberg & Carlson, 2010; Ross, Hebe, & Norton, 1989; Sanders, 1986). There are reports in the literature about studies of the prevalence and severity of dissociation in the general population, including cross-cultural aspects, that used these methods (Akyuz, Dogan, Sar, Yargic, & Tutkun, 1999; Ross, Joshi, & Currie, 1990; Xiao et al., 2006). The results of these studies show a rather high prevalence of dissociation not only among patients with mental disorders, but also among mentally healthy persons. At the same time, as mentioned above, the question of the differences between normal and pathological dissociation is still not fully resolved. Despite recognition of the significant role of dissociation in the clinical manifestations of various mental disorders (Friedl & Draijer, 2000; Gast, Rodewald, Nickel, & Emrich, 2001; Klaric & Lovric, 2018; Ross, Duffy, & Ellason, 2002), the relationship of dissociation to the aetiology of these disorders has also not been thoroughly studied. Identified knowledge gaps in understanding dissociation and its role in normal and pathological mental activity determine the relevance of this study.

Methods

The objective of the study is to complement the existing data about the significance of the dissociation phenomenon in non-psychotic mental disorders.

Tasks of the study:

1. To determine the prevalence of pathological dissociation among patients with non-psychotic mental disorders;
2. To explore dissociation severity in non-psychotic mental disorders with different aetiology;
3. To explore dissociation severity in non-psychotic mental disorders at different demographic groups;
4. To compare dissociation severity in non-psychotic mental disorders of different aetiology with its severity in the general population.

The study was conducted with patients of the Inpatient Non-Psychotic Conditions Department of the Udmurt Republican Clinical Psychiatric Hospital (Izhevsk,

Russia). All adult patients being treated in that department for the three-month period (from 1 October 2019 to 31 December 2019) who agreed to participate in the study were screened, for a total of 62 patients, 13 male and 49 female (gender balance 1 : 3.8). The age of the patients ranged from 21 to 74; the average was 50.4 ± 3.6 years. The diagnostic composition of the sample is presented in *Table 1*. Patients with non-psychotic mental disorders from two blocks of the ICD-10 — "Organic, including symptomatic, mental disorders" (F0) and "Neurotic, stress-related and somatoform disorders" (F4) — were included in the sample. Nineteen patients were diagnosed with a mental disorder from block F0, and 43 patients from block F4. In other words, the mental disorders of 19 patients had an organic aetiology and those of 43 patients had a psychogenic one.

Table 1

Diagnostic composition of the sample according to ICD-10

ICD-10 block	All patients	Male	Female
Organic, including symptomatic, mental disorders (F0)	19	2	17
Neurotic, stress-related and somatoform disorders (F4)	43	11	32
Total	62	13	49

An experimental-psychological method was used to perform the study, the Dissociative Experience Scale (DES) developed by E.M. Bernstein and F.W. Putnam (1986). This scale is currently the most widely recognized tool in the world for identifying and measuring dissociative phenomena. We used the scale variant adapted by N.V. Tarabrina. The patients were screened for general severity of dissociation and its compliance with the normative level, which should not exceed 20.7 points according to the developers of the DES. Also, the severity of particular dissociative phenomena (absorption, distraction, depersonalization, identity violation, and dissociative amnesia) was estimated by focusing on separate paragraphs of the scale appropriate to the context of these phenomena. Student's t-test was used to determine the statistical validity of the results.

Results

Dissociation exceeding the normative level of the DES was detected in 8 patients (12.90% of the sample). All the patients with pathological severity of dissociation were female, and 16.33% of all female patients had a pathological level of dissociation. In patients with psychogenic disorders, dissociation at the pathological level was observed in 7 patients (16.28%), while in patients with organic mental disorders that level was found only in 1 patient (5.26%). Thus, among the patients with psychogenic disorders, the proportion of persons with pathological dissociation was more than three times that of the patients with organic disorders.

The average general dissociation severity in the sample according to the DES was 11.36 points (see *Table 2*). Among the particular dissociative phenomena, absorption, on average, was the most severe in the sample, followed (in descending order of average severity) by distraction, depersonalization, dissociative identity violation, and dissociative amnesia. It is particularly significant that the average level of dissociation in the patients with psychogenic disorders was almost twice that of the patients with organic mental disorders ($p < 0.05$). The average severity of each particular dissociative phenomenon in the former group was also higher.

Table 2

Average severity of general dissociation and particular dissociative phenomena

Dissociative phenomena	**All patients**	**Patients with organic disorders**	**Patients with psychogenic disorders**
General dissociation	11.36	7.83	13.02
Absorption	19.35	14.21	21.62
Distraction	15.20	11.18	16.97
Depersonalization	10.78	6.05	12.87
Identity violation	10.57	6.00	12.58
Dissociative amnesia	9.88	8.79	10.36

A comparison of general dissociation severity in patients by gender (see *Table 3*) shows that in women its average was slightly higher than in men ($p < 0.05$). The average severity of each dissociative phenomenon was also higher among female patients. In conjunction with the higher prevalence of pathological dissociation among the women, this result indicates that dissociative mechanisms in patients suffering from non-psychotic mental disorders are more developed specifically among the women.

Table 3

Comparison of the severity of general dissociation and particular dissociative phenomena in male and female patients

Dissociative phenomena	**Male**	**Female**	**Significance of differences**
General dissociation	10.79	11.57	$p < 0.05$
Absorption	18.46	19.59	$p < 0.05$
Distraction	13.84	15.56	$p < 0.001$
Depersonalization	10.38	10.89	$p > 0.05$
Identity violation	11.05	10.44	$p > 0.05$
Dissociative amnesia	7.91	10.40	$p < 0.001$

For studying dissociation severity in the different age groups of the patients, we used the World Health Organization's (WHO) age periodization. The highest rate of general dissociation was observed in young patients (ages 18–44). In older age groups, that rate gradually decreased (see *Table 4*). The same pattern was observed for each particular dissociative phenomenon. The data suggests that dissociative psychological mechanisms in patients with non-psychotic mental disorders weaken with age.

Table 4

Average severity of general dissociation and particular dissociative phenomena in patients of different ages

Dissociative phenomena	**Young age (18–44 years)**	**Middle age (45–59 years)**	**Advanced age (60–74 years)**
General dissociation	16.98	10.67	7.14
Absorption	25.74	22.77	10.86
Distraction	21.90	15.69	8.69
Depersonalization	17.56	8.40	6.46
Identity violation	16.30	8.95	6.59
Dissociative amnesia	12.51	10.08	7.32

An analysis of the dependence of dissociation severity on the marital status of the patients showed that the highest rates of both general dissociation and particular dissociative phenomena were observed in patients who had never been married, and the lowest rates were observed in widow and widowers (see *Table 5*). Married and divorced patients had medium values according to the considered indicators. It is likely that the described pattern is related to differences in the average age of the patients, as younger people are predominant in the "have never been married" group, while older people are predominant in the "widow and widowers" group.

Table 5

Average rate of general dissociation and particular dissociative phenomena in patients with different marital statuses

Dissociative phenomena	**Unmarried**	**Married**	**Divorced**	**Widows and widowers**
General dissociation	13.57	12.82	13.07	5.74
Absorption	26.67	22.16	26.67	4.61
Distraction	9.17	17.56	13.75	7.30
Depersonalization	10.00	12.33	11.87	6.25
Identity violation	11.87	12.26	13.34	3.87
Dissociative amnesia	14.05	10.15	10.95	6.70

The fact that both the severity of general dissociation and of particular dissociative phenomena appeared higher in divorced patients than in married ones, seems harder to explain, as patients' ages in these categories did not differ much. It is possible that the level of stress in the divorced patients was higher due to dissatisfaction with their personal life or inherently greater emotional instability, which could have been one of the possible reasons for their divorce.

In this study, the average level of dissociation in the sample was also compared with the level of dissociation in the general population. The data about the level of dissociation in the general population were taken from the literature (Ross et al., 1990). We found that the average dissociation rate in the sample is significantly higher ($p < 0.05$) than in the general population (see *Table 6*). In patients with psychogenic disorders, the average dissociation compared to the corresponding value for the general population was even higher than in the study sample as a whole. This result allows us to hypothesize that in the case of psychogenic mental disorders, dissociative processes are indeed stronger and probably play a significant role in the formation of clinical manifestations of these disorders.

Table 6

Comparison of dissociation severity in the sample and in the general population

Cohort	Average severity of dissociation in the sample	Average severity of dissociation in general population (Ross et al., 1990)	Significance of differences
All patients	11.36	10.80	$p < 0.05$
Patients with organic disorders	7.83		$p < 0.001$
Patients with psychogenic disorders	13.02		$p < 0.001$

The average dissociation severity in patients suffering from organic mental disorders, by contrast, was significantly lower than in the general population. This leads us to conclude that in organic mental disorders, unlike mental disorders of psychogenic aetiology, dissociative processes in most cases do not intensify, but rather weaken.

Discussion

The degree of scientific novelty of the results obtained is ambiguous. In particular, the results obtained in the present study, showing greater severity of dissociative processes in women suffering from non-psychotic mental disorders compared to men, confirm the data of several previous studies (Akyüz et al., 1999; Meyer & Waller, 1998; Olff, Langeland, Draijer, & Gersons, 2007; Vanderlinden, van Dyck, Vandereycken, & Vertommen, 1993). As a possible explanation of this fact, one study suggested the different nature of mental injuries that underlie dissociative disorders in

men and women, in particular, the greater vulnerability of women to sexual violence (Wamser-Nanney & Cherry, 2018).

An interesting result is that dissociative processes in patients with non-psychotic mental disorders weaken with age. Several hypotheses can be suggested to explain this phenomenon. First, organic brain changes that occur with age, particularly of vascular or atrophic origin, may contribute to the weakening of dissociation (indeed, the results of this study indicate that organic brain damage resulted in less severe dissociation). Second, our results could be explained by the physiological age-related reduction of psychical mobility (Roshchina & Korsakova, 2020). Third, dissociation can decrease with age due to a certain stabilization of the individual's living conditions and social relations (regular job, family, etc.), resulting in reduced stress and a "calming" of physiological drives. Finally, another possible explanation is gradual disactualization of childhood traumatic experience with age (if dissociation is considered from the point of view of the trauma concept). Clearly, all of these hypotheses require verification in future studies. Also, the present authors do not rule out the possibility that other explanations may be found.

An interpretation of possible causes for the influence of a person's marital status on the severity of his or her dissociative reactions has already been given above. At the same time, it should be noted that the inverse relationship is also possible: Higher levels of average dissociation in persons who have never been married or in divorced persons may not be a consequence, but a cause of their dysfunctional marital status. This means that mental health problems related to the increased dissociation can lead to difficulties in starting a family or to issues in family relationships that might result in a divorce. Clarification of this question also requires further research.

The analysis of the severity of various particular dissociative phenomena in non-psychotic mental disorders showed that in the studied patients these phenomena appear unevenly. As already indicated, absorption reaches the highest level in the sample, followed by distraction, depersonalization, identity violation, and dissociative amnesia. Possibly this result is related to the different degrees of the adaptation violation connected with each of these phenomena and to the different degree of deviation of the corresponding mental functions. Obviously, such dissociative phenomena as absorption or distraction are less severe and disadapting than identity violation or dissociative amnesia. Apparently these dissociative phenomena, typically observed among mentally healthy people, constitute a certain level of so-called normal dissociation. These phenomena are amplified in non-psychotic mental disorders, so their severity becomes significantly higher. Such phenomena as identity violation or dissociative amnesia are not common in a healthy population; they occur, mainly, in cases of mental illness, and require more serious reasons for their formation. Probably they become intense only among a small percentage of non-psychotic patients with sufficiently severe mental disorders. Accordingly, the average rate of identity violation and dissociative amnesia in the sample is not so high in general. Depersonalization occupies a middle position among all the dissociative phenomena by the severity of its disadaptation and therefore its level in the sample is in the medium range.

An important finding of this study requiring a separate discussion is the weakening of dissociation in organic mental disorders that are accompanied by decreasing dissociative reactions even below the conditionally normal level. In our opinion this phenomenon may be caused by the destructive effect of an organic brain process on the physiological bases of dissociation, appearing to be a quite complicated and delicate mechanism in terms of brain physiology and requiring a sufficiently intact condition of its anatomical structures.

Conclusion

In this study, dissociation at the pathological level was found in about one-eighth of all the patients with non-psychotic mental disorders. It can be assumed that dissociation plays a significant role in the formation of clinical manifestations of mental illnesses among those patients. Dissociation makes an especially major contribution in the cohort of young females who have never been married. According to the results obtained, the increase of dissociative mechanisms is characteristic mainly of mental disorders of psychogenic origin. In the case of organic mental disorders, on the contrary, these mechanisms weaken, possibly due to the destructive effect of the organic brain process on their physiological bases.

Limitations

Generalization of the results of this study is limited by the small sample size.

Ethics Statement

All patients who took part in the study, upon admission to treatment in the Udmurt Republican Clinical Psychiatric Hospital, personally signed standard informed consent for examination and treatment, which included consent to psychological testing. All patients participating in the study are adult and capable.

Author Contributions

R. Iskanderova and V. Vasilyev conceived of the idea. R. Iskanderova has examined patients with the DES and performed the computations. V. Vasilyev verified the analytical methods and supervised the findings of the work. All authors discussed the results and contributed to the final manuscript.

Conflict of interest

Both authors declare that there are no conflicts of interest.

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Psychometric Properties of the Copenhagen Burnout Inventory in a Sample of Medical Students in Kazakhstan

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Background. The Copenhagen Burnout Inventory (CBI) has demonstrated good psychometric properties among different populations, but there is no known data on its validity among Russian-speaking medical students. The CBI-Student Survey focuses only on fatigue, but measures exhaustion in four different life domains: Personal Burnout (PB), Studies-Related Burnout (SRB), Colleague-Related Burnout (CRB), and Teacher-Related Burnout (TRB).

Objective. To investigate the psychometric properties of the Russian version of the Copenhagen Burnout Inventory–Student Survey (R-CBI-S).

Design. A cross-sectional study was carried out among 771 medical students at Astana Medical University (Nur-Sultan, Kazakhstan). Statistical analyses included test-retest reliability, internal consistency, item analysis, convergent and concurrent validity, and confirmatory factor analysis. Concurrent validity was evaluated by bivariate correlations of R-CBI-S with anxiety, depression, and satisfaction with the study.

Results. Test-retest reliability showed an ICC of 0.81. All item-total correlations for the total scale were positive (range 0.31–0.76). The Cronbach's alpha coefficient was 0.94 (0.896 for PB, 0.884 for SRB, 0.874 for CRB, and 0.926 for TRB). The Barlett's sphericity test result was significant ($p < 0.001$), and the KMO measure of sampling adequacy exceeded 0.947. Convergent validity analysis results: PB (AVE = 0.52, CR = 0.87), SRB (AVE = 0.50, CR = 0.87), CRB (AVE = 0.51, CR = 0.86), TRB (AVE = 0.56, CR = 0.88). The R-CBI-S achieved good levels of goodness-of-fit indices (RMSEA = 0.0611; CFI = 0.940; TLI = 0.933).

Conclusion. The test results indicated that the R-CBI-S scale appears to be a reliable and valid instrument. The R-CBI-S may be a useful tool in future research to identify burnout factors based on specific life domains for developing effective prevention measures among medical students.

Keywords: burnout; medical students; Kazakhstan; Copenhagen Burnout Inventory; validation

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Introduction

Burnout is a growing epidemic among medical students, which has been shown to have psychological and performance-related detriments (Bullock et al., 2017). Medical students are not only more likely to be burned out compared to the general population, but are increasingly likely to suffer burnout as they advance in their medical training (Dyrbye et al., 2014; Dyrbye et al., 2006). This often leads to significant psychological changes that manifest as depression, insomnia, substance abuse disorders, poor physical health, psychosomatic conditions, relational problems, social withdrawal, and professional dysfunction (Aguiar et al., 2009; Almeida et al., 2016). Burnout can also affect medical students' will to continue to espouse professional qualities, such as honesty, integrity, altruism, and self-regulation (Dyrbye et al., 2010). Based on these findings, it is clear that burnout is a serious problem in the training and professional development of medical students.

Several methods have been developed to study burnout among students, namely the Maslach Burnout Inventory–General Survey for Students (MBI-SS; Maslach, Jackson, & Leiter, 2017), the Oldenburg Burnout Inventory for college students (OLBI-S; Demerouti & Bakker, 2008), and the Copenhagen Burnout Inventory (CBI) proposed by Kristensen, Borritz, Villadsen, and Christensen (2005). The MBI-SS assesses the prevalence of burnout based on subjects' emotional exhaustion, depersonalization, and reduced professional satisfaction and effectiveness, as captured by 22 items. The OLBI-S includes two dimensions, exhaustion and disengagement, with the distinction that it captures exhaustion across physical, affective, and cognitive dimensions compared to the single emotional dimension measured by the MBI-SS (Demerouti & Bakker, 2008). By comparison, CBI focuses only on fatigue/emotional exhaustion, but measures the respondent's attribution of this exhaustion to three different life domains: Personal Burnout, Work-Related Burnout, and Client-Related Burnout (Molinero Ruiz, Basart Gómez-Quintero, & Moncada Lluis, 2013). The CBI measures burnout in a more straightforward way (Yeh, Cheng, Chen, Hu, & Kristensen, 2007). According to one systematic review of the CBI and the OLBI, the quality of evidence for sufficient content validity was moderate, while for the MBI it was very low. Moreover, the CBI was more appropriate for valid and reliable use in medical research and practice (Shoman et al., 2021). A systematic review and meta-analysis conducted among midwives showed that the CBI addressed more realistically the levels of physical and mental exhaustion and was very useful (Suleiman-Martos et al., 2020).

In recent years, the CBI has been validated in different countries and study populations, such as university professors and academic staff members at Brazilian public universities (Rocha et al., 2020), an academic healthcare institution sample in the U.S. (Thrush, Gathright, Atkinson, Messias, & Guise, 2020), Greek doctors (Papaefstathiou, Tsounis, Malliarou, & Sarafis, 2019), Iranian nurses (Mahmoudi et al., 2017), Korean homecare workers (Jeon, You, Kim, Kim, & Cho, 2019), and U.S. nurses (Montgomery, Azuero, & Patrician, 2021). In all cases, the CBI demonstrated adequate validity and reliability for measuring burnout. Andrew Chin et al. (2018) investigated the validity of the CBI among Malaysian medical students, but using the original three-dimensional structure. Campos, Carlotto, and Marôco (2013) adapted

the CBI original inventory for students as the CBI–Student Survey, and developed items measuring students' Personal Burnout, Studies-Related Burnout, Colleague-Related Burnout, and Teacher-Related Burnout.

This study aims at evaluating the reliability and validity of the Russian version of the Copenhagen Burnout Inventory–Student Survey (R-CBI-S) in a sample of medical students at the Astana Medical University, Kazakhstan.

Methods

Participants

All medical students at any stage of their medical education at Astana Medical University were eligible to participate. Participants were invited via the "messenger" app and the university's information portal, Sirius, to fill out an online questionnaire created on the 1ka platform (www.1ka.si) during the period October–December 2019. The questionnaire was completed by 771 students (response rate 40%). Of the participants, 25.0% were male. Academic year distribution among students was 1 year (218), 2 year (137), 3 year (125), 4 year (62), 5 year (60), and 6 year (169). The average age of the respondent was 20.7 years (ranged in age from 18 to 33).

Procedure

The Copenhagen Burnout Inventory–Student Survey was converted into the Russian language from the original English version using a forward-backward translation process performed by specialists in the field of psychology and language. The final questionnaire was revised based on feedback from a sample of 20 participants through a pilot study.

Data analysis was conducted using Microsoft Excel 2007, SPSS version 20.0, and Jamovi version 1.2.17. A statistically significant difference was accepted at a p-value of less than 5%.

The reliability of the scale (performed on a sample of 20 subjects during a two-week interval) was evaluated using the intraclass correlation coefficient (ICC). According to Koo and Li (2016) ICC values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability.

Internal consistency was evaluated by the total scale and subscales reliability analysis reflected by Cronbach's alpha coefficient. A Cronbach's alpha coefficient with a value of ≥ 0.7 is acceptable (Taber, 2018). Corrected item-total correlation was carried out.

Convergent validity was checked with average variance extracted (AVE) and composite reliability (CR). Values of 0.5 or more for AVE and 0.6 or more for CR were considered as having significant convergent validity (Kline, 2011). Concurrent validity was evaluated by bivariate correlations of R-CBI-S with anxiety (GAD-7; Spitzer, Kroenke, Williams, & Lowe, 2006), depression (PHQ-9; Kroenke & Spitzer, 2002), and satisfaction with the study.

Construct validity was established by the confirmatory factor analysis (CFA) technique, with Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy used to test the dataset for factor analysis suitability. The

CFA is used to assess the overall goodness of fit: the Root Mean Square of Error Approximation RMSEA (< 0.08); the Comparative Fit Index CFI (> 0.9); and the Tucker-Lewis Index TLI (> 0.9) (Xia & Yang, 2019).

Questionnaire

The Russian version of the Copenhagen Burnout Inventory was adapted for students. The R-CBI-S consists of 25 items that represent four dimensions: Personal Burnout (PB) — 6 items (numbers 1, 2, 3, 4, 5, and 6), Studies-Related Burnout (SRB) — 7 items (numbers 7, 8, 9, 10, 11, 12, and 13), Colleague-Related Burnout (CRB) — 6 items (numbers 14, 15, 16, 17, 18, and 19), and Teacher-Related Burnout (TRB) — 6 items (numbers 20, 21, 22, 23, 24, and 25). The answers that can be given to each item are "always," "frequently," "sometimes," "rarely," and "never." The scores attributed to these answers are 100, 75, 50, 25, and 0% respectively, with inverse scoring for item 10. For each scale, a total average score was calculated. According to Kristensen's criteria of burnout levels, scores of 50 to 74 are considered moderate, 75–99 high, and a score of 100 is considered severe burnout (Borritz et al., 2006).

Results

The final translated Russian version of the R-CBI-S is presented in *Table 1*.

The test-retest reliability showed an ICC of 0.81 (CI 95% 0.63–0.94) for the R-CBI-S. The overall Cronbach's alpha coefficient of the R-CBI-S was 0.939 (0.896

Table 1

Russian version of the Copenhagen Burnout Inventory–Student Survey. Cronbach's alpha internal consistency and convergent validity analysis

Item	R-CBI-S	Corrected item-total correlation	α if item deleted
	Personal Burnout Cronbach's alpha = 0.896, AVE = 0.52, CR = 0.87		
1	How often do you feel tired? *Как часто Вы чувствуете усталость?*	0.599	0.937
2	How often are you physically exhausted? *Как часто Вы физически истощены?*	0.603	0.937
3	How often are you emotionally exhausted? *Как часто Вы эмоционально истощены?*	0.680	0.936
4	How often do you think: "I can't take it anymore"? *Как часто Вы думаете: «Я не могу больше этого терпеть»?*	0.700	0.935
5	How often do you feel worn out? *Как часто Вы чувствуете себя измотанным?*	0.672	0.936
6	How often do you feel weak and susceptible to illness? *Как часто Вы чувствуете себя слабым и восприимчивым к болезни?*	0.584	0.937
	Studies-Related Burnout Cronbach's alpha = 0.884, AVE = 0.50, CR = 0.87		
7	Do you feel worn out at the end of the working day? *Чувствуете ли Вы усталость в конце учебного дня?*	0.595	0.937

8	Are you exhausted in the morning at the thought of another day at work? *Вы чувствуете истощенность по утрам от мыслей о новом дне на учебе?*	0.688	0.935
9	Do you feel that every working hour is tiring for you? *Вы чувствуете, что каждый учебный час утомляет Вас?*	0.703	0.935
10	*Do you have enough energy for family and friends during leisure time? **У Вас достаточно энергии для семьи и друзей в свободное время?*	0.435	0.939
11	Are your studies emotionally exhausting? *Является ли Ваша учеба эмоционально истощающей?*	0.725	0.935
12	Do your studies frustrate you? *Расстраивает ли Вас ваша учеба?*	0.643	0.936
13	Do you feel burnout because of your studies? *Вы чувствуете себя выгоревшим из-за учебы*	0.757	0.934
	Colleague-Related Burnout Cronbach's alpha = 0.874, AVE = 0.51, CR = 0.86		
14	Do you find it hard to work with colleagues? *Вам тяжело работать с коллегами?*	0.525	0.938
15	Does it drain your energy to work with colleagues? *Вы тратите силы на работу с коллегами?*	0.308	0.940
16	Do you find it frustrating to work with colleagues? *Вам неприятно работать с коллегами?*	0.451	0.939
17	Do you feel that you give more than you get back when you work with colleagues? *Вы чувствуете, что отдаете больше, чем получаете, когда работаете с коллегами?*	0.330	0.940
18	Are you tired of working with colleagues? *Вы устали работать с коллегами?*	0.496	0.938
19	Do you sometimes wonder how long you will be able to continue working with colleagues? *Вы иногда задаетесь вопросом, как долго вы сможете продолжать работать с коллегами?*	0.469	0.938
	Teacher-Related Burnout Cronbach's alpha = 0.926, AVE = 0.56, CR = 0.88		
20	Do you find it hard to work with teachers? *Вам тяжело работать с преподавателем?*	0.702	0.935
21	Does it drain your energy to work with teachers? *Вы тратите силы на работу с преподавателем?*	0.589	0.937
22	Do you find it frustrating to work with teachers? *Вам неприятно работать с преподавателем?*	0.676	0.936
23	Do you feel that you give more than you get back when you work with teachers? *Вы чувствуете, что отдаете больше, чем получаете, когда работаете с преподавателем?*	0.607	0.937
24	Are you tired of working with teachers? *Вы устали работать с преподавателем?*	0.728	0.935
25	Do you sometimes wonder how long you will be able to continue working with teachers? *Вы иногда задаетесь вопросом, как долго вы сможете продолжать работать с преподавателем?*	0.709	0.935

*Note. * Reversed item.*

for PB, 0.884 for SRB, 0.874 for CRB, and 0.926 for TRB), which indicates a high level of internal consistency. Corrected item-total correlation is shown in Table 1. All item-total correlations for the total scale were positive (range 0.31–0.76) within the criterion of the item-total correlation greater than 0.30 (DeVellis, 2003).

The Barlett's sphericity test result was significant ($p < 0.001$), and the KMO measure of sampling adequacy exceeded 0.947. Extracted AVE and CR from convergent validity analysis showed in Table 1. According to the CFA analysis, the model fit of the four-factor R-CBI-S model was confirmed by the indices: $\chi 2/df$ 3.881; RMSEA = 0.0611; CFI = 0.940; TLI = 0.933, with cumulative variance at 59.5% (by com-

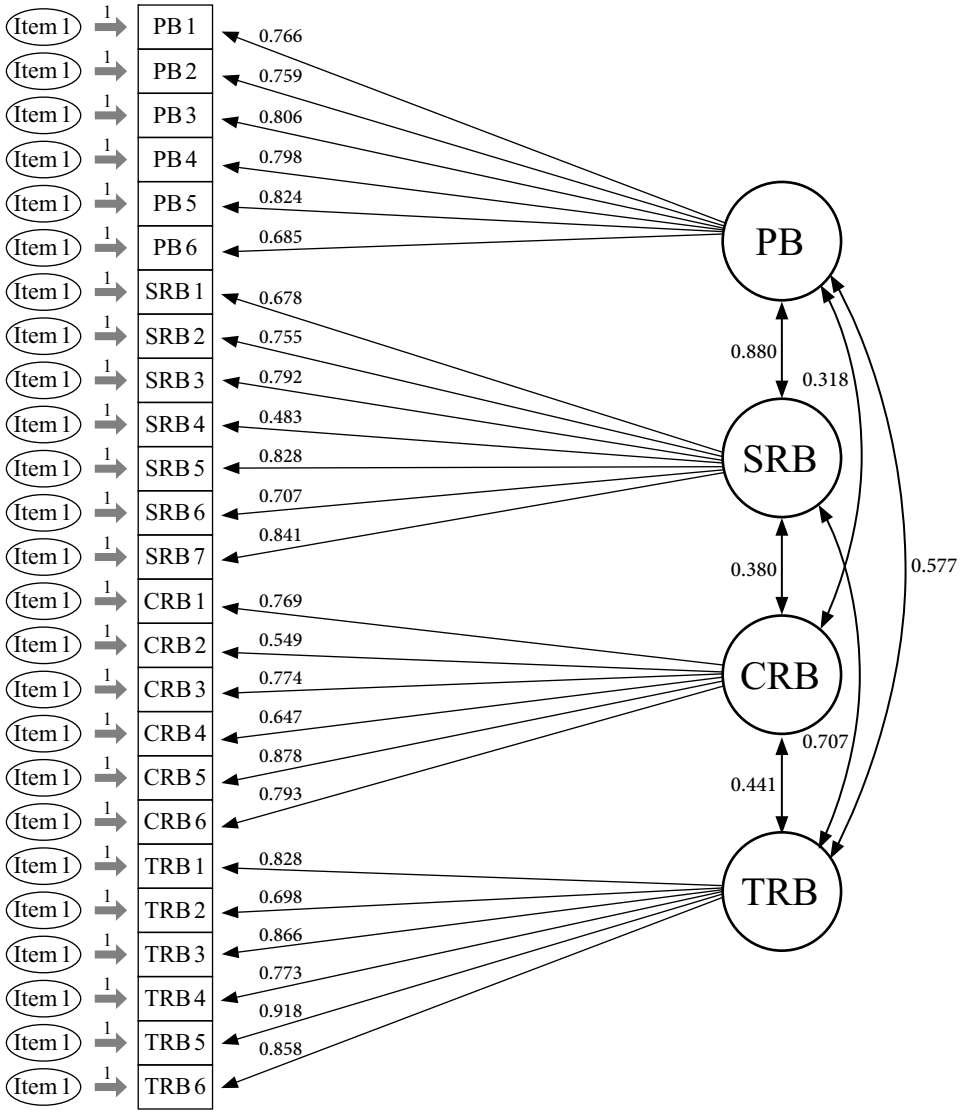

Figure 1. Confirmatory Factor Analysis of the Russian version of the Copenhagen Burnout Inventory–Student Survey (R-CBI-S) [$\chi 2/df = 3.881$; CFI = 0.940; TLI = 0.933; RMSEA = 0.0611]

parison, a one-factor model showed $\chi 2/df = 17.963$; RMSEA = 0.148; CFI = 0.638; TLI = 0.605). *Figure 1* shows the factor model. Analysis of the eigenvalues indicated that four factors extracted with values above 1.0 (9.76 for TRB, 2.33 for the CRB, 1.44 for the SRB, and 1.12 for the PB) according to Henson & Roberts (2006).

Table 2
Concurrent validity of the R-CBI-S

Variables	(1)	(2)	(3)	(4)
Satisfaction with study (1)	–			
GAD-7 (2)	–0.203	–		
PHQ-9 (3)	–0.342	0.560	–	
R-CBI-S (4)	–0.237	0.412	0.419	–

Note. All correlations are significant at $p < 0.001$.

Table 2 shows the correlations of the R-CBI-S with other variables. Weak positive correlations were found for R-CBI-S and GAD-7, PHQ-9. Satisfaction with the study was found to be negatively associated with R-CBI-S.

The total R-CBI-S mean score was 39.96, and the mean subscale scores for this sample were 52.62 (PB), 50.93 (SRB), 23.50 (CRB), and 32.77 (TRB).

Discussion

Analysis of the literature showed that burnout is an important component of medical students' mental health, which can affect the learning process and have further professional consequences. A feature of the CBI is that it divides burnout into four components. This makes it possible to identify predictors of burnout covering not only exhaustion, but dividing it into personal, studies-related, colleague-related, and teacher-related burnout, ultimately to draw up a more comprehensive approach to organization of the educational process. We agree with the opinion of Sedlar, Šprah, Tement, and Sočan (2015), that before using the scale, one must go through a validation process to obtain the most reliable results.

The purpose of this study was to examine the psychometric properties of the Russian version of the CBI-S. Following adaptation and psychometric tests, this study found that the survey was reliable and valid for assessing burnout among Russian-speaking medical students in Kazakhstan. The ICC analysis showed that the R-CBI-S had high stability within 2 weeks of the test-retest (mean ICC 0.81).

The internal consistencies of the four subscales were satisfactory, with all the Cronbach's alpha values ranging from 0.874 to 0.926, and Cronbach's alpha for R-CBI-S being 0.939. These results are slightly lower than those reported by Campos et al. (2013), with Cronbach's alpha ranging from 0.875 to 0.931, and 0.957 for the CBI-S. The results of the current study present good internal consistency values. The corrected item-total correlation values obtained for the items are relatively high, which demonstrates that the items of R-CBI-S are relatively homogeneous and are measuring the same overall construct.

AVE for all dimensions was equal to or more than 0.5, suggesting an adequate level of convergent validity. The CR values of the R-CBI-S constructs ranged between 0.86 and 0.88, which indicates a high level of convergent validity.

The R-CBI-S was associated with anxiety, depression, and satisfaction with the study, lending support to the scale's concurrent validity. A validated Chinese version of CBI was correlated not only with anxiety and depression, but also with physical distress and social support (Fong, Ho, & Ng, 2013).

The R-CBI-S demonstrated satisfactory construct validity, as tested by CFA. The results indicated that most fit indices were in acceptable ranges. Sufficiency of the model was demonstrated by Bartlett's test of sphericity and the KMO measure.

Conclusion

The R-CBI-S appears to be a reliable and valid instrument in measuring medical students' burnout. The instrument could be useful for future efforts to develop an effective preventive intervention for burnout syndrome determination among Russian-speaking medical students.

Ethics Statement

The study was approved by the Local Ethics Committee of the NpJSC "Astana Medical University" (extract from protocol No. 3, dated September 20, 2018).

Author Contributions

Conceptualization: A.K.B. and A.Zh.A.; Methodology: T.Z.S.; Formal analysis: D.S.S. and A.K.B.; Investigation: B.B.I.; Writing — draft preparation: A.K.B.; Writing — review and editing: H.H.; Supervision: T.Z.S. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Resource Factors Allowing People with Alcohol-addicted Parents to Overcome Their Negative Emotions: A Latent Variable Model and Content Analysis

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Background. People with alcohol-addicted parents are at risk of psychoactive addictions, co-dependency, and suicidal behavior. Most studies of these people are aimed at confirming the inevitability of the impact of negative childhood experiences on their lives, and thus do not seek to identify resource factors which would allow them to overcome the negative emotions they experienced.

Objective. The purpose of this study was to create a model of resource factors which would allow people with alcohol-addicted parents to overcome the negative emotions they experienced.

Design. The participants were 58 healthy individuals (17 men and 41 women; M=25.2; SD=4.4) whose parents were alcohol addicts (they were participants in the 12-step recovery program "Adult Children of Alcoholics"), and 50 healthy individuals (15 men and 35 women, M=24.2; SD=3.7) whose parents were not alcohol addicts. The participants completed the questionnaires "Interpersonal Guilt," "Family Emotional Communication," and "Coping Strategies," and were interviewed on the resource factors which allowed them to overcome negative emotions. We used the content analysis of the interviews and latent variable modeling to analyze the questionnaires.

Results. The model of resource factors (CFI=0.895, RMSEA=0.064) showed that the rules set by the parental dysfunctional family (the taboo on the expressing emotions, and external well-being) were associated with being unable to recognize current negative emotions and with avoiding problems. The ability to recognize negative emotions was connected with the participant's willingness to accept responsibility for his/her life. The resource factors which allowed these subjects to overcome their negative emotions included: communication with relatives and friends; keeping a diary of emotions; and participating in recovery programs.

Conclusion. Our model of resource factors explains the mechanism connecting dysfunctional family rules with the resource factors and negative emotions experienced by people with alcohol-addicted parents.

Keywords: 12-step recovery program; alcohol addiction; content analysis; guilt; latent variable modeling; resource factors; shame

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Introduction

"Alcohol use disorder is a progressive disease characterized by a pathological attraction to alcohol, the development of withdrawal symptoms when alcohol is stopped, and in advanced cases, persistent somato-neurological disorders and mental degeneration" (Ivanets & Neumann, 1988). The topic of family alcohol use disorder has been actively studied during the last 10 years in Europe and Russia, largely due to the widespread prevalence of alcohol addiction (Baikova & Merinov, 2018; Brown-Rice et al., 2018; Gridneva & Tashcheva, 2018; Litvinova, 2017; Lutsenko, 2019; Lyvers & Hayatbakhsh, 2019; McCoy & Dunlop, 2017; Park & Schepp, 2015). According to Russian and American family system psychologists, psychoactive addictions, including alcohol addiction, are a family disease (Moskalenko, 2009; Potter-Efron, 2014; Woititz, 1983). The likelihood of alcohol addiction is five times higher for a person whose parents were alcohol addicts than for a person from a healthy family, and it is often impossible to live with a patient with alcohol addiction without emotional involvement in this problem (Haverfield & Theiss, 2016; Lukashyk & Filippova, 2015).

A dysfunctional family rule is often imposed in such families: "Do not talk, do not trust, do not feel." (Tuchina et al., 2019; Woititz, 1983). This rule is meant to prevent a family member from talking about his own feelings and discussing family problems with a psychologist. The taboo on expressing negative emotions in dysfunctional families can lead to the onset of alexithymia, suppression, and experiential avoidance in adulthood (Moskalenko, 2009).

J. Woititz has argued that people with alcohol-addicted parents have a desire for external well-being and a tendency to make their expression of negative emotions taboo. (Woititz, 1983). External well-being means distrust and hostility towards people and, at the same time, the desire to make a good impression in communication. Woititz ascribed the following personal characteristics of people whose parents suffered from alcohol addiction: low self-esteem; a tendency to procrastination; a tendency to experience guilt and shame; and difficulties in establishing and maintaining friendships and family relationships. People with alcohol-addicted parents are at risk of psychoactive addictions, co-dependency, and suicidal behavior (Merinov & Shustrov, 2011; Tuchina et al., 2019). However, most of the participants in these studies were psychoactive addicts and lived with their alcohol-addicted parents. Thus these studies could not allow the identification of the personal characteristics of healthy people with alcohol-addicted parents, and the resource factors which would allow these people to overcome negative emotions (Hall & Webster, 2007; Merinov & Shustrov, 2011; Tuchina et al., 2019; Woititz, 1983).

The focus of our research was to study the emotional characteristics of mentally healthy individuals whose parents were alcohol addicts, and to identify the resource factors which would allow them to overcome their negative emotions. These people were able to overcome their negative emotions and, in some cases, help their parents overcome alcohol addiction, so studying their experience in dealing with family problems can help to understand the behavioral mechanisms that contribute to overcoming addiction.

J. Woititz, A.V. Merinov, and other researchers have emphasized the tendency to experience feelings of guilt and shame as an important factor hindering the ability of persons with alcohol-addicted parents to adapt (Baikova & Merinov, 2018). Their research found that the feeling of shame was considered "a negative emotion emerging as a result of the awareness of one's own defect." The feeling of guilt was considered "a negative emotion emerging as a result of attributing to a patient or his relatives the causality of negative events and real or imaginary misconduct." J.P. Tangney and his students believed that the feeling of guilt is more productive than the feeling of shame, because the feeling of guilt contributes to a change in a person's behavior and does not affect his positive perception of himself as a person (Tangney, 2004).

U. Orth studied families with depressed patients (Orth, Berking, & Burkhardt, 2006). He relied on Tangney's concepts and wrote that the feeling of guilt can be associated with a patient's acceptance of responsibility for his/her life, and with searching for social support, as opposed to the feeling of shame, which can be associated with the avoidance of the problems and the intensification of the taboo on expressing emotions. However, Orth's investigation of the association between dysfunctional family rules, negative emotions (the feelings of guilt and shame), and the strategy of avoidance of problems was based only on data from patient interviews. We used quantitative data to create the latent variable model of resource factors which allow negative emotions to be overcome.

R.T. Potter-Efron studied the resource factors that allow people with alcohol-addicted parents to overcome their negative emotions and described a cycle of recurring emotions and behavior in these families (Potter-Efron & Potter-Efron, 1989). He wrote that since the awareness of one's own defects leads to feelings of guilt and shame, the alcohol addict wants to avoid these emotions; therefore, he or she begins to drink, and then feels even more defective. In this cycle, family members play an important role because they can either support or impede the alcohol behavior. For example, the wife and children of an alcohol addict may not allow the patient to fulfill family roles and feel necessary to the family; such an approach will help confirm the patient's conviction of his defectiveness. The Potter-Efron's cycle does not imply access to resource factors, since a person who has fallen into the cycle will plunge more and more deeply into it. This approach does not include possible ways out of alcohol addiction based on the family's resource factors.

M. Jarvinen, however, did explore possible ways out of alcohol addiction based on the family's resource factors. She identified three resource factors in families with alcohol-addicted members: 1) communication with healthy relatives and friends; 2) hobbies; and 3) the ability to make positive plans for the future (Jarvinen, 2015). However, her study lacked a control group, and thus did not allow the identification of specific resource factors for people with alcohol-addicted parents.

J. Woititz wrote that there are differences between the behavioral interventions that can help adults whose parents were alcohol addicts to become healthy, versus behavioral interventions that can help people from healthy families. For example, communication with relatives may be the effective resource factor for healthy families, but lead to suicidal behavior in adults whose parents were alcohol addicts (Woititz,

1983). The participants in Woititz's study were psychoactive addicts and could use resource factors specific to alcohol addicts. We decided to include the content analysis of interviews with our subjects in our research, in order to check whether the factors we identified in the quantitative research were specific to people with alcohol-addicted parents. The control group was used only for the qualitative part of the study because we wanted to compare the resource factors of the experimental and control groups.

The objective of our research was to investigate the behavioral resource factors of people with alcohol-addicted parents and create a model of resource factors which would allow them to overcome negative emotions. We hypothesized that: 1) the taboo on the expression of emotions experienced by people with alcohol-addicted parents is associated with the tendency to external well-being and the impossibility of recognizing shame and guilt; 2) shame is associated with the avoidance of the problems and the intensification of the taboo on expressing emotions; 3) guilt is connected with the participant's acceptance of responsibility for his/her life; and 4) there are differences between the behavioral interventions that can help adults whose parents were alcohol addicts to be healthy, versus the behavioral interventions that can help people from healthy families.

Methods

Participants

The research was conducted by the authors of this article in Moscow in the period from January to May 2019. We are clinical psychologists who specialize in family system psychotherapy.

The study participants were 58 healthy individuals (17 men and 41 women; M=25.2; SD=4.4) whose parents were alcohol addicts (they were participants in the 12-step recovery program "Adult Children of Alcoholics"), and 50 healthy individuals (15 men and 35 women; M=24.2; SD=3.7) whose parents were not alcohol addicts. All participants were between 18 and 35 years old. Seventy-nine people (39 people from experimental and 40 people from control group) had higher education; 15 people (9 people from experimental and 6 people from the control group) had secondary specialized the education; and 14 were students (10 people from the experimental and 4 from the control group).

The inclusion criteria for the experimental group were: 1) one of the participant's parents was an alcohol addict and was treated for this disorder throughout his/her life; 2) this parent lived with our participant and took part in his/her upbringing; and 3) the symptoms of parental alcohol addiction occurred when the participants in this research were between 6 months and 5 years old. The exclusion criteria for participation were: children from 0 to 18 years old; patients with mental disorders; patients with psychoactive addictions; and patients who were not able to sign informed consent. All participants did not have mental disorders and did not suffer from alcohol or other psychoactive addictions.

We used the Mini-Mental State Examination (MMSE) and classical pathopsychological techniques ("Pictogram," 10 words, filling in words missed in the text,

"Classification of objects," and "Interpretation of proverbs") to diagnose and exclude mental disorders. The participants' self-reports and the Structured Clinical Interviews were used to diagnose and exclude alcohol or other psychoactive addictions. The Mini-Mental State Examination (MMSE) is a 30-point questionnaire that is used to examine cognitive functioning, including orientation, attention, calculation, ability to follow simple commands, ability to understand language, and recall. Six participants refused to participate in the survey, and four participants in the experimental group and two participants in the control group were excluded because they were found to have impaired cognitive functioning in the Mini-Mental State Examination (MMSE).

Procedure

People whose parents were alcohol addicts were recruited from the recovery program "Adult Children of Alcoholics" and through the social network group "Adult Children of Alcoholics." "Adult Children of Alcoholics" is the 12-step recovery program that supports people whose parents were alcohol addicts. This program has been open in Moscow since 1994. The program includes attending open and closed meetings, independent step-by-step work (following the prescribed 12 steps under the guidance of a mentor), and lectures. The main goal of "Adult Children of Alcoholics" is to create a safe space where adults whose parents were alcohol addicts can freely and constructively share their stories.

The controls in our study (people whose parents were not alcohol addicts) were recruited through social networks. Psychologists talked with the participants about their health and families and diagnosed their preservation of cognitive functions before including them in this research (Lebow, 2017).

The people whose parents were alcohol addicts completed the questionnaires and were interviewed on the topic of the resource factors which allow them to overcome their negative emotions. The controls were interviewed on the topic of resource factors which allow them to overcome their negative emotions. In the interviews, the participants spoke about themselves, their families, and their own emotional experiences. The control group was used only for the qualitative part of the study. We used face-to-face contact between the respondent and the researcher for the interviews; each interview was conducted for 50 minutes to 2 hours.

Measures

We used the "Family Emotional Communication Questionnaire," "The Interpersonal Guilt Questionnaire," and the "Coping Strategies" questionnaires. All were in the Russian language.

The "Family Emotional Communication Questionnaire" consists of 30 statements (Kholmogorova et al., 2016). The Cronbach's alpha coefficients for the individual scales of the questionnaire varied from a minimum value of 0.607 for the family perfectionism scale, up to the maximum values of 0.787 for the scales of external well-being, and 0.712 for the taboo on expressing emotions. This result

indicates good internal consistency. All 30 points of the questionnaire showed even better consistency: Cronbach's alpha was 0.807 (Kholmogorova et al., 2016). This questionnaire is aimed at diagnosing the dysfunctional family beliefs of the adult patient's parents. Dysfunctional cognition was measured with three subscales: 1) a taboo on expressing emotions (six statements); 2) external well-being, or the desire of the family to hide, not see, and not reveal their problems (three statements); and 3) family perfectionism, which indicates very high standards for family members (three statements). Answers were measured on a 4-point scale (0 = not at all; 1 = no; 2 = maybe; 3 = yes).

"The Interpersonal Guilt Questionnaire" consists of 45 statements (Connor & Berry, 1997). Vasileva and Korotkova translated and established the procedure for standardizing the scales (Vasileva & Korotkova, 2004). They reported an internal consistency of 0.89 (Cronbach's alpha) for the guilt of responsibility; 0.83 for the guilt of separation; 0.81 for survivor guilt; and 0.74 for the feeling of shame (Connor & Berry, 1997). This questionnaire is aimed at diagnosing actual guilt and shame. The feeling of guilt was measured with three subscales: 1) the guilt of responsibility; 2) the guilt of separation; and 3) survivor guilt. The feeling of shame was measured with one subscale. Answers were measured on a 4-point scale (0 = not at all; 1 = no; 2 = maybe; 3 = yes).

"The Coping Strategies" questionnaire (Lazarus & Folkman, 1988) consists of 50 statements. Cronbach's alpha was analyzed for all factors proposed, resulting in the following coefficients: 1) acceptance of responsibility ($\alpha = 0.77$); 2) avoidance ($\alpha = 0.66$); and 3) search for social support ($\alpha = 0.86$); these results indicate a good internal consistency (Krukova, 2001). Krukova translated and established the procedure for standardizing the scales (Krukova, 2001). We used this questionnaire to measure family resource factors in individuals whose parents were alcohol addicts. The results pertained to eight subscales. Three subscales were used for the cognitive-behavioral model of resource factors because these subscales correlated with guilt and shame: 1) search for social support (six statements); 2) acceptance of responsibility (four statements); and 3) escape-avoidance (eight statements). The answers were measured on a 4-point scale (0 = not at all; 1 = no; 2 = maybe; 3 = yes).

Data Analysis

We applied content analysis of the transcripts of the interviews with the participants of the rehabilitation program "Adult Children of Alcoholics" and with the controls. Our data collection came from each participant being interviewed and answering the question: "What helped you overcome negative emotions associated with family dysfunction?" We identified and highlighted semantic units of analysis, grouped units by topics (eight categories related to the family resource factors were described and interpreted), calculated the percentage of responses, and interpreted the data obtained (Riffe, 2019; Ylanovski, 2007).

Statistical Analysis

The EQS 6.2 Structural Equations Program Manual statistics program was used for quantitative analyses of the structural model of family resource factors (Bentler,

2006). We used latent variable modeling for data analysis. Estimations were based on the covariance matrix and the maximum likelihood method. Fixation of factor loadings was used as the scaling method. Five fit indices assessed model fit: IFI = Incremental Fit Index; CFI = Comparative Fit Index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation; and the Confidence Interval of RMSEA. Values less than or equal to 0.05 for RMSEA, values less than or equal to 0.08 for SRMR, and values greater than or equal to 0.80 for IFI and CFI indicated good fit.

Degree of freedom and $\chi 2$ statistics were also used to judge the fit of the model. The $\chi 2$-distribution with n degrees of freedom is the distribution of a sum of the squares of independent standard normal random variables. The ratio of $\chi 2$ statistics to the number of degrees of freedom df should not be greater than 2. We used the k-factor-corrected Satorra-Bentler scaled (not adjusted) test statistic to evaluate model fit in small samples. We used the Bonferroni correction to control for multiple tests.

Correlation statistical analysis was conducted using SPSS statistics (Version 22.0). We used the Pearson correlation coefficient to measure the linear correlation between negative emotions experienced by people with alcohol-addicted parents and their resource factors, between the rules set by the parental dysfunctional family and the resource factors, and between the rules set by the parental dysfunctional family and negative emotions. The Pearson correlation coefficients ranged from −1 to 1. Values of less than 0.3 indicated a low correlation; values greater than or equal to 0.3 indicated significant correlations.

Results

The Pearson Correlation Coefficient

We used the Pearson correlation coefficient to measure the linear correlation between negative emotions experienced by people with alcohol-addicted parents (the feelings of guilt and shame, which was measured using the "The Interpersonal Guilt Questionnaire"), the rules set by the parental dysfunctional family (taboo on expressing emotions, external well-being, and family perfectionism, which were measured using the "Family Emotional Communication Questionnaire"), and the family resource factors (search for social support, acceptance of responsibility, and escape-avoidance, which were measured using "The Coping Strategies"). In the preliminary analyses, the means, standard deviations, and the Pearson correlation coefficients of indicators were estimated, as seen in *Table 1*.

To build the structural model of resource factors, which would allowing people with alcohol-addicted parents to overcome their negative emotions, we used only those coping strategies that correlated with the feelings of guilt or shame. Therefore, we excluded the following strategies from the model as unrelated to the emotions we were studying: 1) confrontation (the correlation between confrontation and guilt = -0.12; confrontation and shame = 0.10); 2) distance (the correlation between distance and guilt = 0.13; distance and shame = 0.12); 3) self-control (the correlation

Table 1

Means, Standard Deviations and Pearson's r of indicators used to measure Taboo on expressing emotions, External well-being, Family perfectionism, Guilt, Shame, Search for social support, Acceptance of responsibility, and Escape-avoidance (N=58)

Scales	M	SD	1	2	3	4	5	6	7
1. Taboo on expressing emotions (6 Indicators)	1.75	0.6	–						
2. External well-being (3 Indicators)	1.91	0.83	0.22	–					
3. Family perfectionism (3 Indicators)	1.84	0.81	0.06	0.42*	–				
4. Guilt (3 Indicators)	1.90	0.45	–0.27	–0.04	0.00	–			
5. Shame (1 Indicator)	1.55	0.73	–0.08	–0.30*	–0.02	0.18	–		
6. Search for social support (6 Indicators)	2.04	0.55	0.05	–0.10	0.06	–0.27	–0.09	–	
7. Acceptance of responsibility (4 Indicators)	1.77	0.56	–0.08	–0.32*	–0.18	0.17	0.43*	0.06	–
8. Escape-avoidance (8 Indicators)	1.70	0.44	0.14	–0.19	–0.04	–0.01	0.34*	0.21	0.25

Note $p<0.05$*

between self-control and guilt = 0.10; self-control and shame = –0.09); 4) planning a solution to a problem (the correlation between planning a solution to a problem and guilt = –0.10; planning a solution to a problem and shame = –0.02); and 5) positive revaluation (the correlation between positive revaluation and guilt = 0.02; positive revaluation and shame = –0.10).

The Pearson's r results showed that the taboo on expressing emotions experienced by people with alcohol-addicted parents was associated with external well-being, and negatively associated with the feeling of guilt. External well-being indicates the desire of the family to hide, rather than see and reveal their problems. External well-being was positively associated with family perfectionism and a tendency to avoid responsibility, and negatively associated with the feeling of shame. The feeling of guilt was negatively associated with the search for a social support coping strategy. The feeling of shame was associated with the acceptance of responsibility for their lives and escape-avoidance. Escape-avoidance was associated with the acceptance of responsibility and with the search for social support.

A Latent Variable Model of the Resource Factors

Our structural model of the resource factors which allow people with alcohol-addicted parents to overcome their negative emotions, was created based on our correlation analysis (*Figure 1*).

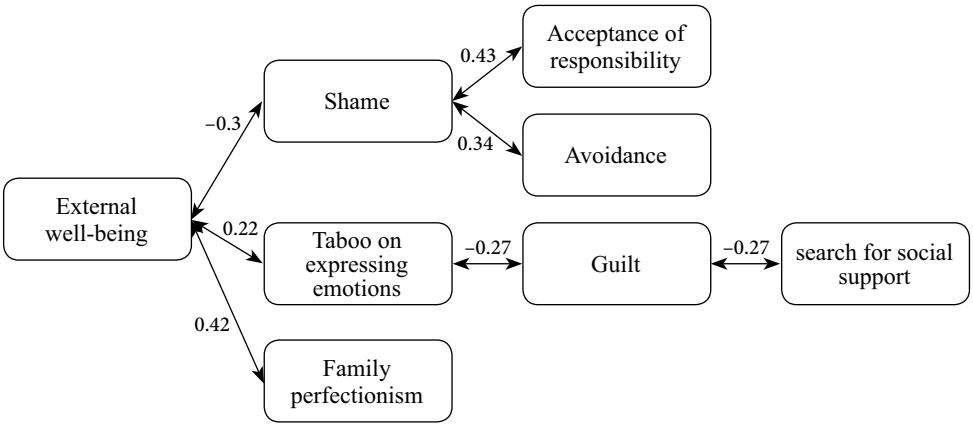

Figure 1. The structural model of resource factors and negative emotions experienced by people with alcohol-addicted parents

Our structural model of resource factors and negative emotions was tested, as seen in *Table 2*. We used latent variable modeling to test our first model. This model did not fit well with the data, so we excluded three factors (escape-avoidance, acceptance of responsibility, and search for social support) to improve it. Model 2 thus consisted of five factors: external well-being; family perfectionism; taboo on expressing emotions; and the feelings of guilt and shame. The suitability indices of the model 2 can be considered good.

Table 2

Indicators for Measurement Models (N=58)

Models	X^2	df	IFI	CFI	SRMR	RMSEA	90% confidence interval of RMSEA
Model 1: Parental influence, emotions and coping strategies	796.696	518	0.538	0.503	0.119	0.097	0.083 to 0.109
Model 2: Parental influence and emotions	123.619	100	0.904	0.895	0.096	0.064	0.000 to 0.098

Note. IFI = Incremental Fit Index; CFI = Comparative Fit Index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation. p<0.05.

The Content Analysis of the Interviews

The control group was used only for the qualitative part of the study so that we could compare the resource factors of the experimental and control groups. Content analysis of the interviews with both groups consisted of data collection (each participant answered the question: "What helped you overcome negative emotions associated with family dysfunction?"), highlighting semantic units of analysis, calculating the percentages of the various responses, and interpreting the data obtained. The subjects

were asked to describe how eight categories related to the family resource factors helped them overcome the consequences of family dysfunction, as seen in *Table 3*.

Table 3

Content analysis of the family resource factors in experimental and control groups

Categories	Experimental group (N=58)		Control group (N=50)	
	Number of responses	Percentage of responses	Number of responses	Percentage of responses
keeping a diary	8	13.8	4	8
participation in a rehabilitation program	12	20.6	0	0
communication with friends	7	12.1	16	32
communication with grandparents	10	17.2	10	20
sport	3	5.2	12	24
illness	8	13.8	3	6
escape-avoidance	4	6.9	2	4
faith	6	10.3	3	6

Keeping a diary: Eight people of the experimental group and four people of the control group kept diaries of their thoughts and emotions in the family context. They said that keeping a diary helped them to understand their emotions and, in some cases, to overcome feelings of guilt and anger towards alcohol-addicted parents. People whose parents had alcohol addiction mentioned this type of family resource factors more often than the control group because people from the experimental group kept diaries while participating in the rehabilitation program.

Some examples: "The diary helps me to understand myself, my emotions, and my family. I usually write down what I feel in my family; it helps me to analyze the situation and to understand how I can help my mother and myself." "When I was very angry with my alcohol-addicted mother in my childhood, I began to keep a diary. It helped me to express my feelings and to relieve my aggression." "Keeping a diary helped me to understand that I do not want to live like my alcohol-addicted parents. I do not want to drink, to fight, to break dishes, to beg for money from relatives. I decided to completely abandon alcohol."

Participation in a rehabilitation program: People from the experimental group mentioned this resource factor because they took part in the rehabilitation program "Adult Children of Alcoholics" and believed that this program could help them. People whose parents had alcohol addiction paid attention to the opportunities of the rehabilitation program: they could speak about their family problems in the program, find new friends, understand their feelings, and try to find their own resource factors. In the rehabilitation program, the participants come to understand that they are not alone and that they can overcome their negative emotions.

Some examples: "Participation in the 12-step rehabilitation program "Adult Children of Alcoholics" helps me to understand that I am not alone, my problem is not unique, and I can overcome the consequences of family problems. I usually visit open

and closed meetings of the program and I feel safe there." "I understand that in my family there is a problem. Before my participation in the 12-step rehabilitation program, I had never thought that it is not normal that my parents do not take care about me and my sister, that I cannot invite friends to visit me in my flat. I thought that it was normal, but now I can explain the problems of my family and I believe that I can overcome them."

Communication with friends: This type of resource factor was mentioned by both the control and experimental groups. People whose parents had alcohol addiction said that friends helped them to understand moral norms and caretaking behavior. In some cases, friends' parents became the ideal models of family communication. Two participants mentioned that friends helped them to find the rehabilitation center for their parents.

Some examples: "I need somebody to help me accept my feelings and discuss my family problems. My ex-boyfriend was a drug addict; I tried to save our relationship and discuss my family problems with him. Nowadays I know that alcohol and drug addictions are dangerous diseases and I try to communicate with healthy people. My friends help me to feel that I am not alone and together we can help my father to become healthy." "My friend helped me find the rehabilitation center for my mother. My friend taught me how to cook because my mother had alcohol addiction."

Communication with grandparents: Both the control and the experimental groups mentioned this type of resource factor. People whose parents had alcohol addiction usually reported that healthy grandparents were directly involved in their upbringing and took care of them. Some of the participants wanted to be like their grandparents. Grandparents from such families were strict with their grandchildren, because they did not want a recurrence of alcohol problems in the families of their grandchildren.

Some examples: "My grandmother was directly involved in my upbringing. I know that my parents are patients with alcohol addiction. However, I do not have psychoactive addictions because my strict grandmother took care of me in my childhood. I remember my grandmother and understand that I have an opportunity to be healthy and to have healthy children." "My father was an alcohol addict. When I think about the image of a man, I think about my grandfather. He was strict, but everyone respected him, he did not avoid accepting responsibility for the whole family. I want to be like my grandfather in my own family."

Sport: People whose parents had alcohol addiction noticed that team sports helped them to keep a healthy lifestyle, to communicate with friends from healthy families, and to feel safe. Some participants came to sports because they wanted to protect themselves and their younger siblings from parental aggression.

Some examples: "I enrolled in the wrestling team to be able to protect myself in the family. There I made friends from healthy families. Sport has protected me from alcohol."

Illness: People with alcohol-addicted parents used this coping strategy more often than people from the control group. People whose parents had alcohol addiction wrote that their illness, in some cases, helped their parents to stop drinking and begin to try to take care of their children. Illness also helped people with alcohol-addicted

parents to stay home and postpone visits to parents with whom they did not want to communicate.

Some examples: "When I have a disease, I don't think about my parental alcohol family; I need to become healthy. Illness helps you to understand that you value life and you can forgive your parents." "When I try to think about my childhood and parents, I get a headache. I think my headache prevents me from remembering my childhood."

Escape-avoidance: Some participants in both the control and experimental groups reported that the best way to solve the problem was to ignore it. For example, some people whose parents had alcohol addiction completely cut off communication with their parents, whose behavior they did not like.

Some examples: "I don't communicate with my parents. I don't visit them because I don't want to see that they drink alcohol. They are very weak; I don't want to have such parents."

Faith: Some participants thought that the best way to deal with a parental problem was to rely on God's help and pray. Some of them wanted to give up the responsibility for their lives and the lives of their families and shift all responsibility to God.

Some examples: "I prayed that my father would stop beating my mom and drinking alcohol. Father became less aggressive after a rehabilitation course. God heard me, so He is on my side." "When my mother came home after a noisy party with alcohol and went to bed, I could only pray that our neighbors and my friends would not know about her behavior. Only God could save me from the feeling of shame."

Discussion

The sample in our study was unusual, because researchers usually study psychoactive addicts with alcohol-addicted parents, but we studied healthy individuals whose parents had alcohol addiction. These people were able to overcome the consequences of family problems and, in some cases, help their parents to overcome alcohol addiction, so studying their experience can help us to understand the behavioral mechanisms that contribute to overcoming addiction. We created a model of the resource factors which would allow healthy individuals whose parents had alcohol addiction to overcome their negative emotions. This model expands the understanding of the characteristics of negative emotions and the resource factors of these people for use in clinical practice.

Our model of resource factors explains the mechanism which connects the dysfunctional family's rules (the taboo on the expressing emotions and external well-being) with the resource factors and negative emotions experienced by people with alcohol-addicted parents. The results showed that the resource factors allowing them to overcome negative emotions included: communication with relatives and friends; keeping a diary of emotions; and participating in recovery programs.

The importance of this study lies in the fact that it shows the relationship between parental dysfunctional rules and the coping strategies of children in the family who became mentally healthy people. The data we obtained on the types of resource factors can be used in clinical practice to work with the negative emotions of people with alcohol-addicted parents.

Our results showed that the negative emotions experienced by people with alcohol-addicted parents (the feelings of guilt and shame) are associated with the dysfunctional family's rules (the taboo on the expressing emotions and stress on external well-being). J. Woititz wrote that usually there is a dysfunctional family rule in families with alcohol-addicted parents: "Do not talk, do not trust, and do not feel." (Woititz, 1983). This rule forbids members of the dysfunctional families to express emotions. However, she studied alcohol addicts whose parents were alcohol addicts, and only analyzed interviews with them. In our research, where the participants were not alcohol addicts, but the participants' parents were, we found similar results.

The taboo on expressing emotions in families with members addicted to alcohol is associated with the tendency to external well-being in these families ($r = 0.22$). A.V. Merinov wrote that people whose parents were alcohol addicts have a tendency toward suicidal and co-dependent behavior, and usually use emotion-focused coping strategies (Baikova & Merinov, 2018). He explained their behavior by a tendency to external well-being and a lack of the ability to speak about their family problems.

We expected that shame would be associated with the avoidance of the problems and the intensification of taboo on expressing emotions, and guilt would be connected with the acceptance of responsibility for the respondent's life. According to J.P. Tangney (2004) and her students, the feeling of guilt is more productive than the feeling of shame, because guilt contributes to motivating a change in a person's behavior and does not affect his positive perception of himself as a person. However, in our study the feeling of guilt was not connected with the acceptance of responsibility for the respondent's life. The results of the content analysis of the interviews showed that the feeling of guilt was not seen as an emotion leading to accessing the family's resources. The participants said that the feeling of guilt prevented them from searching for social support when they needed it, and did not allow them to accept responsibility for their lives.

The results showed that the inability to recognize shame was associated with problem avoidance and the intensification of the taboo on expressing emotions. R.T. Potter-Efron described a cycle of recurring negative emotions and behavior in families with members addicted to alcohol (Potter-Efron, 2014). He wrote that the awareness of one's own defects leads to feelings of shame; since the alcohol addict wants to avoid these emotions, he/she begins to drink and feels more defective. The Potter-Efron's cycle does not include access to resource factors, since a person who has fallen into the cycle will plunge more and more deeply into it. Our research shows that there is an opportunity to exit the cycle through the recognition of a feeling of shame and taking responsibility for this feeling. The ability to recognize shame was connected with the participant's acceptance of responsibility for his/her life.

There are differences between the behavioral interventions that can help adults whose parents were alcohol addicts to be healthy versus the behavioral interventions that can help people from healthy families. These data expand the list of resource factors for this category of individuals that family system psychotherapists obtained in previous studies (Drapkin et al., 2015; Kim & Ko, 2019). Adults whose parents were alcohol addicts use communication with grandparents and friends, keeping a diary

of emotions, participating in recovery programs, and taking classes in sports. The participants also used three dysfunctional resource factors (illness, escape-avoidance, and faith) to temporarily cope with their emotions. The study participants called these three factors dysfunctional, because they helped to cope with the problem temporarily, but did not change the situation in the long term. People whose parents were not alcohol addicts did not mention participation in rehabilitation programs, and rarely resorted to the use of illness and avoidance of responsibility.

We expect that these results should have some benefit for creating rehabilitation programs for people with alcohol-addicted parents, because this study clearly identified the resource factors these people can access.

Conclusion

In this study, we created a structural model of resource factors which would allow people with alcohol-addicted parents to overcome their negative emotions. This model explained the mechanism connecting the family's dysfunctional rules with the resource factors and the current emotions experienced by people whose parents were alcohol addicts. The family rules of the parental dysfunctional family (the taboo on expressing emotions and external well-being) were associated with the difficulty of recognizing the current shame and guilt experienced by people whose parents were alcohol addicts. The ability to recognize shame was connected with the acceptance of responsibility for the participant's life. The family resource factors of adults with alcohol-addicted parents included: communication with grandparents and friends, keeping a diary of emotions, participating in recovery programs, and taking sports classes.

It would be useful to study people whose parents were drug addicts and to compare them with people whose parents had alcohol addiction. We expect that the models of resource family factors for families with members addicted to alcohol and for families with drug-addicted members would not differ significantly. If this expectation is true, the structural model of family resource factors in patients with alcohol addiction could be useful for describing the mechanisms connecting the dysfunctional family's rules with resource factors with their current emotions experienced by families with psychoactive addicted patients.

Limitations

There are some limitations to this research. The sample was not large, and that may be a serious limitation, because in small samples, many structural models may be accepted (not rejected statistically) that would not hold up in larger samples. Thus, we can only characterize the correlations revealed in the study as trends. In further research, it is necessary to test our model and other variants of the models of resource factors on a large sample ($n > 100$). We did not test for gender differences in the study, because 95% of the "Adult Children of Alcoholics" program members are women. This can also be a serious limitation, because avoidant coping strategies often differ between men and women (Panayiotou et al., 2017).

The experimental group included only healthy individuals whose parents were alcohol addicts, and who were the participants in the 12-step recovery program "Adult Children of Alcoholics." We did not study people who were not the participants of the 12-step rehabilitation program and who were psychoactive addicts; these groups of people do not want to use participation in recovery programs as a primary resource factor. We expect that these groups of people may use other resource factors to overcome negative emotions, such as alcohol, exercising self-control, and isolation.

Ethics Statement

The participants were volunteers and did not receive any material rewards for their participation. All people gave their informed consent for inclusion prior to participation. The participants received feedback on the results of research and information on the resource family factors. The research was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the Faculty of Psychology at Lomonosov Moscow State University (№38, 18.10.2017).

Author Contributions

Alla Spivakovskaya and Anna Lutsenko conceived of the idea. Anna Lutsenko developed the theory and performed the computations. Alla Spivakovskaya supervised the findings. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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The Performance of Visual Perceptual Tasks in Patients with Schizotypal Personality Disorder

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Background. The most significant features for clinical diagnosis of schizotypal personality disorder (SPD) are cognitive-perceptual and disorganized symptoms. Experimental study of visual perceptual processes is important to elucidate the psychological mechanisms of cognitive-perceptual impairment in SPD.

Objective. To research the performance of visual perceptual tasks in SPD.

Design. Series I and II presented the subjects with visual perceptual tasks with different types of instructions (vague, verbal, or visual perceptual cues). The Wechsler Adult Intelligence Scale (WAIS-R) was also administered. The participants were 39 SPD patients, 36 obsessive-compulsive personality disorder (OCPD) patients (F.21.8, F.60.5 in ICD-10, respectively), and 102 healthy controls.

Results. SPD patients had a significantly lower number of correct answers in conditions of vague instruction and verbal cues in Series I of a visual-perceptual task in comparison with healthy subjects ($p \le 0.01$). With visual perceptual cues in Series II, patients with SPD had the same number of correct answers as controls, whereas OCPD patients had the same number of correct answers as controls with verbal cues in Series I. SPD patients had significantly lower scores in most verbal and nonverbal WAIS-R subtests in comparison with controls. SPD patients differed from OCPD patients in that they had lower scores in the "Information" ($p \le 0.05$) and "Comprehension" ($p \le 0.05$) subtests.

Conclusion. With visual-perceptual cues, SPD patients were able to achieve normative results in the performance of visual-perceptual tasks, whereas patients with OCPD demonstrated lower productivity. In SPD patients, the basic impairments were associated with difficulties in inhibition of peculiar responses, stability of a subjective manner of performance and inability to revise it, low orientation to the model, and slipping into subjective associations with the stimuli.

Keywords: personality disorders; schizotypal personality disorder; obsessive-compulsive personality disorder; cognitive functions; visual perceptual tasks; Wechsler Adult Intelligence Scale (WAIS-R)

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Introduction

Psychiatric research on cognitive deficits in schizophrenia and in non-psychotic disorders within the schizophrenia spectrum is considered to be a promising approach for understanding mental dysfunction (Carruthers, Van Rheenen, Gurvich, Sumner, & Rossell, 2019; Rosell, Futterman, McMaster, & Siever, 2014). Schizotypal personality disorder (SPD) shares many biological features with schizophrenia and represents an intermediate schizophrenia-spectrum phenotype. This makes it possible to study mental disorders that do not reach the level of psychosis, to better understand the genetics, pathogenesis, and cognitive symptoms related to psychotic illnesses. At the same time, clinicians and researchers are uncertain about the boundaries on the continuum of personality pathology and psychotic pathology in SPD (Anderson & Sellbom, 2018; Smulevich, Romanov, Mukhorina, & Atadzhikova, 2017). There are different mechanisms and factors that could lead to a transition from constitutional traits to susceptibility to the development of psychotic disorders: neuroanatomical peculiarities (Dickey et al., 2005; Dickey, McCarley, & Shenton, 2002; Liu et al., 2016), genetic factors (Zouraraki, Karamaouna, Karagiannopoulou, & Giakoumaki, 2017), psycho-physiological mechanisms (Ahn, Lustenberger, Jarskog, & Fröhlich, 2020; Hazlett et al., 2015; Rabella et al., 2016), etc.

Cognitive dysfunction is an essential line of modern clinical and psychological research into schizophrenia-spectrum disorders as one of the levels of the disease (Rodriguez et al., 2019; Siddi, Petretto, & Preti, 2017). Moreover, cognitive impairment in SPD is considered a prognostic indicator for the development of schizophrenia. For instance, the severity of impairment of visual perceptual processes is associated with earlier onset of the disease, the development of delusions and hallucinations, bizarre behavior, depressive symptoms, and a low level of social functioning in childhood and adolescence. In addition, a number of disturbances of the visual-perceptual processes (altered perception of one's face, body, the faces of other people, pseudo-movement, reversions, etc.) are stable and don't depend on the duration of the disease or the type of pharmacotherapy (Keane, Cruz, Paterno, & Silverstein, 2018).

Clinicians suggest that the most significant clinical diagnostic criteria for SPD are cognitive-perceptual (magical ideation, unusual perceptual experiences) and bizarreness, disorganized criteria (for example, eccentric behavior and speech, inappropriate, restricted affect) (Zouraraki et al., 2017). A distinctive characteristic of cognitive-perceptual processes in SPD is their multidimensionality, not only dysfunctional manifestations, but also compensatory strategies. Psychological studies report that, on the one hand, cognitive and perceptual deficits in SPD facilitate an altered state of creativity and immersion into unusual perceptual experience; on the other, cognitive and perceptual peculiarities are an adequate way to compensate for the schizotypal maladaptation (Kallai et al., 2019). Recent studies also report the absence of manifestations of speech disorders in the aspect of originality (increasing the number of original answers), and semantic flexibility in subjects with high schizotypal traits (Rodríguez-Ferreiro & Aguilera, 2019).

Psychological studies on visual perceptual processes in SPD focus on several different aspects. The neuropsychological approach describes dysfunction of spatial

working memory (Smith & Lenzenweger, 2013), executive functions, information processing (Giakoumaki, 2012), processing speed (McClure, Harvey, Bowie, Iacoviello, & Siever, 2013), and attention (Carrión et al., 2011; Dickey et al., 2005). The factors determining disturbances of visual perceptual processes, speech, and thinking in SPD include increased stress and uncertainty of visual perceptual stimuli (Silverstein & Palumbo, 1995). In these conditions, patients with SPD demonstrated diminished accuracy of visual spatial memory (Smith & Lenzenweger, 2013). Disorganization of speech is reported while patients view both pleasant and stressful photographs (Minor & Cohen, 2010). The role of negative affect (general psychological distress) in the occurrence of cognitive impairment in individuals with high schizotypy scores has also been discussed (Carrigan & Barkus, 2017).

Experimental studies of perception in patients with SPD have shown intact early visual perceptual processes and heightened mental imagery (Maróthi & Kéri, 2018), which probably contribute to perceptual aberration in SPD. One of the psychological mechanisms of unusual body experience (self-face perception abnormalities, loss of self-other boundaries) in schizophrenia spectrum disorders was demonstrated by using the Strange-Face-in-the Mirror illusion and Mirror-Gazing test (Bortolon et al., 2017; Caputo, 2010). The particular interest of modern studies of visual perceptual processes in schizophrenia spectrum disorders focuses on sensitivity to changes in target shape (for instance, target detection in symmetrical patterns and noise, configural superiority effect, global-local divided attention task, performance on closed-contour tasks). These studies indicate a specific difficulty with the perceptual organization of stimuli and heterogeneity of cognitive perceptual functioning in patients with schizophrenia and SPD (Panton, Badcock, & Badcock, 2016).

Social cognition is a significant facet of visual perceptual processing. Patients with SPD were characterized by empathic dysfunction with regard to others' negative feelings, which was associated with lower indices of social support (Ripoll et al., 2013). It is important to note the inconsistency of social cognition impairment in schizophrenia spectrum disorders. Respondents with high schizotypal traits displayed a contradiction between low cognitive empathy (ability to shift from the first-person perspective to third-person perspective and back) and high affective empathy (perceptual accuracy for negative cues) (Kallai et al., 2019; Lindeman, Svedholm-Häkkinen, & Lipsanen, 2015). Studies of the Theory of Mind (ToM) in patients with SPD also demonstrate inconsistent findings. While some studies showed ToM impairment in unaffected relatives of schizophrenia patients (Bora & Pantelis, 2013), studies of individuals with psychometrically defined schizotypy (Morrison, Brown, & Cohen, 2013), studies of individuals with elevated positive schizotypy scores (Pflum, Gooding, & White, 2013), and other studies found no significant differences between respondents with schizotypal–schizoid personality disorders and controls in any of the ToM measures (Booules-Katri, Pedreño, Navarro, Pamias, & Obiols, 2019).

The cultural-historical approach discusses the systemic structure of mental activity in schizotypal disorders, and the significant role of culture in accepting cognitive-perceptual symptoms of SPD as normative experiences (Fonseca-Pedrero et al., 2018). This approach also discusses the relations of personal components (low ethnic identity, low self-concept clarity) and cognitive components (aberrant salience) of

mental activity (Cicero & Cohn, 2018). A specific relationship was established in patients between affective components ("emotional investment in relationships", "affective tone of relationships", empathy) and cognitive components ("complexity of representations", "understanding of social causality") of mentalization (Sokolova & Andreyuk, 2018; Sokolova, Andreyuk, & Ryzhov, 2018), which emphasizes the importance of interpersonal context for understanding impairment of cognition in SPD. Various studies point out the unique role of stressful events in social relations (college enrollment, adaptation to a new social environment, external requirements, etc.) for the manifestation of symptoms of SPD (Geng et al., 2013; Quide et al., 2018).

Therefore, SPD is characterized by destabilization of mental activity in situations of social interaction (Herpertz & Bertsch, 2014), which is a common pattern in personality disorders. Patients with different types of personality disorders display in social situations disturbances of emotional regulation and control, and of executive functions; less ambiguity tolerance, loss of internal consistency and sense of self-coherence (Gawda, Bernacka & Gawda, 2016; Giakoumaki, 2012; Osma, García-Palacios, Botella, & Barrad, 2014).

Thus, the investigation of visual perceptual functions in SPD requires the development of a particular methodological approach that explores the processes of mental activity in an expanded form. This approach is based on the close relationship between cognitive performance, and emotional and personality features. It includes methods that allow the researcher to vary the emotional intensity of stimuli, increase the degree of uncertainty, change instructions for tasks, and use different manners of stimulus presentation. Such an organization of an experiment is more sensitive and informative with regard to the structure of mental activity and the specific characteristics of executive functions of patients with SPD. Based on the principle of cognitive-affective unity, this approach proved its effectiveness in the investigation of hysterical personality disorder (Tkhostov & Vinogradova, 2013).

The study of interdependence, different aspects of cognitive performance, emotional and personality features, represents an integrative approach to the interpretation of experimental data. This methodology allows us to overcome limitations of the description of cognitive impairment in personality disorder at the level of separate phenomena (Duff & Kinderman, 2006) and provides a complete approach at the level of factor constellations (primary and secondary disturbances, compensatory mechanisms) (Chepeliuk & Vinogradova, 2018).

The crucial role of the cognitive-perceptual and disorganization criteria of SPD identified in clinical studies, as well as the significance of special conditions of manifestation of cognitive disturbances (an increase of emotional stress, visual perceptual characteristics of stimuli) indicate the prospects for psychological study of strategies for solving visual perceptual tasks for better understanding of the psychological mechanisms of cognitive impairment in SPD. The inconsistency of visual perceptual productivity, and the ability to find solutions corresponding to the norm differentiate SPD from schizophrenia. These peculiarities of visual perceptual processes in SPD align with the cognitive functions in personality disorders. At the same time, it is important to create conditions in which discrepancies among different types of severe personality disorders (for instance, in compensatory strategies, evaluative abilities,

manner of performance) could be revealed. In our experimental study, we elaborated the conditions of different degrees of uncertainty, social regulation of answers, and complexity of stimuli to detect which is more sensitive in SPD patients. We have proposed that inconsistency of cognitive functioning productivity in SPD is manifested in steady alteration of conditions and the necessity to find new ways to adapt. These manifestations are differentiated from those in other severe personality disorders (such as obsessive-compulsive personality disorder).

This study aimed to research the performance of visual perceptual tasks in patients with SPD, their ability to create and use compensatory strategies, conditions of normative performance and manifestation of impairments, and their severity.

Methods

Participants

The clinical groups comprised 39 patients with SPD (F21.8 in ICD-10) aged 18–55 (experimental group) and 36 patients with obsessive-compulsive personality disorder aged 18–56 (F60.5 in ICD-10, OCPD). The clinical comparison group (OCPD) is more severe than other types of personality disorders. This allows for comparability of results of cognitive tests in patients with SPD and OCPD, to elucidate similarities and differences in psychological mechanisms of performance of visual perceptual tasks in SPD and other personality disorders.

The control group consisted of 102 healthy individuals between the ages of 18 and 54. Patients were recruited from mental health clinics in Moscow (Kannabikh State Psychiatric Hospital and International Institute of Psychosomatic Health). They were consulted by psychiatrists and signed an informed consent agreement. Patients with personality disorders and normal controls had an equivalent educational level, except in the group of patients with OCPD, who generally had higher education ($p = 0.02$) (*Table 1*). All patients were examined before the treatment.

Table 1

Socio-demographic characteristics of respondents

Characteristics		Subjects		
		Patients with SPD	**Patients with OCPD**	**Healthy individuals**
Age (Mean ± Standard Deviation)		29.23 ± 8.39 years	31.89 ± 9. 70 years	28.18 ± 8.48 years
Gender	Female	22 (56%)	26 (68%)	54 (53%)
	Male	17 (44%)	12 (32%)	48 (47%)
Education	Higher education	22 (56%)	30 (83%)	58 (55%)
	Incomplete higher education	12 (31%)	5 (14%)	29 (29%)
	Secondary education	5 (13%)	1 (3%)	18 (16%)

Procedure

There were two series of visual perceptual problem-solving tests (visual perceptual test). The embedded figures of Witkin and Goldstein (Witkin, 1950) were used as stimuli. In Series I, complex figures were covered by eight simple figures and the subject had to decide whether the complex figure contains the simple one (for all 96 trials), without feedback from the experimenter. In Series II, each trial showed two complex figures simultaneously, to increase the visual perceptual load (for all 96 trials).

Three types of instructions were used. The first one was vague ("Do you think this figure is in a complex one?") and was presented after the first simple figure had been shown alongside the first complex figure in Series I. The second instruction provided verbal clues about the criteria for correct answers: "Every simple figure is not necessarily embedded within every complex one, but if you find a simple figure, it should be the same as the one in the model". This verbal clue was presented before a demonstration of the second complex figure in Series I. The third instruction involved visual perceptual cues in Series II, when one of the two simultaneously presented complex figures could be considered as a corrector for the answers. Thus, the procedure provides the opportunity to moderate uncertainty of stimuli and experimental conditions.

The analysis of performance of visual perceptual tasks included the number of correct answers in the different types of instructions.

To analyze different aspects of the cognitive functions of patients with SPD, the study included the WAIS-R test (Wechsler Adult Intelligence Scale, revised form), with six verbal and five performance subtests (Filimonenko & Timofeev, 2006).

Statistical significance was ascertained by Student's t-test for comparing independent groups, the Spearman rank correlation coefficient, a two-way 3×3 factorial analysis of variance, and Fisher's exact test to compare categorical variables.

Results

Performance of Series I and Series II

Visual Perceptual Tasks in Patients with Schizotypal Personality Disorder, Healthy Subjects, and Patients with Obsessive-Compulsive Personality Disorder.

Table 2 shows that the significance values of group and type of instruction are equal, $p = .096$, so there is no interaction effect by group and type of instruction of visual perceptual tasks on the number of right answers in Series I and II. ANOVA showed a significant effect of group and a significant effect of type of instruction on the number of right answers in Series I and II.

Figure 1 shows the values of the correct answers for the different types of instructions. The data shows that all subjects had the smallest number of answers when the key figure was presented with "vague" instructions. However, the healthy individuals had significantly more correct answers with "vague" instructions compared to the patients with personality disorders (*Table 3*). Patients with SPD had significantly fewer correct answers with verbal cues in comparison with the healthy subjects (*Table 3*). OCPD patients had intermediate outcomes with verbal cues, with more right answers than SPD patients and less than the healthy controls, without significant differences with either the SPD patients or healthy subjects (*Figure 1*). This result indicates the

Table 2

Factorial ANOVA calculation results (Dependent variable: right answers in Series I and II)

Source of variance	Type III Sum of Squares	Df	Mean Square	F	Signif.
Corrected model	18.938[a]	8	2.367	8.103	.000
Intercept	84.680	1	84.680	289.845	.000
Group	6.092	2	3.046	10.426	.000
Type of instruction	8.960	2	4.480	15.334	.000
Group × type of instruction	2.321	4	.580	1.986	.096
Error	118.908	407	.292		
Total	250.000	416			
Corrected total	137.846	415			

Note. [a] $R^2 = .137$ *(Adjusted* $R^2 = .120$*)*

possibility of increasing the productivity of performance of visual perceptual tasks by patients with OCPD at the level of standard indicators, when the degree of uncertainty of the stimulus was reduced.

In Series II, with visual perceptual cues, there was an equal percentage of healthy subjects who found the key figures and of those who could not. The same was observed in patients with SPD, with slightly more patients who found the key figures in the pair of complex figures (*Table 3*). SPD patients had no significant differences in the number of correct answers in comparison with the controls (*Figure 1*). Patients with OCPD had significantly fewer correct answers with visual perceptual cues in comparison with healthy individuals (*Table 3*).

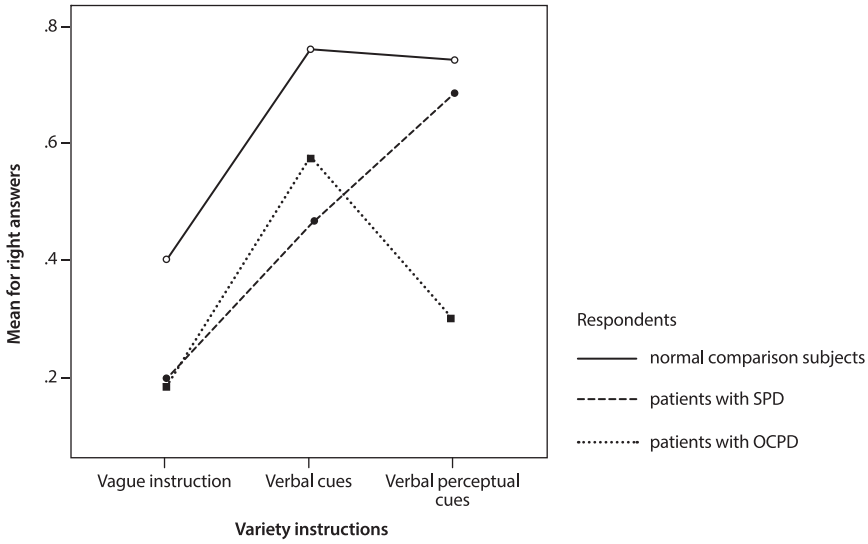

Figure 1. The number of right answers with different types of instruction in Series I and II for visual perceptual tasks with patients with personality disorders and healthy controls

Table 3

Average of correct answers within different instructions for visual perceptual tasks within healthy subjects and patients with personality disorders in Series I and II.

Type of instruction	Respondents	Mean ± Standard Deviation	Proportion of the answers without correct figure/with correct figure
Vague instruction	Healthy subjects	0.40 ± 0.49*[3]**[2]	64% / 36%
	Patients with SPD	0.19 ± 0.09**[1]	80% / 20%
	Patients with OCPD	0.18 ± 0.39*[1]	81% / 19%
Verbal cues	Healthy subjects	0.76 ± 0.43**[2]	27% / 73%
	Patients with SPD	0.46 ± 0.51**[1]	57% / 43%
	Patients with OCPD	0.58 ± 0.50	47% / 53%
Visual perceptual cues	Healthy subjects	0.74 ± 0.72*[3]	50% / 50%
	Patients with SPD	0.69 ± 0.72*[3]	46% / 54%
	Patients with OCPD	0.30 ± 0.52*[1 2]	74% / 26%

*Note. Fisher's test for comparing: [1]healthy subjects; [2]patients with SPD; [3]patients with OCPD. *$p \leq .05$, **$p \leq .01$*

Comparison of Results of the Wechsler Adult Intelligence Scale (WAIS-R) in Patients with SPD and Healthy Subjects

To further illuminate the performance of visual perceptual tasks, nonverbal WAIS-R subtests were analyzed for patients with SPD in comparison with healthy subjects. *Table 4* shows that the scores on the WAIS-R for patients with SPD were significantly different from those of healthy individuals. The patients scored significantly lower on nonverbal subtests such as the "Digit Symbol" ($p \leq .05$), the "Picture Completion" ($p \leq .01$), and the "Block Design" ($p \leq .01$). Patients with SPD managed to fill in the same number of digits on the Digit Symbol subtest as the healthy subjects in the allotted time, but they displayed differences in the quality of writing of the symbols. The patients more often had a change in the slope or character size, an incorrect alignment of lines in the symbol, or extra lines.

The lower scores in the Block Design subtest in patients with SPD was associated with difficulty analyzing parts within the whole, when this was required to compare the results of their performance with an externally provided sample.

Patients with SPD had lower productivity in the Picture Completion subtest because of a tendency to focus on insignificant, peculiar aspects of the stimuli.

An important characteristic of the cognitive processes of patients with SPD was the significantly lower score on WAIS-R verbal subtests. Analysis of performance of verbal tasks by patients with SPD allowed us to elucidate the general psychological mechanisms, which can also determine the impairment of visual perceptual processes in SPD.

Patients with SPD differed statistically from healthy subjects in the performance of the Information ($p \leq .01$), Comprehension ($p \leq .01$), Arithmetic ($p \leq .05$), Digit Span ($p \leq .05$), and Vocabulary ($p \leq .05$) verbal subtests.

On the Information subtest, SPD patients showed a paradoxical combination of difficulty in extracting information reinforced by experience, and ease answering the most difficult questions.

The lower scores in the Comprehension subtest in patients with SPD was caused by disregarding the social context, relying solely on the subjective manner of behavior in stimulus situations (egocentric position). In some cases, the answers of patients with SPD included both egocentric solutions and standard social criteria. When conveying the figurative meaning of non-frequent expressions, SPD patients tended to resort to magical meanings combined with situation-based generalizations. It should be noted that the patients could give the correct answers in tasks where they were asked to explain the figurative meaning of common proverbs and expressions, which suggests the ability of these patients to operate with conventionalized abstract meaning.

Table 4

Comparison between WAIS-R scores of patients with personality disorders and healthy subjects

WAIS-R subtests	Participants	Mean ± SD
Information	Healthy subjects	13.65 ± 3.22*,2
	Patients with SPD	11.56 ± 3.71*,1 *,3
	Patients with OCPD	13.27 ± 1.94*,2
Comprehension	Healthy subjects	13.10 ± 2.96*,2
	Patients with SPD	11.16 ± 2.46*,1 *,3
	Patients with OCPD	12.72 ± 2.43*,2
Arithmetic	Healthy subjects	11.02 ± 2.67*,2
	Patients with SPD	9.97 ± 2.65*,1
	Patients with OCPD	10.48 ± 3.22
Similarities	Healthy subjects	13.53 ± 2.18
	Patients with SPD	13.03 ± 2.23
	Patients with OCPD	13.57 ± 2.25
Digit Span	Healthy subjects	11.69 ± 2.45*,2 *,3
	Patients with SPD	10.61 ± 2.45*,1
	Patients with OCPD	10.00 ± 2.73*,1
Vocabulary	Healthy subjects	14.22 ± 2.52*,2
	Patients with SPD	13.26 ± 2.21*,1
	Patients with OCPD	13.94 ± 2.30
Sum of verbal scores	Healthy subjects	77.18 ± 10.88*,2
	Patients with SPD	70.64 ± 11.55*,1
	Patients with OCPD	73.85 ± 8.47
Digit Symbol	Healthy subjects	10.55 ± 2.73*,2 3
	Patients with SPD	9.27 ± 2.52*,1
	Patients with OCPD	9.48 ± 1.95*,1

WAIS-R subtests	Participants	Mean ± SD
Picture Completion	Healthy subjects	12.02 ± 1.92**[2 3]
	Patients with SPD	10.94 ± 2.10**[1]
	Patients with OCPD	10.34 ± 1.94**[1]
Block Design	Healthy subjects	13.83 ± 2.56**[2 3]
	Patients with SPD	12.06 ± 3.29**[1]
	Patients with OCPD	12.03 ± 2.57**[1]
Picture Arrangement	Healthy subjects	10.24 ± 2.00
	Patients with SPD	9.53 ± 2.67
	Patients with OCPD	9.78 ± 1.43
Object Assembly	Healthy subjects	7.68 ± 2.13
	Patients with SPD	8.11 ± 2.61
	Patients with OCPD	8.22 ± 2.52
Sum of performance scores	Healthy subjects	54.31 ± 6.63*[2]*[3]
	Patients with SPD	49.86 ± 10.02*[1]
	Patients with OCPD	50.13 ± 6.58**[1]
Full Scale Scores	Healthy subjects	131.60 ± 15.32**[2] *[3]
	Patients with SPD	120.94 ± 19.88**[1]
	Patients with OCPD	123.81 ± 11.86*[1]

*Note. Student's t-test for comparing independent groups: [1]healthy subjects; [2]patients with SPD; [3]patients with OCPD; *p ≤ .05, **p ≤ .01.*

Patients with SPD had lower scores on the Arithmetic subtest in comparison with healthy subjects, which can be explained by the former's inconsistent productivity in counting operations. These patients, when faced with difficulties in tasks with one-phase counting, did not attempt to find an answer. More rarely, patients with SPD expressed unwillingness to count. By contrast, the patients performed well on easy tasks on the Arithmetic subtest with two-phase counting, and obtained additional points for speed in these tasks. In the most complicated tasks of the Arithmetic subtest, patients with SPD easily substituted a correct description of the necessary actions, thereby avoiding counting operations.

Comparison of Performance on the Wechsler Adult Intelligence Scale (WAIS-R) in Patients with OCPD and Healthy Subjects

Table 4 shows a significant difference between the WAIS-R performance by patients with OCPD and healthy individuals only in the Digit Span verbal subtest ($p \leq .01$). However, in nonverbal subtests, the results of patients with OCPD were significantly lower than with healthy subjects (in the Digit Symbol ($p \leq .05$), in the Picture Completion ($p \leq .01$) and in the Block Design ($p \leq .01$) subtests).

The lower scores on the Digit Span subtest were associated with a shift of patients' attention from the instruction for the task to thoughts of failure, greater doubts about one's own performance, abilities, etc. Patients with OCPD demonstrated on the Digit Symbol subtest the intention to accurately imitate the symbols specified by the instruction, which led to an excessive focus of attention on verifying the result. They

also corrected their mistakes, which slowed their performance. Preoccupation with details made the patients with OCPD take a long time searching for answers in the Picture Completion subtest, going beyond the time allocated to each item.

Patients with OCPD gave a detailed analysis of the parts that presented difficulties when synthesizing them into a whole, were unable to revise their work method, doubted the correctness of the process, and often canceled the correct answers, which reduced their productivity in the Block Design nonverbal subtest.

Patients with OCPD had significantly higher scores than patients with SPD on the Information ($p \leq .05$) and Comprehension ($p \leq .05$) verbal subtests. Analysis of the performance of nonverbal subtests by patients with different types of personality disorders revealed no significant differences.

Correlations of Parameters of the Wechsler Adult Intelligence Scale and of the Visual Perceptual Tasks in Patients with Different Types of Personality Disorders

In healthy subjects and patients with OCPD, there were no significant correlations between the number of right answers on the Series I and Series II visual perceptual tasks with different types of instructions, and their scores on WAIS subtests.

In patients with SPD there were significant positive correlations between the number of correct answers under the condition of visual perceptual cues, and the Sum of Performance scores ($r = 0.37$, $p \leq .05$) and scores on the Object Assembly subtest ($r = 0.49$, $p \leq .01$).

Discussion

The study revealed that patients with different types of personality disorders had similarities in their profiles of reduced effectiveness in nonverbal tasks in comparison with standard indicators. The lack of differences in performance of nonverbal tasks between patients with schizotypal and obsessive-compulsive personality disorders suggests that working with visual perceptual information is the most sensitive to deviations from standard indicators in patients with personality disorders.

Performance of the Series I and Series II visual perceptual tasks with vague instructions, and with verbal and visual perceptual cues, allows us to elucidate the psychological mechanisms behind differences in cognitive impairment and compensatory strategies in personality disorders. Although in conditions of high uncertainty with vague instruction, patients with SPD and OCPD did not differ from healthy controls, the introduction of verbal cues in Series I brought to the fore the principal impairments in SPD patients (lack of social regulation, inability to change the manner of decision-making by comparing their solutions with the model), and the adaptive ability of patients with OCPD. The latter were able to develop their own effective criteria based on the verbal cue (using the verbal cue "to be exactly like the model") in searching for the key figures embedded in the complex ones.

In the performance of Series II tasks with visual perceptual cues, the situation is the opposite. SPD patients could switch their attention to the second figure and treat it as a corrector to their own solutions, so, they had standard results, whereas patients with OCPD demonstrated a significant decrease in performance of visual perceptual tasks when two complex figures are presented simultaneously. These findings indicate the abilities of patients with SPD to find a new way of adapting when the

conditions of performance were changed and to follow it effectively. This corresponds to the fact that patients with SPD had no discrepancies with normative indicators when working on nonverbal tasks with visually presented social context (the Picture Arrangement subtest) and concrete content (the Object Assembly subtest). This fact suggests that patients with SPD had no decrease in social regulation of activity in case of direct visual support of the social context. At the same time, patients with SPD display lower productivity in verbal tasks associated with a social context. Therefore, among nonverbal tasks, the performance of tasks with abstract visual perceptual information is the most sensitive to impairments in patients with SPD. This result is consistent with the significant role of cognitive-perceptual criteria for diagnosis of SPD identified in clinical studies (Zouraraki et al., 2017).

The decline in most cognitive parameters of the Wechsler Adult Intelligence Scale in patients with SPD corresponds to data from meta-analyses of cognitive impairment in schizophrenia spectrum disorder (Carruthers et al., 2019) and suggests greater severity of cognitive impairment in SPD patients in comparison with patients with OCPD.

SPD patients' inconsistent productivity in performing verbal tasks was caused by difficulties in inhibiting subjectively significant responses when socio-deterministic formal criteria were available for making judgments; the stability of a subjective manner of performance and inability to revise it; vagueness in definition of concepts; and slipping into subjective associations with the stimuli. OCPD patients are characterized by relatively intact ability to solve verbal tasks, as evidenced by lower scores than normative on only one of the verbal subtests.

Although patients with SPD and OCPD did not differ significantly in their scores on nonverbal tasks, the qualitative analysis revealed the principal differences in the psychological mechanisms of their impairments. In SPD patients, the lower scores on nonverbal subtests were a result of low orientation toward the model, ease of subjective transformation of the targets, and impairment of the selectivity of cognitive processes. The latter is specific for patients with schizophrenic spectrum disorders. This impairment is characterized by a tendency to rely on insignificant, bizarre, unusual attributes of concepts (Kritskaya & Meleshko, 2015; Kritskaya, Meleshko, & Polyakov, 1991). The lower productivity on nonverbal subtests of patients with OCPD was associated with their detailed analysis of parts that present difficulties in their synthesis, preoccupation with details, inability to revise their work method, and doubts about their accuracy, often with the rejection of correct answers.

For healthy subjects and patients with OCPD, there was no association in Series I and Series II between productivity in performing visual perceptual tasks under conditions of different instructions, and the parameters on the intelligence scale, whereas in SPD patients, the productivity of the search for figures under condition of visual perceptual cues was associated with nonverbal subtests and the integrative performance score.

Conclusion

The patients with SPD had more severe cognitive impairment than the OCPD patients. The former had lower productivity in performance of verbal and nonverbal

tasks. Patients with OCPD had difficulties only in the performance of nonverbal tasks, whereas in verbal tasks they had scores corresponding to the normative.

It is important to note the specific mechanisms of impaired cognitive functioning in SPD. The basic impairment in these patients was associated with difficulties in inhibition of bizarre responses, stability of the subjective manner of performance and inability to revise it, low orientation to the model, and slipping into subjective associations with the stimuli. In OCPD it was associated with a shift of patients' attention from the instruction about the task to thoughts of failure, strengthening of doubts, and excessive focus on checking one's performance.

Varying the degree of uncertainty of the visual perceptual tasks with abstract stimuli made it possible to reveal the specific compensatory strategies of patients with SPD, which help to increase the productivity of the performance. So, under the condition of visual perceptual cues, these patients could achieve normative results, whereas patients with OCPD demonstrated lower productivity. These facts also suggest that the performance of visual perceptual tasks in patients with SPD is characterized by inconsistent productivity and the availability of compensatory strategies that increase the performance to normative levels.

This experimental study has some clinical implications. First, these findings broaden the pathopsychological picture of impairments of visual perceptual processes and compensatory strategies of patients with SPD. Second, it should be useful for differential diagnostics of severe personality disorders, SPD, and other schizophrenia-spectrum disorders. Furthermore, these results contribute to addressing complex issues of social and daily-life adaptation, occupational activity, and productivity of SPD patients.

Limitations

The current study had several limitations that should be addressed in future research. First, it might be informative to compare the results of cognitive tasks of patients with SPD and schizophrenic patients (pseudoneurotic type), to discuss specific and general impairment of cognitive productivity in schizophrenia-spectrum disorders. Second, it would be promising to discuss the duration of clinical symptoms and their association with the change or intactness of cognitive productivity in the performance of the visual perceptual tasks in patients with SPD.

Ethics Statement

All participants were consulted by psychiatrists voluntarily and signed an informed consent before taking part in the research.

Author Contributions

Marina Vinogradova and Anastasia Chepeliuk conceived of the idea. Anastasia Chepeliuk developed the theory and performed the computations. Marina Vinogradova supervised the findings. The authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors report no potential conflict of interest.

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Measuring Spatial Ability for Talent Identification, Educational Assessment, and Support: Evidence from Adolescents with High Achievement in Science, Arts, and Sports

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Background. Spatial ability (SA) is a robust predictor of academic and occupational achievement. The present study investigated the psychometric properties of 10 tests for measuring of SA in a sample of talented schoolchildren.

Objective. Our purpose was to identify the most suitable measurements for SA for the purpose of talent identification, educational assessment, and support.

Design. Our sample consisted of 1479 schoolchildren who had demonstrated high achievement in Science, Arts, or Sports. Several criteria were applied to evaluate the measurements, including an absence of floor and ceiling effects, low redundancy, high reliability, and external validity.

Results. Based on these criteria, we included the following four tests in an Online Short Spatial Ability Battery "OSSAB": Pattern Assembly; Mechanical Reasoning; Paper Folding; and Shape Rotation. Further analysis found differences in spatial ability across the three groups of gifted adolescents. The Science track showed the highest results in all four tests.

Conclusion. Overall, the study suggested that the *Online Short Spatial Ability Battery (OSSAB)* can be used for talent identification, educational assessment, and support. The analysis showed a unifactorial structure of spatial abilities. Future research is needed to evaluate the use of this battery with other specific samples and unselected populations.

Keywords: education; educational streaming; factor analysis; investment of effort; gifted children; reliability; spatial ability

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Introduction

Spatial ability can be defined as the ability to generate, retain, retrieve, and transform visual images (Lohman, 1996). It plays an important role in academic performance (Kell, Lubinski, Benbow, & Steiger, 2013; Tosto et al., 2014; Xie et al., 2020), particularly in interest and accomplishment in Science, Technology, Engineering, and Mathematics (STEM) fields (Super & Bachrach, 1957; Wai, Lubinski, & Benbow, 2009; Li & Wang, 2021).

For example, individuals from Project Talent (Flanagan et al., 1962) with more pronounced spatial ability (compared to verbal ability) were more involved in math and science courses in high school (Wai et al., 2009). They were also more likely to choose the STEM fields for future education, while those with the opposite pattern (verbal ability advantage over spatial) were more likely to choose educational programs and careers focused on education, humanities, and social sciences.

Moreover, it appears that the likelihood of obtaining an advanced degree in STEM (from a BSc to a PhD) increases as a function of spatial ability: 45% of all those holding STEM PhDs scored within the top 4% on spatial ability 11 years earlier; and nearly 90% of all those holding STEM PhDs were in top 23% or above. Similarly, about 30% of those holding STEM terminal master's degrees, and 25% of those holding STEM terminal bachelor's degrees, also scored in the top 4% of spatial ability (Wai et al., 2009).

Another study (Kell, Lubinski, Benbow, & Steiger, 2013) examined the spatial ability data for 563 participants from the Study of Mathematically Precocious Youth (SMPY; Shea et al., 2001). Levels of spatial ability, measured at age 13–14, added explanatory power 35 years later, accounting for 7.6% of the variance in creative achievement (number of patents and published articles), in addition to the 10.8% of variance explained by scores on the mathematics and verbal sections of the Scholastic Assessment Test (SAT). Lubinsky and team emphasized the necessity of adding a spatial assessment to talent search programs. This might help children and adolescents with high levels of spatial ability to reach their full potential. Without formal identification, spatially gifted adolescents may lack opportunities to develop their skills (Lohman, 1994; Lubinski, 2016), and even disengage from education (Lakin & Wai, 2020).

Despite being a robust predictor of future STEM achievement, spatial ability assessment is often not included in talent searches. This is because time for such assessments is generally limited and focused mostly on the numerical and verbal domains (Lakin & Wai, 2020). Few studies have examined the role of spatial ability in high achievement in nonacademic domains, such as sports and the arts. The results of existing studies are inconsistent, with some finding such links (Blazhenkova & Kozhevnikov, 2010; Hetland, 2000; Ivantchev, & Petrova, 2016; Jansen, Ellinger, & Lehmann, 2018, Notarnicola et al., 2014; Ozel, Larue, & Molinaro, 2002, 2004; Stoyanova, Strong & Mast, 2018), and others failing to do so (Chan, 2007; Heppe, Kohler, Fleddermann, & Zentgraf, 2016; Sala & Gobet, 2017). One way to improve understanding of the role of SA in high achievement is to use the same test battery in samples selected for high achievement in different domains. To our knowledge, our study is the first to carry out such an investigation.

Irrespective of achievement domain, it is not clear which spatial abilities are most relevant. Numerous spatial ability tests are available which tap into supposedly different processes, such as spatial information processing, mental rotation, spatial visualization, or manipulation of 2D and 3D objects (Uttal, Meadow, Tipton, Hand, Alden, & Warren, 2013).

However, several recent studies (Esipenko et al., 2018; Likhanov et al., 2018; Malanchini et al., 2019; Rimfeld et al, 2017) showed that spatial ability might have a unifactorial rather than multidimensional structure. For example, research has shown that the 10 spatial ability tests which form a King's Challenge test battery (Rimfeld et al., 2017), constitute a single factor in British and Russian samples, explaining 42 and 40 percent of overall variance in spatial ability measures, respectively (Likhanov et al., 2018; Rimfeld et al., 2017). Interestingly, in a Chinese sample assessed with the same battery, a two-factorial structure of spatial ability emerged (explaining 40% of the total variance), with Cross-sections and Mechanical Reasoning forming a separate factor. Further research is needed to identify the sources of these differences across the samples.

The unifactorial structure of spatial ability was further demonstrated in another study that examined 16 measures of spatial ability in a UK sample (Malanchini et al., 2019). In this study, three factors emerged: navigation, object manipulation, and visualization; these in turn loaded strongly on a general factor of spatial ability. The unifactorial structure found in the UK and Russian samples suggests that, at least in these populations, a smaller number of tests can be used for rapid assessment of spatial ability.

The main purpose of the current study was to identify the most suitable spatial ability tests for creating a short online battery for educational assessment and talent identification. To this end, we investigated the psychometric properties of 10 spatial ability tests, as well as performance on these tests, in three adolescent samples selected for high achievement in science, arts, or sports. Comparison between these areas of expertise may provide additional insight into the role of spatial ability in these areas.

As the study was largely exploratory, we investigated the following research questions rather than testing specific hypotheses:

Research question 1: What are the best performing spatial ability tests in terms of psychometric properties?

Research question 2: What is the relationship between spatial ability and the three areas of expertise: Science, Sports, and Arts?

Research question 3: Does the previously shown unifactorial structure of spatial ability replicate in these expert samples?

Method

Participants

The study included 1470 adolescents, who were recruited at the Sirius educational center in Russia (645 males, 468 females, and 357 participants who did not provide information on gender). The ages of the participants ranged from 13 to 17 years

(M = 14.78, SD = 1.20). Sirius is an educational center which provides intensive four-week educational programs for schoolchildren who have demonstrated high achievement in Science, Arts, or Sports. Adolescents from all regions of Russia are invited to apply for participation in these educational programs. Participation, as well as travel and other expenses, are free for participants. The socio-economic status (SES) of the participants was not measured. However, the participants likely represented a wide range of SES backgrounds, since the program application is open for everyone, participants come from all Russian geographic regions, and participation is fully funded.

We invited high-achievers to participate in one of the three tracks, selected on the basis of the following criteria:

- Science (339 males, 208 females): high school achievement, such as winning in a subject Olympiad (maths, chemistry, physics, informatics, IT, biology, etc.); or excellent performance in a scientific project;
- Arts (50 males, 198 females): winning in different competitions and demonstrating high achievement in painting, sculpture, choreography, literature, or music;
- Sports (220 males, 55 females): participation and winning in high-rank sport competitions (hockey, chess, and figure skating).

Due to the limited sample size, we were not able to analyze differences within the tracks (*e.g.,* math vs. chemistry; sculpture vs. choreography; or chess vs. hockey). We plan to explore those differences once the sample size needed for such research is achieved.

Procedure

The study was approved by the Ethical Committee for Interdisciplinary Research. Parents or legal guardians of participants provided written informed consent. Additionally, verbal consent was obtained from the participants before the study. The testing took place in the regular classrooms of the educational center, which are quite similar to each other.

Measures

King's Challenge battery. Participants were presented with a gamified online battery called the "King's Challenge" (KC), which had a test-retest reliability of r = 0.65 on average for the 10 spatial tests (Rimfeld et al., 2017); the battery was adapted for administration in Russian. The battery consists of 10 tests (see *Table 1*) and is gamified, with a general theme of building a castle and defending it against enemies. When they finished the battery, participants received feedback on their performance.

We used the total of all correct items to score each test for use in further analysis. A total score for all 10 tests was computed by summing up the scores for each (KC Total), following the procedure described by Rimfeld and colleagues (2017).

Non-verbal intelligence. Non-verbal intelligence was measured by a shortened version of the Raven's progressive matrices test (Raven, Raven, & Court, 1998). The test was modified to included six (only odd) items from the C, D, and E series, and three items from the F series (The A and B series were excluded). A discontinuation

Table 1

Description of the 10 tests in the King's Challenge battery

Subtest name	N of items	Time limit per item (sec)	Description
Cross-sections	15	20	visualizing cross-sections of objects
2D drawing	5	45	sketching a 2D layout of a 3D object from a specified viewpoint
Pattern assembly	15	20	visually combining pieces of objects to make a whole figure
Elithorn mazes	10	7	joining together as many dots as possible from an array
Mechanical reasoning	16	25	multiple-choice naive physics questions
Paper folding	15	20	visualizing placement of holes, after they punched through folded piece of paper
3D drawing	7	70	sketching a 3D drawing from a 2D diagram
Shape rotation	15	20	choosing the rotated target figure among others
Perspective-taking	15	20	visualizing objects from a different perspective
Mazes	10	25	searching for a way through a 2D maze in a time-limited task

Note: Example items for each test are provided in the Supplementary Materials provided at the conclusion of this article. You will find the figures included there referenced with the S prefix in the text. Detailed information on the battery can be found in Rimfeld et al., 2017.

rule was applied in order to reduce the duration of the test: a series was terminated after three incorrect responses, and the test automatically progressed to the next series (in the F series, the test terminated immediately). The percentage of all correct responses out of the total number of 21 items was used for analysis.

Academic achievement. We used self-reported school Year grades for Math (Year grade Math) and the Russian Language (Year grade Rus). These grades are awarded by teachers to assess a student's performance for the whole school year in a respective subject (based on performance across the year). The grading system is 1 to 5, where 1 = "terrible/fail"; 2 = "bad/fail"; 3 = "satisfactory"; 4 = "good"; and 5 = "excellent". A 1 is practically never given, and a 2 is given only rarely (see Likhanov et al., 2020, for a discussion of the limitations of this grading system). In our sample, we had a restricted range of Year grades, with no 1 and 2 grades, since students who received these marks are unlikely to be invited to Sirius. The data for Year grades was available for 1109 participants.

We also collected self-reported grades for the State Final Assessment, a standardized exam hereafter referred to as the Exam. This test, taken at the end of 9th grade (15–16 years of age), is a measurement of students' performance that serves as a major educational assessment tool. In the current study, only scores for the Math (Exam Math) and Russian language (Exam Rus) exams were used. Exam marks range from 1 to 5. No participants in our study had a 1 or 2 on this exam. The data for Exam results

was available for only 306 participants, since not all study participants were of the age to undergo this exam at the time of data collection.

Spatial test selection criteria

In order to select the most informative spatial tests for educational assessment and talent search, we focused on six characteristics:

1. Absence of floor and ceiling effects — clustering of participants' scores towards the worst or best possible scores (reflecting the unsuitability of the test difficulty level for the sample);
2. Differentiating power — the ability of the test to differentiate between Science, Arts, and Sports tracks in terms of average performance and distribution;
3. Low redundancy — this criterion allowed us to exclude tests which demonstrated very high correlations (above .7) with other tests in the battery;
4. Specificity — identifying tests that had small factor loadings on the latent "spatial ability" factor and/or loading on an additional factor, potentially suggesting specificity;
5. High reliability — having sufficiently high (.8) internal consistency;
6. High external validity — having common variance with non-verbal intelligence and educational achievement measures.

To check for floor and ceiling effects, we examined descriptive statistics, the shapes of distributions, and percentages of the highest and lowest values in each test. Distribution shapes also provided information on track differences. Differentiating power was further assessed with a series of ANOVAs. Factor structure was investigated by Principal Component Analysis (PCA). We also explored intercorrelations among all spatial measures to identify redundant tests indicated by strong bivariate correlations. Internal consistency was measured by the split-half reliability test, which randomly divides the test items into halves several times and compares the correlations between the two halves. External validity was assessed by correlating SA test scores with measures of non-verbal intelligence and academic achievement in Math and the Russian language.

Outliers were not deleted from the dataset, as we expect a significant proportion of children in this sample to demonstrate high performance in SA. For example, some studies showed that adolescents selected for math ability score higher than the third quartile of distribution in SA tests (see Benbow 1992; Lubinski & Dawis, 1992 for discussion), which is usually recognized as a threshold for outliers (Tukey, 1977). Similarly, some participants from non-academic tracks might show particularly low scores since they were not selected for the program based on academic achievement, or due to their investment of effort in sport or music training. For this reason, low outliers were also kept in the data set. The percentage of outliers ranged from 0.5 to 8.6% of the sample. Data on the number of outliers are presented in *Table S10*. (See Supplemental Materials)

Most of the analysis was done in SPSS 22.0. R 3.1 was used to clean the data, to calculate split-half reliability analysis and to draw correlation heatmaps.

Results

Data Analysis

The main purpose of the current study was to identify the most suitable spatial ability tests for creation of a short online battery for educational assessment and talent identification. Specifically, we examined six test characteristics as described in the method section. Descriptive statistics for the whole sample and for different tracks separately are presented in *Tables 2* and *3*. *Figure S1* (See Supplemental Materials) presents distributions for all tests for each track. The numbers differed for different measurements: for spatial ability measurements, the missing data ranged from 52 to 264, as some participants did not complete the whole battery; for Year grades, the missing data ranged from 359 to 402, as these participants did not report their grades. In addition, as explained above, the data for Exams was available only for the older subsample which had completed the Exam. In most analyses reported in this paper, we used the data for the maximum number of participants which was available for each measure.

Table 2

Descriptive statistics for the whole sample: number of correct responses in spatial ability measures, exam and year grades, and non-verbal intelligence

Test (number of items)	N	Mean (SD)	Min	Max	Skewness
Cross-sections (15)	1418	6.11 (4.16)	0	15	0.026
2D drawing (5)	1356	3.38 (1.45)	0	5	–0.912
Pattern assembly (15)	1414	6.00 (3.31)	0	14	–0.125
Elithorn mazes (10)	1206	7.77 (1.68)	0	10	–1.239
Mechanical reasoning (16)	1412	9.80 (2.92)	2	16	–0.137
Paper folding (15)	1404	8.06 (4.71)	0	15	–0.226
3D drawing (7)	1351	2.50 (2.03)	0	6.9	0.340
Shape rotation (15)	1373	7.30 (4.42)	0	15	–0.077
Perspective–taking (15)	1360	4.24 (4.28)	0	15	0.819
Mazes (10)	1357	5.31 (2.20)	0	10	–0.486
KC total (123)	1356	60.62 (23.65)	11.5	111.6	0.080
Exam Math (2-5)	306^	4.79 (0.53)	3	5	–2.29
Exam Rus (2-5)	306^	4.83 (0.49)	3	5	–2.56
Year grade Math (2-5)	1068	1.00 (0.72)	3	5	–0.63
Year grade Rus (2-5)	1111	4.44 (0.63)	3	5	–1.01
Raven's score (21)	1327	0.74 (0.17)*	0.05	1	–0.9

*Note. Total = total score for King's Challenge battery; the number of items in each test is presented in brackets; * Raven's score is calculated by dividing the number of correct answers by the total number of items; ^ The N for Exam was low because most of the study participants had not reached the age when this Exam is taken.*

Table 3

Descriptive statistics for all Tracks: spatial ability, exam performance, and non-verbal intelligence

Test (number of items)	Science				Art				Sport			
	N	Mean (SD)	Min	Max	N	Mean (SD)	Min	Max	N	Mean (SD)	Min	Max
Cross-sections (15)	547	8.61 (3.57)	0	15	248	5.62 (3.77)	0	14	275	2.88 (2.76)	0	11
2D drawing (5)	529	4.22 (.86)	0	5	243	3.57 (1.08)	0	5	270	2.05 (1.43)	0	4.9
Pattern assembly (15)	546	7.85 (2.75)	0	14	248	5.52 (2.99)	0	12	274	3.71 (2.66)	0	10
Elithorn mazes (10)	488	8.34 (1.51)	0	10	238	7.40 (1.56)	1	10	234	7.05 (1.85)	0	10
Mechanical reasoning (16)	546	11.43 (2.53)	4	16	246	9.06 (2.36)	4	15	274	7.86 (2.42)	2	14
Paper folding (15)	545	11.11 (3.49)	1	15	239	7.43 (4.20)	0	15	274	4.03 (3.33)	0	13
3D drawing (7)	521	3.78 (1.81)	0	6.91	229	2.45 (1.62)	0	6.77	270	.78 (1.07)	0	5.1
Shape rotation (15)	532	9.99 (3.70)	0	15	226	6.61 (3.78)	0	15	269	4.34 (3.52)	0	14
Perspective–taking (15)	527	6.17 (4.63)	0	15	220	3.34 (3.44)	0	14	268	2.32 (3.09)	0	14
Mazes (10)	526	6.28 (1.90)	0	10	218	5.06 (1.94)	0	9	268	4.17 (2.27)	0	9
KC total (123)	526	78.2 (18.2)	18.2	111.6	218	56.1 (16.9)	19.7	103.1	267	39.1 (14.6)	11.5	87.5
Exam Math (2–5)	203	4.93 (.43)	4	5	93	4.57 (.60)	3	5	10	3.90 (.32)	3	4
Exam Rus (2–5)	203	4.86 (.50)	3	5	93	4.80 (.46)	3	5	10	4.50 (.53)	4	5
Year grade Math (2–5)	537	4.79 (.50)	3	5	249	4.45 (.78)	3	5	282	3.95 (.71)	3	5
Year grade Rus (2–5)	554	4.58 (.59)	3	5	254	4.65 (.51)	3	5	303	4.02 (.58)	3	5
Raven's score (21)	504	.83 (.12)*	.14	1	220	.73 (.15)*	.24	1	259	.60 (.18)*	.05	1

*Note. The number of items (possible range) is shown in brackets next to each test name with the name of the subtest. KC Total = total score for King's Challenge battery; the number of items in each test is pre-sented in the brackets; * Raven's score is calculated by dividing the number of correct answers by the total number of items; ^Total score for 2D and 3D drawing tasks had decimals as a score for an individ-ual trial in both tests ranged from 0 to 1, reflecting the number of correct lines drawn in the time given for this trial.*

Absence of floor and ceiling effects. Mechanical reasoning and Mazes demonstrated normal distribution, both across and within tracks. For Shape rotation, Paper folding, and Pattern assembly, the scores were negatively skewed for the Science track and positively skewed for the Sports tracks. Shape rotation, Paper folding, and Cross-sections tests demonstrated bimodal distributions for the whole sample. The ceiling effect for the whole sample was observed for the 2D-drawing and Elithorn mazes tests: in the 2D-drawing test, 43% of participants had scores of 4 or 5 (out of 5); in the Elithorn mazes test, 53% of participants had scores from 8 to 10 (out of 10). The floor effect was present in 3D-drawing and Perspective-taking tests: for the 3D-drawing test, 46.9% of participants had scores of 2 or lower (out of 7), and for Perspective-taking test, 54% of participants had scores of 3 or lower (out of 15).

For further investigation of the floor and ceiling effects, we estimated the difficulty of each test by calculating the percentages of correct responses (see *Table S1*). For the whole sample, the Elithorn mazes and 2D-drawing were the easiest tests in the battery (77.7% and 68% of responses correct, respectively), whereas Perspective-taking was the most difficult one (28.2% responses correct).

Differentiating power. We used ANOVA to examine potential differences among the Science, Arts, and Sports tracks. As described in the Method section, gender distribution across tracks was uneven. Previous studies that employed the same SA battery showed moderate gender differences in a British sample of young adults (Toivainen et al, 2018) and samples of Russian (Esipenko et al., 2018) and Chinese students (Likhanov et al., 2018). We examined gender effects in 11 one-way ANOVAs (10 tests and the total score) that showed male advantage for three tests, as well as a total SA score, and female advantage for two tests. All effects were negligible to modest (between .004 and .05; See *Table S2* for details). Gender was regressed out in all further analyses.

Thereafter, these standardized residuals were used in one-way ANOVAs to compare educational tracks (Science, Arts, and Sports). Homogeneity of variance was assessed by the Levene's test (Levene, 1960). Welch's ANOVA was used to account for the heterogeneity of variance in some tests (Field, 2013). Variance heterogeneity among tracks was found for all tests ($p \leq 0.01$), with the exception of Mechanical reasoning ($p = 0.25$) and Shape rotation ($p = 0.13$).

Overall, the ANOVAs showed significant average differences across the three tracks in every spatial measure and the total score, with effect sizes (η^2) ranging from .13 to .65. The results of Welch's F-tests, p-values, and η^2 are presented in *Table S3*. Due to non-normal distribution within tracks in all tests, with the exception of Mechanical reasoning and Mazes, we conducted non-parametric tests to confirm the results of the ANOVA. The Kruskal-Wallis H test confirmed significant differences between tracks in all spatial tests and total scores (χ^2 (3, N = 1070) = [133.1 – 423.5]; $p < .01$). Means for all SA tests according to track are presented in *Figure 1*. Post-hoc analyses showed that each track significantly differed from each other track in each test ($p < .05$ for all comparisons). The science track had the highest scores and the Sports track had the lowest.

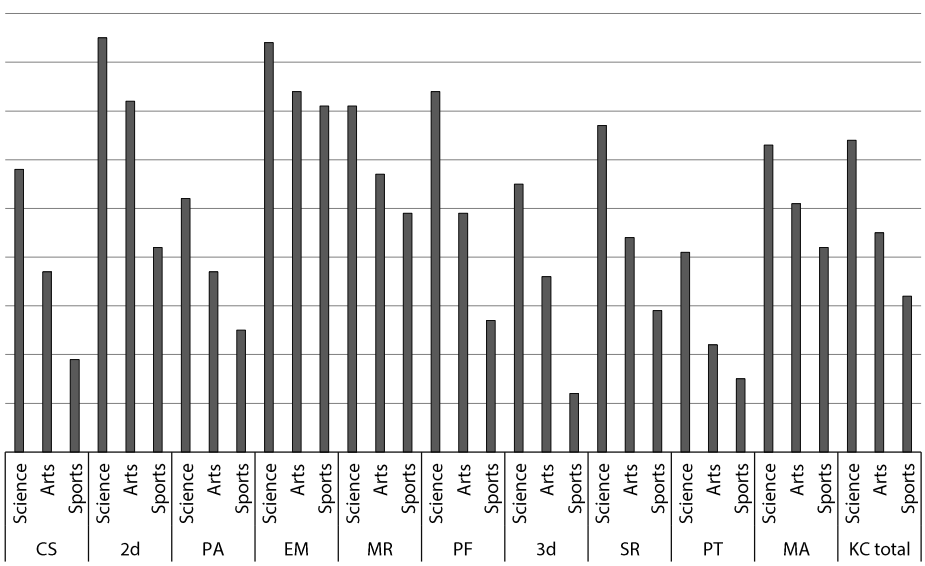

Figure 1. Percent of correct scores for each test across the three tracks.

CS = Cross-sections; 2D = 2D-drawing; PA = Pattern assembly; EM = Elithorn mazes; MR = Mechanical reasoning; PF = Paper folding; 3D = 3D-drawing; SR = Shape rotation; PT = Perspective-taking; MA = Mazes; KC Total = total score for King's Challenge battery.

Significant differences across the tracks were also found for non-verbal intelligence ($F(2, 980) = 19.42$; $p < .01$; $\eta^2 = .31$), with means of .83 (SD = .12), .73 (SD = .15), and .60 (SD = .18) for the Science, Arts, and Sports tracks, respectively.

Table 4

Correlational matrix for the whole sample (N = 1150-1412; p<0.05 for all correlations)

	1	2	3	4	5	6	7	8	9	10	KC total
1. CS	1	.582**	.506**	.339**	.535**	.617**	.630**	.527**	.431**	.384**	.768**
2. 2d	.582**	1	.579**	.390**	.584**	.672**	.673**	.580**	.476**	.474**	.779**
3. PA	.506**	.579**	1	.358**	.523**	.597**	.600**	.551**	.405**	.415**	.746**
4. EM	.339**	.390**	.358**	1	.453**	.389**	.428**	.392**	.340**	.368**	.552**
5. MR	.535**	.584**	.523**	.453**	1	.609**	.591**	.547**	.505**	.466**	.774**
6. PF	.617**	.672**	.597**	.389**	.609**	1	.712**	.623**	.459**	.497**	.848**
7. 3d	.630**	.673**	.600**	.428**	.591**	.712**	1	.652**	.529**	.531**	.838**
8. SR	.527**	.580**	.551**	.392**	.547**	.623**	.652**	1	.462**	.492**	.799**
9. PT	.431**	.476**	.405**	.340**	.505**	.459**	.529**	.462**	1	.382**	.689**
10. MA	.384**	.474**	.415**	.368**	.466**	.497**	.531**	.492**	.382**	1	.638**
KC total	.768**	.779**	.746**	.552**	.774**	.848**	.838**	.799**	.689**	.638**	1

CS = Cross-sections; 2D = 2D-drawing; PA = Pattern assembly; EM = Elithorn mazes; MR = Mechanical reasoning; PF = Paper folding; 3D = 3D-drawing; SR = Shape rotation; PT = Perspective-taking; MA = Mazes; KC Total = total score for King's Challenge battery.

Low Redundancy. All pairwise correlations were significant and positive, ranging from r = .34 to r = .85 (*Tables S4* for within-track correlations). The data showed the highest correlations for the 3D-drawing, 2D-drawing, and Paper folding tests (>.67), which suggests that having all of them in one battery is unnecessary. Elithorn mazes and Mazes tests showed the lowest correlations with other spatial ability tests within the Arts track and the whole sample.

Specificity. We performed Principal Component Analysis (PCA) on the raw data (sum of the correct responses for each spatial test) for the whole sample and individual tracks. To ensure that the data was suitable for factor analysis, we applied the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett's test of sphericity for both the whole sample and each track separately (see *Table S5*). The results indicated that the data was suitable for factor analysis (Hair et al., 1998).

Table 5

Factor analysis results: component matrices for the whole sample and each track separately

Test	Whole sample N=1086	Science N=443	Arts N=203		Sports N=223
	Component	Component	Component		Component
	1	1	1	2	1
Cross-sections	0.75	0.64	0.71		0.4
2D drawing	0.81	0.67	0.71		0.77
Pattern assembly	0.74	0.63	0.71		0.5
Elithorn mazes	0.58	0.56		0.53	0.55
Mechanical reasoning	0.79	0.69	0.62		0.7
Paper folding	0.84	0.76	0.69		0.64
3D drawing	0.85	0.79	0.67		0.74
Shape rotation	0.79	0.69	0.65		0.6
Perspective-taking	0.66	0.66	0.51		0.57
Mazes	0.66	0.62		0.85	0.67
Eigenvalues	5.65	4.58	3.96	1.07	3.87
% of variance explained	56.48	45.76	39.68	10.79	45.76

For the whole sample, the PCA scree plot (see *Figure S2*) and the eigenvalues suggested single factor extraction (explaining 56.48% of variance; see *Table 5*). All tests showed high loadings on this factor (.58 – .85). For the Science and Sports tracks, the factor structure was also unifactorial: a single factor explained 45.76% and 38.74% of variance, respectively. For the Arts track, two factors explained 50.41% of variance: factor 1 = 39.68%; and factor 2 = 10.79%. Factor 1 included all tests except the Elithorn mazes and Mazes, which formed factor 2. These findings indicate that one test from a battery would be able to assess the underlying spatial ability factor to

some degree. Factor loadings and eigenvalues for the whole sample and each track separately are shown in *Table 5*.

Reliability. Split-half reliabilities for the whole sample and separate tracks are shown in *Table S6*. Split-half reliability varied from weak to strong across the tests in the whole sample (r = .27 – .95). High reliabilities (> .8) were shown for Cross-sections, 2D drawing, Pattern assembly, Paper folding, 3D drawing, Shape rotation, and Perspective-taking. Moderate reliabilities were shown (>.65) for Mechanical reasoning and Mazes. Low reliability (.27) was shown for Elithorn mazes. The pattern of reliability was similar for all tracks.

External validity. *Table 6* presents the correlations between the spatial ability tests, Raven's progressive matrices, and academic achievement for the full sample (see *Tables S7 — S9* for correlations within tracks).

Table 6

Correlations for spatial measures with non-verbal intelligence, and Year grades (whole sample)

Test	Nonverbal intelligence N=1327	Year grade Maths N = 907–1013	Year grade Rus N = 957–1166	Fisher's Z Maths vs. Rus
Cross-sections	.49**	.38**	.21**	4.32**
2D drawing	.62**	.44**	.30**	4.19**
Pattern assembly	.51**	.38**	.22**	4.05 **
Elithorn mazes	.40**	.24**	.16**	1.78
Mechanical reasoning	.53**	.37**	.16**	4.7**
Paper folding	.59**	.44**	.30**	4.62**
3D drawing	.59**	.44**	.28**	4.47**
Shape rotation	.53**	.35**	.22**	4.49**
Perspective-taking	.38**	.27**	.12**	3.9**
Mazes	.47**	.33**	.20**	3.42**
KC total	.68**	.49**	.29**	5.88**

Note. $p \le 0.05$. ** $p \le 0.001$. Fisher's Z refers to the comparison between correlations of spatial scores with Math vs. Russian grades.*

All tests showed significant positive weak to strong correlations with non-verbal intelligence: $r\,(1325) = [.38 – .62]$, $p \le .01$ for the whole sample and within tracks.

For the whole sample, SA was correlated with the Year grades for both Mathematics ($r(1056) = [.24 – .49]$, $p \le .01$), and the Russian language, ($r\,(1107) = [.12 – .30]$, $p \le .01$.) Fisher's r-z transformation showed that correlations were higher for Math than for Russian ($z = [3.9 – 5.88]$, $p \le .01$), with the exception of Elithorn mazes.

The pattern of correlations between the students' Year grades and SA tests was slightly different within tracks (see *Table S10*). On the Science track, there were significant weak to moderate correlations between SA tests and Year grade for Mathematics ($r(547) = [.12 – .30]$, $p \leq .01$), but no correlations between spatial tests and the Year grade for the Russian language. On the Arts and Sports tracks, there were consistent significant correlations between the Year grades in Math and SA, and some between Year grades in Russian and SA (Fisher's Z was non-significant).

Tables S10 and *S11* present the results for correlations between SA and the Exam. In the whole sample, the Math Exam showed weak to moderate correlations with SA ($r(304) = [.20 – .34]$, $p \leq .05$); the Russian Exam was only weakly correlated with SA ($r(304) = [.12 – .16]$, $p \leq .05$). Within tracks, only a few correlations between SA and Exam reached significance.

Tests selected for inclusion in the Online Short Spatial Ability Battery (OSSAB). Four of the tests matched the criteria for selection, including the predicted pattern of moderate correlations with nonverbal intelligence and mathematics achievement (*e.g.*, Tosto et al., 2014). Below we describe the selected tests:

1. *Paper Folding* is a widely used measure of spatial visualization (Carrol, 1993), which has previously been recommended for talent identification (Hegarty & Waller, 2005; Linn & Petersen, 1985; Uttal et al., 2012). In the present study, *Paper Folding* appeared very similar to 2D and 3D drawing tests in correlational patterns, discriminant validity, factor loadings, and reliability. However, 2D and 3D drawing tests were excluded, as they showed either ceiling or floor effects;
2. *Shape Rotation* taps into a different dimension of spatial ability — mental rotation (Shepard & Metzler, 1971). This parameter was selected as it matched all established criteria, including high reliability and different distributions for the different tracks;
3. *Mechanical Reasoning* taps into a construct of Mechanical Aptitude — the ability to understand and apply mechanical concepts and principles to solve problems (Wiesen, 2015); it is recognized as important in educational tracking and career planning (Muchinsky, 1993). We selected the *Mechanical Reasoning* test, which showed better results than Cross-sections and Elithorn mazes in terms of normally distributed scores for all three tracks, as well as significant track differences;
4. *Pattern assembly* measures spatial relations — another important aspect of spatial ability (Carrol, 1993). This test showed the same pattern of distribution across tracks (along with Shape Rotation and Paper Folding), as well as high reliability, high factor loadings, and good correlations with other tests. By contrast, Mazes had low correlations with other tests and low discriminant validity; and Perspective-taking had high reliability, factor loadings, and correlations with other tests, but showed a strong floor effect.

Discussion

The purpose of the present study was to investigate the psychometric properties and factor structure of 10 spatial ability tests in order to create a short battery suitable for educational assessment and talent search. We collected data using an existing extensive spatial ability battery (King's Challenge; Rimfeld et al., 2017) in a sample of schoolchildren who had demonstrated high achievement in Science, Arts, or Sports. Based on our analysis, four tests were identified to be included into an Online Short Spatial Ability Battery "OSSAB." The following four best-performing tests were selected: Paper Folding, Shape Rotation, Mechanical Reasoning, and Pattern Assembly. All selected tests are available at https://github.com/fmhoeger/OSSAB.

We analyzed our data to demonstrate the utility of the OSSAB for educational purposes. In particular, we ran the analysis by splitting the sample into three educational tracks (Science, Arts, and Sports). The analysis showed significant differences between tracks, with η^2 ranging from .32 to .67. For example, the Science track showed the highest results in all four tests. We also compared the results of the Science track with previous results and found higher average performance in the Science track than that of unselected university students from China and Russia (Esipenko et al., 2018; Likhanov et al., 2018) and of an unselected population of young adults from UK (Rimfeld et al., 2017). Our result was also consistent with repeatedly found correlations between math and spatial ability (.43; Tosto et al., 2014), and between intelligence and academic achievement (.60 - .96; Bouchard & Fox, 1984; Deary, Strand, Smith, & Fernandes, 2007; Kemp, 1955; Wiseman, Meade, & Parks, 1966). Considering that SA was not part of the admission criteria for the Science track, the results suggest that SA might be a useful marker for high STEM performance.

These results provide further support for adding SA tests to verbal and math tests in order to establish patterns of strengths and weaknesses that can be predictive of future achievement in different domains (Shea, Lubinski, & Benbow, 2001; Webb, Lubinski, & Benbow, 2007). Moreover, talent search programs that focus mostly on verbal and math ability may overlook people with high SA only, which may lead to disengagement and behavioral problems in these young people (Lakin & Wai, 2020). These individuals will benefit from early identification of their high SA, and from personalized educational programs that capitalize on their strengths, including such activities as electronics, robotics, and mechanics.

For the Sports track, a positive skew was shown in Shape rotation, Paper folding, and Pattern assembly. It is possible that the relatively low performance of the Sports track on SA and other cognitive and academic achievement measurements is the result of these students' extreme investment of effort in sports training (see Likhanov, 2021, in preparation; for discussion). It is also common for athletes to disengage from traditional academic studies (Adler & Adler, 1985) and fall behind academically (*e.g.,* due to attending training camps). SA training that involves more enjoyable activities — for example, using computer games and VR or AR (augmented reality) (Uttal et al., 2014, Papakostas et al., 2021) — might be beneficial for their academic performance.

It is also possible that the battery used in this study did not tap into the ability of athletes to process visuo-spatial information in a natural environment, such as attentional processes or long-term working memory, which was shown in some studies to be highly developed in professional athletes, including hockey players (Belling et al 2015; Mann et al, 2007; Voss et al., 2010). The tests in this study measured mostly small-scale SA, *i.e.,* the ability to mentally represent and transform two- and three-dimensional images that can typically be apprehended from a single vantage point (Likhanov et al., 2018; Wang and Carr, 2014). Further research is needed that includes both small- and large-scale spatial ability tests.

For the Arts track, the average performance fell somewhere in between the Science and Sports tracks. This track is heterogeneous, but the sample size was not large enough to investigate spatial ability in separate sub-tracks (*e.g.,* fine arts vs. music). Therefore, in this study, the Arts track can be considered unselected in terms of academic achievement.

Cross-track differences also emerged in the structure of SA. Results from the factor analysis for the whole sample on the Science and Sports tracks replicated the previous findings of the unifactorial structure of the spatial ability (Esipenko et al., 2018; Likhanov et al., 2018; Rimfeld et al., 2017). However, for the Arts track, a two-factorial structure emerged (Elithorn mazes and Mazes tests formed the second factor).

A number of speculative explanations for this can be proposed. The Arts track included high achievers in music (20%), literature (40%), and fine art (30%). The second factor may reflect an advanced ability of the fine art students to process visual information in two-dimensional space, as these two tests are hypothesized to measure an ability for 2D image scanning (Poltrock, & Brown, 1984). Alternatively, a number of methodological issues may also have led to the second factor on the Arts track. The two tests showed lower correlations with other spatial ability measures (lower than .26) for the Arts track, which could have stemmed from the smaller sample size for this track (though sufficient, *e.g.*, according to Comrey and Lee, 1992) and lower reliability of the two tests.

Conclusion

The *Online Short Spatial Ability Battery (OSSAB)* can be used for talent identification, educational assessment, and support. Future research is needed to evaluate the use of this battery with other specific samples and unselected populations.

Limitations

Our study had a number of limitations. Firstly, sample sizes differed among sex and track groups, precluding fine-grained investigation of these effects. Secondly, the study had only limited access to students' academic achievement: the majority of the sample had not yet taken the state exam; and the Year grades only provided a very crude estimate of achievement as they range from 2 to 5, with 2 absent from this sample. Thirdly, as mentioned above, large-scale spatial ability was not measured in the current study. Further research is needed to evaluate the relative strengths and weak-

nesses in small- and large-scale spatial abilities for different tracks. Fourthly, there were some differences in reliability across measures. Moreover, some tests could be more enjoyable. Future research needs to explore whether and how enjoyment may be related to the test validity.

Ethics Statement

Our study was approved by the Ethics Committee for Interdisciplinary Research of Tomsk State University, approval № 16012018-5.

Informed Consent from the Participants' Legal Guardians

Written informed consent to participate in this study was provided by the participant's parents, legal guardian, or next of kin. And also an oral consent of the minor was provided at the moment of the testing.

Author Contributions

A.B. and M.L. planned the study and data collection. M.L. significantly contributed to the text of the manuscript. A.B., A.Z. and E.S. did the data collection and wrote the first draft. E.B did the statistical analysis. T.T. made a contribution to the text of the paper. Y.K. conceived of the idea and supervised work on the study and reviewed the paper. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Appendix

Table S1

Proportion (%) of correct responses for King's Challenge tests.

Test	Whole sample	Science	Arts	Sports
	Mean* (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Cross-sections	40.77 (27.72)	57.37 (23.77)	37.45 (25.15)	19.22 (18.38)
2D drawing	68.04 (28.65)	84.68 (17.03)	71.66 (21.50)	41.34 (28.55)
Pattern assembly	39.97 (22.09)	52.32 (18.35)	36.77 (19.94)	24.74 (17.72)
Elithorn mazes	77.72 (16.69)	83.64 (14.61)	73.92 (15.60)	71.20 (18.11)
Mechanical reasoning	61.38 (18.07)	71.45 (15.83)	56.61 (14.74)	49.13 (15.11)
Paperfolding	53.71 (31.38)	74.09 (23.30)	49.54 (28.03)	26.86 (22.20)
3D drawing	36.62 (29.00)	54.35 (25.75)	35.33 (23.21)	11.76 (15.86)
Shape rotation	48.64 (29.46)	66.58 (24.67)	44.04 (25.20)	28.95 (23.47)
Perspective - taking	28.25 (28.56)	41.15 (30.86)	22.27 (22.96)	15.45 (20.62)
Mazes	53.14 (21.97)	62.78 (19.02)	50.64 (19.40)	41.68 (22.75)
KC Total	49.26 (19.23)	63.56 (14.80)	45.59 (13.74)	31.80 (11.87)

*Note: *Proportion (%) of correct responses; the tests represent tests from King's Challenge battery (Rimfeld et al., 2017); KC Total = total scoresfor King's Challenge battery.*

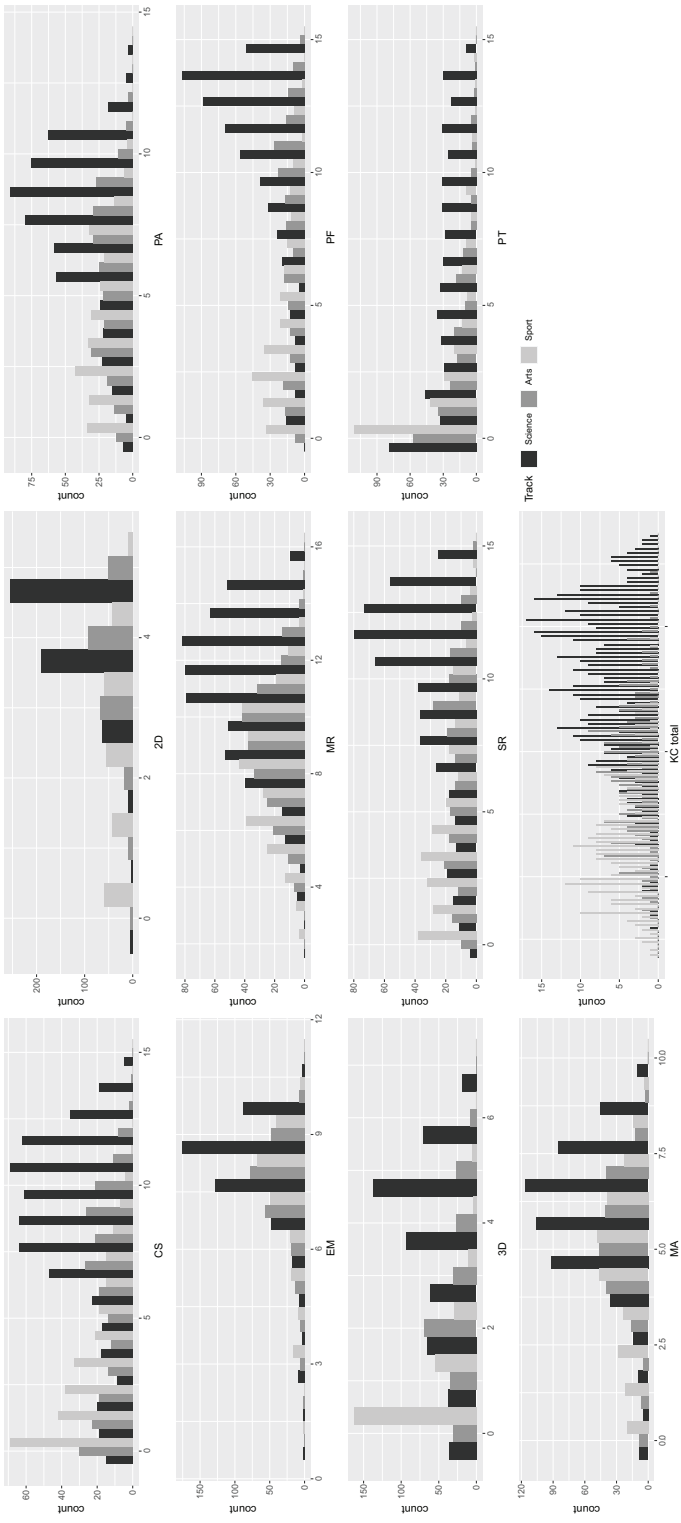

Figure S1. Distribution plots for three tracks: Science, Art, Sport.
Note: CS = Cross-sections; 2D = 2D-drawing; PA = Pattern assembly; EM = Elithorn mazes; MR = Mechanical reasoning; PF = Paper folding; 3D = 3D-drawing; SR = Shape rotation; PT = Perspective-taking; MA = Mazes; KC Total = total score for King's Challenge battery.

Table S2

ANOVA for sex within track and the whole sample for all SA subtests

Test (number of items)	Sex	Whole sample					Science track					Arts track					Sports track				
		N	M	(SD)	F	η^2	N	M	(SD)	F	η^2	N	M	(SD)	F	η^2	N	M	(SD)	F	η^2
Cross-sections (15)	male	609	6.45	(4.37)	10.6	ns	339	8.99	(3.52)	10.6**	0.02	50	5.32	(3.68)	0.39	ns	220	2.8	(2.67)	0.91	ns
	female	461	6.43	(3.94)			208	7.98	(3.55)			198	5.69	(3.8)			55	3.2	(3.09)		
2D drawing (5)	male	592	3.4	(1.57)	12.19**	0.01	327	4.32	(0.82)	12.2**	0.02	49	3.53	(1.3)	0.07	ns	216	1.96	(1.42)	4.36**	0.02
	female	450	3.65	(1.14)			202	4.06	(0.9)			194	3.57	(1.01)			54	2.41	(1.41)		
Pattern assembly (15)	male	607	6.34	(3.48)	20	ns	338	8.25	(2.68)	20**	0.04	50	5.04	(3.16)	1.59	ns	219	3.67	(2.68)	0.25	ns
	female	461	6.13	(3.02)			208	7.19	(2.75)			198	5.64	(2.94)			55	3.87	(2.58)		
Elithorn mazes (10)	male	534	7.97	(1.8)	27.59**	0.01	299	8.62	(1.47)	27.6**	0.05	50	7.55	(1.38)	0.57	ns	185	7.04	(1.93)	0.01	ns
	female	426	7.56	(1.57)			189	7.9	(1.47)			188	7.36	(1.6)			49	7.06	(1.54)		
Mechanical reasoning(16)	male	607	10.4	(3.16)	99.57**	0.03	338	12.2	(2.29)	99.6**	0.16	50	8.94	(2.73)	0.15	ns	219	7.86	(2.43)	0.02	ns
	female	459	9.43	(2.46)			208	10.2	(2.4)			196	9.09	(2.26)			55	7.85	(2.38)		
Paper folding (15)	male	607	8.18	(5.07)	7.05**	0.01	338	11.4	(3.49)	7.05**	0.01	50	5.98	(4.45)	7.74**	0.03	219	3.67	(3.21)	13.5**	0.05
	female	451	8.81	(4.13)			207	10.6	(3.45)			189	7.81	(4.06)			55	5.47	(3.45)		
3D drawing (7)	male	589	2.65	(2.24)	18.9	ns	324	4.04	(1.86)	18.9**	0.04	48	2.01	(1.67)	4.52**	0.02	217	0.71	(1.05)	5.31**	0.02
	female	431	2.74	(1.73)			197	3.34	(1.66)			181	2.56	(1.59)			53	1.09	(1.11)		
Shape rotation (15)	male	602	7.94	(4.64)	18.9	ns	335	10.5	(3.62)	18.9**	0.04	49	6.27	(3.68)	0.51	ns	218	4.36	(3.56)	0.04	ns
	female	425	7.52	(4.04)			197	9.09	(3.67)			177	6.7	(3.81)			51	4.25	(3.38)		
Perspective – taking (15)	male	598	5.37	(4.72)	82.94**	0.05	332	7.48	(4.63)	82.9**	0.14	49	3.8	(3.49)	1.1	ns	217	2.5	(3.22)	3.93**	0.02
	female	417	3.35	(3.52)			195	3.94	(3.69)			171	3.21	(3.43)			51	1.55	(2.38)		
Mazes (10)	male	596	5.47	(2.33)	9.41	ns	331	6.47	(1.83)	9.41**	0.02	48	4.9	(1.99)	0.46	ns	217	4.06	(2.32)	2.59	ns
	female	416	5.44	(2.02)			195	5.95	(1.97)			170	5.11	(1.93)			51	4.63	(2.05)		
KC total (123)	male	595	64.4	(26.7)	57.68**	0.00	331	82.6	(17.7)	57.7**	0.1	48	53.8	(18.2)	1.1	ns	216	38.8	(14.6)	0.79	ns
	female	416	61.3	(19.1)			195	70.7	(16.5)			170	56.7	(16.5)			51	40.8	(14.5)		

*Note: ** — $p \leq 0.001$; KC Total = total score for King's Challenge battery, ns — nonsignificant*

Table S3

ANOVA for the three Tracks

Test	Track	N	M (SD)	Levene's test p-value	F	η^2
Cross-sections	Science	547	8.61 (3.56)	.00	322.96**	0.495
	Arts	248	5.62 (3.77)			
	Sports	275	2.88 (2.75)			
2D drawing	Science	529	4.22 (.86)	.00	265.17**	0.648
	Arts	243	3.57 (1.08)			
	Sports	270	2.05 (1.43)			
Pattern assembly	Science	546	7.85 (2.75)	.00	227.03**	0.402
	Arts	248	5.52 (2.99)			
	Sports	274	3.71 (2.65)			
Elithorn mazes	Science	488	8.34 (1.51)	.00	55.72**	0.128
	Arts	238	7.4 (1.55)			
	Sports	234	7.05 (1.85)			
Mechanical reasoning	Science	546	11.43(2.53)	.79	229.29**	0.413
	Arts	246	9.06 (2.35)			
	Sports	274	7.86 (2.41)			
Paper folding	Science	545	11.11(3.49)	.00	399.62**	0.671
	Arts	239	7.43 (4.20)			
	Sports	274	4.03 (3.33)			
3D drawing	Science	521	3.78 (1.81)	.00	424.10**	0.607
	Arts	229	2.45 (1.62)			
	Sports	270	0.78 (1.07)			
Shape rotation	Science	532	9.99 (3.7)	.00	229.45**	0.321
	Arts	226	6.61 (3.78)			
	Sports	269	4.34 (3.52)			
Perspective-taking	Science	527	6.17 (4.62)	.00	123.57**	0.448
	Arts	220	3.34 (3.44)			
	Sports	268	2.32 (3.09)			
Mazes	Science	526	6.28 (1.9)	.00	94.62**	0.203
	Arts	218	5.06 (1.94)			
	Sports	268	4.17 (2.27)			
KC total	Science	526	78.18(18.21)	.00	557.71**	0.492
	Arts	218	56.08 (16.9)			
	Sports	267	39.17(14.6)			

*Note: ** — $p \leq 0.001$; KC Total = total scores for King's Challenge battery. Sex is regressed out from all scores for this analysis.*

Table S4

Bivariate correlations for the three tracks

Science (N = 468 – 546)										
Test	1	2	3	4	5	6	7	8	9	10
1 Cross-sections										
2 2D drawing	.42**									
3 Pattern assembly	.35**	.38**								
4 Elithorn mazes	.27**	.31**	.27**							
5 Mechanical reasoning	.42**	.40**	.42**	.37**						
6 Paper folding	.48**	.50**	.43**	.33**	.47**					
7 3D drawing	.49**	.49**	.45**	.40**	.45**	.56**				
8 Shape rotation	.35**	.42**	.43**	.32**	.42**	.48**	.50**			
9 Perspective-taking	.33**	.40**	.31**	.33**	.44**	.38**	.48**	.39**		
10 Mazes	.26**	.31**	.33**	.30**	.35**	.39**	.47**	.41**	.32**	
11 KC total	.67**	.62**	.64**	.53**	.70**	.75**	.76**	.73**	.70**	.58**
Arts (N = 213 – 248)										
Test	1	2	3	4	5	6	7	8	9	10
1 Cross-sections										
2 2D drawing	.43**									
3 Pattern assembly	.33**	.47**								
4 Elithorn mazes	.15*	.16*	.22**							
5 Mechanical reasoning	.35**	.38**	.35**	.32**						
6 Paper folding	.40**	.41**	.44**	.18**	.50**					
73D drawing	.37**	.54**	.41**	.24**	.39**	.47**				
8 Shape rotation	.36**	.39**	.45**	.26**	.36**	.44**	.48**			
9 Perspective-taking	.22**	.25**	.30**	.16*	.24**	.29**	.29**	.34**		
10 Mazes	-.03	.16*	.11	.14*	.15*	.22**	.24**	.23**	.05	
11 KC total	.63**	.62**	.68**	.41**	.66**	.76**	.68**	.74**	.55**	.32**
Sports (N = 234 – 275)										
Test	1	2	3	4	5	6	7	8	9	10
1 Cross-sections										
2 2D drawing	.29**									
3 Pattern assembly	.20**	.33**								
4 Elithorn mazes	.24**	.32**	.25**							
5 Mechanical reasoning	.20*	.50**	.28**	.42**						
6 Paper folding	.25**	.44**	.29**	.28**	.34**					
7 3D drawing	.28**	.50**	.23**	.29**	.34**	.42**				
8 Shape rotation	.08	.35**	.17**	.28**	.28**	.32**	.46**			
9 Perspective-taking	.18**	.44**	.19**	.21**	.39**	.25**	.35**	.26**		
10 Mazes	.20**	.39**	.23**	.33**	.42**	.38**	.41**	.38**	.29**	
11 KC total	.47*	.70**	.52**	.55**	.67**	.68**	.66**	.61**	.59**	.65**

*Note: * — p≤0.05. ** — p≤0.001; KC Total = total score for King's Challenge battery.*

Table S5
Assumptions for factor analysis

Statistic	Whole sample	Science	Arts	Sports
KMO	.95	.93	.87	.91
Bartlett's Chi-Square	5665.6	1434.68	534.81	534.81

Note: Chi-Square p-value for all tracks was < .001

Table S6
Split-Half reliability for all spatial tests for the whole sample and tracks

Test	N of items	Full sample		Science track		Arts track	
		S-HR	(SD)	S-HR	(SD)	S-HR	(SD)
Cross-sections	15	.87**	(.04)	.81**	(.05)	.84**	(.06)
2D drawing	5	.88**	(.07)	.81**	(.06)	.78**	(.09)
Pattern assembly	15	.80**	(.04)	.68**	(.04)	.76**	(.05)
Elithornmazes	10	.27*	(.01)	.23*	(.01)	.04*	(.02)
Mechanical reasoning	16	.67**	(.03)	.61**	(.04)	.47**	(.04)
Paper folding	15	.91**	(.04)	.84**	(.04)	.87**	(.07)
3D drawing	7	.95**	(.11)	.92**	(.11)	.92**	(.13)
Shape rotation	15	.88**	(.04)	.82**	(.05)	.81**	(.05)
Perspective - taking	15	.90**	(.06)	.90**	(.07)	.85**	(.07)
Mazes	10	.70**	(.03)	.62**	(.03)	.60**	(.05)

*Note: * = p≤0.05. ** = p≤0.001; S-HR = split-half reliability, SD = standard deviation for split-half reliability.*

Table S7
Bivariate correlations between SA and Raven's within tracks

Test	Science N=482-503	Arts N=190-220	SportsN=222-259
Cross-sections	.33**	.26**	.22**
2D drawing	.36**	.38**	.52**
Pattern assembly	.37**	.32**	.30**
Elithorn mazes	.28**	.20**	.32**
Mechanical reasoning	.30**	.37**	.42**
Paper folding	.40**	.32**	.30**
3D drawing	.40**	.35**	.35**
Shape rotation	.38**	.31**	.33**
Perspective - taking	.17**	.28**	.30**
Mazes	.26**	.20**	.35**
KC total	.47**	.49**	.54**

Note: = p≤0.05. ** = p≤0.001; KC Total = total score for King's Challenge battery.*

Table S8

Bivariate correlation between SA and Year grades for Mathematics and Russian language within tracks

Test	Science (N=509–547)			Arts (N=213–248)			Sports (N=212–267)		
	Math	Russian language	Fisher's Z	Math	Russian language	Fisher's Z	Math	Russian language	Fisher's Z
Cross-sections	.15**	.05	ns	.18**	.04	ns	.10	–.07	ns
2D drawing	.10*	.03	ns	.26**	.12	ns	.24**	.09	ns
Pattern assembly	.18**	.03	ns	.15*	.14*	.29	.19**	.05	ns
Elithorn mazes	.15**	.04	ns	.03	.11	ns	.17*	.13*	ns
Mechanical reasoning	.12**	–.07	ns	.20**	.13*	.16	.20**	.08	ns
Paper folding	.15**	.05	ns	.21**	.16*	.48	.30**	.23**	1.24
3D drawing	.22**	.03	ns	.23**	.22**	.61	.20**	.17**	0.27
Shaperotation	.11*	–.02	ns	.07	.08	ns	.23**	.17**	1.01
Perspective - taking	.15**	.01	ns	.07	.01	ns	.11	.01	ns
Mazes	.14**	.02	ns	.12	.20**	–.22	.26**	.09	1.32
KC total	.22**	.02	ns	.25**	.19**	ns	.32**	.15*	ns

Note: = p≤0.05. ** = p≤0.001. NS = no Fisher's z analysis was conducted when correlation(s) was non-significant*

Table S9

Bivariate correlations between SA and Exam for Mathematics and Russian language

Test	Whole sample N = 296 – 304		Science N = 190 – 200		Arts N = 76 – 92		Sports N = 10	
	Exam Math	Exam Rus	Exam Math	Exam Rus	Exam Math	Exam Rus	Exam Math	Exam Rus
Cross-sections	.24**	.11	.09	.16*	.08	–.06	.23	–.25
2D drawing	.20**	.11	–.04	.05	.13	.12	.52	–.01
Pattern assembly	.25**	.12*	–.01	.02	.2	.2	.21	.01
Elithorn mazes	.23**	.14*	.10	.05	.18	.28**	.16	–.17
Mechanical reasoning	.21**	.10	.02	.01	.07	.14	.21	.13
Paperfolding	.29**	.09	.02	–.01	.24*	.13	–.21	–.07
3D drawing	.29**	.13*	.14	.09	.18	.14	.15	–.48
Shape rotation	.27**	.10	.03	.01	.22	.19	–.12	–.11
Perspective - taking	.24**	.11	.11	.08	.2	.15	.01	–.52
Mazes	.24**	.15**	.03	.02	.25*	.34**	.15	.28
KC total	.34**	.16**	.08	.07	.30**	.27*	.14	–.15

*Note: * — p≤0.05. ** — p≤0.001. Fisher's Z analysis showed no significant differences in SA correlations with Math vs. Russian Exam.*

Table S10

Outliers for three tracks for SA tests.

Test (number of items)	Science			Art			Sport		
	N	Number of outliers	Sample %	N	Number of outliers	Sample %	N	Number of outliers	Sample %
Cross-sections (15)	547	15	2.74	248	–	–	275	–	–
2D drawing (5)	529	18	3.40	243	8	3.29	270	–	–
Pattern assembly (15)	546	–	–	248	–	–	274	–	–
Elithorn mazes (10)	488	25	5.12	238	10	4.20	234	5	2.14
Mechanical reasoning (16)	546	8	1.47	246	–	–	274	–	–
Paper folding (15)	545	32	5.87	239	–	–	274	–	–
3D drawing (7)	521	–	–	229	–	–	270	21	7.78
Shape rotation (15)	532	4	0.75	226	–	–	269	–	–
Perspective – taking (15)	527	–	–	220	–	–	268	23	8.58
Mazes (10)	526	8	1.52	218	–	–	268	–	–
KC total (123)	526	3	0.57	218	1	0.46	267	2	0.75

Note: KC Total = total scoress for King's Challenge battery.

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Elements of Sensory-Emotional Experience as an Integral Part of Forming Visual Meanings: the Role of Conceptual Abilities

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Background. This article analyzes the relationship between sensory-emotional experience in the process of semantic description of vague visual figures, and the level of conceptual (categorical and generative) abilities.

Objective. The objective of our study was, first, to show the differences in the degree and features of activation of elements of sensory-emotional experience in the process of constructing the meanings of vague visual figures; and, second, to show the relationship of these differences with the level of categorical and generative abilities.

Design. We studied 102 older adolescents ages 15–16 years. The research program included the following methods: 1) "Description of vague figures" (E.Yu. Artemyeva's technique change, 1980; 1999); 2) "Generalization of three words" (Kholodnaya, 2012; Kholodnaya et al., 2019); and 3) "Conceptual synthesis" (Kholodnaya, 2012; Kholodnaya et al., 2019).

Results. Our results showed that generative abilities play the leading role in determining the degree of severity and diversity of different modalities in forming visual meanings, as compared with categorical abilities. The transition simulation hypothesis explains the results. However, the embodied character of mental modeling (simulation) is not determined "bottom-up" by the individual's bodily state or the activity of corresponding brain zones. On the contrary, conceptual (namely, generative) structures determine the form of the conceptual representations from the "top down."

Conclusion. Generative abilities represent the highest level of organization of personal conceptual experience, which acquires a multimodal quality, due to the integral nature of conceptual (generative) structures.

Keywords: conceptual abilities; categorical abilities; generative abilities; visual meanings; modality; sensory-emotional experience; generative structures; embodied simulation hypothesis

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Introduction

The idea of the higher verbal-logical (conceptual) forms of intellectual activity being based on sensorimotor and emotional experience has a long history. Thus, M.V. Sechenov put forward the idea that the interaction of visual ("visual crushing") and tactile-kinesthetic ("muscle feeling") impressions is not only the basis for the development of mental abilities in childhood, but that it also acts as a mechanism for adult conceptual thinking. "A thought constructed of symbols of any degree of generalization continues to represent a separate sensory group or sensory expression of the nervous process …" (Sechenov, 2001, p. 43). According to J. Piaget, the stage of formal thinking ("reflexive intelligence") has its roots in a child's sensorimotor experience, since mature intelligence has the quality of "incorporating" (integrating) all earlier forms of cognitive adaptations. That is why "… the roots of logical operations lie deeper than linguistic ties" (Piaget, 1969, p. 20).

L.M. Vekker emphasized the polymodal (intersensory) nature of thought. He noted that the manifestations of the polymodality of thinking grow to the point that they increase the degree of generalization by several levels in the process of conceptual thinking (Vekker, 1976). A series of empirical studies have supported this trend. In particular, the process of adult conceptual thinking manifests a variety of sensory-emotional impressions (visual, sound, tactile, and motor impressions with a pronounced emotional coloring), as well as varying degrees of generalization of visual images (Kholodnaya, 1974; Menshikova, 1975; Osorina, 1976).

F.E. Vasilyuk studied concepts using pictograms and concluded that "… any image, even the image associated with the abstract idea itself, is always embodied in sensitive material; it is always 'executed' by a whole ensemble of conscious and unconscious bodily movements and feelings" (Vasilyuk, 1993, p. 16). The reverse procedure — a verbal description of the meaning of vague visual figures — is associated with various "intermodal transitions." Thus, "semantic-perceptual universals" have their roots in the deep structures of subjective experience (Artemieva, 1980).

There is a trend in linguistics which asserts that perceptual and sensorimotor experience is the basis for language. This view began to take shape in the early 1990s. This line of research posits a relationship between the characteristics of a person's bodily organization and his direct interaction with his environment (*embodied cognition*, or *grounded cognition*) (Valera, Thompson, & Rosch, 1991; Barsalou, 2010; Barsalou et al., 2003; 2008; Lakoff & Johnson, 2004; Wilson & Golonka, 2013; and others). According to this approach, various aspects of sensory experience, including proprioception (*e.g.*, run, lift) and introspection (*e.g.,* hungry, happy) (Barsalou, 1999; Shallice, 1988) are the basis for high-level cognitive processes associated with the processing of verbal information. So "meaning structure" comes from "cognitive-emotional structures in a person's mind whereby he/she makes sense of the objects and events in his/her world" (Lundh, 1995, p. 363).

This trend characterizes itself as a new and independent one (as in "the embodiment revolution began," according to B.K. Bergen), in the absence of any references to similar, earlier psychological studies in this area.

Empirical data began to accumulate, confirming and expanding the idea that sensory-emotional experience not only plays a role in the assimilation and function-

ing of language, but also in the formation of the human's conceptual sphere. In particular, cognitive linguistics has obtained empirical evidence that the concept includes sensory-perceptual, conceptual, and value elements of human experience (Maslova, 2007; Karpinets, 2004; Mahon & Caramazza, 2008; Blinnikov, 2019; and others).

The results testify to the critical role of emotional experience, even in the formation of abstract concepts. "Whereas sensorimotor information plays a central role in learning, representing, and processing concrete concepts and words, emotional information plays a central role in learning, representing, and processing abstract concepts and words" (Kousta et al., 2011). According to our research, various elements of sensory-emotional experience (in terms of 35 indicators on a modified scale of "semantic differential") contribute to abstract concepts of a person (such as "resources" and "potential") (Volkova & Kholodnaya, 2018). Moreover, their severity affects intellectual activity in different ways. In particular, according to the results of regression analysis, the more signs of sensory-emotional experience in the composition of a person's concepts, the lower his indicators of analytical abilities (in terms of progressive Raven matrices) and the higher the indicators non-verbal creativity as measured by Torrance's Unfinished Images tests of creative thinking.

Gradually, the idea of "multimodal" conceptual knowledge emerged, suggesting that an individual's conceptual system participates in various modalities, such as audio, vision, touch, smell, and taste (Kibrik, 2010; Liutsko, 2013; Bruni et al., 2014; Beinborn, Botschen, & Gurevych, 2018). Experiments which visualize brain activity have reinforced this idea: the conceptual processing of information sequentially activates brain structures specific to different modalities. That is, the processes of formation and use of conceptual knowledge involve various modal systems associated with the sensory-emotional processing of information.

V. Evans formulated more subtle criteria for differences between semantic structures and conceptual structures (Evans, 2009; 2016). Conceptual structures were associated with the activation of modal systems (including sensorimotor, proprioceptive, interceptive, and affective experiences), while semantic structures functioned to offer the necessary "scaffolds" for conceptual structures.Thus, semantic structures are structures of a schematic type. By contrast, conceptual structures are structures with a wide contextual variety in the form of multimodal states.

Despite the significant differences between modern approaches to embodiment (Loginov & Spiridonov, 2017), they all focus on the idea that sensory-motor and emotional states constitute an individual's conceptual experience "from below."

Note that the study of elements of sensory-emotional experience as part of verbal meanings (concepts) inspired most of these studies. However, the representation of sensory-emotional experience in composing visual meanings is no less impressive, especially in the process of the semantic description of vague visual figures. Moreover, our interest was in how the degree and nature of sensory-emotional signs in the composition of visual meanings correlated with the level of formation of conceptual abilities.

In our earlier studies, the existence of different types of conceptual abilities was substantiated, including categorical and generative abilities (Kholodnaya, 2012). Categorical abilities are mental properties related to productivity of the categorization

processes and to ensuring that a person will assign the corresponding object to a certain class based on transformations in the system of categorical attributes with varying degrees of generalization. Generative abilities are mental properties related to the productivity of conceptualization processes. It is an opportunity to generate some new mental constructs that are not represented in real external circumstances and are absent in the person's acquired knowledge (*ibid*.).We set out to identify the different roles of categorical and conceptual abilities in enhancing sensory and emotional experience in the construction of visual meanings in this study.

Thus, the goal of this study is, first, to determine the differences in the degree and features of elements of sensory-emotional experience in the process of constructing the meaning of vague visual figures; and, second, to find the relationship of these differences with the level of formation of conceptual (categorical and generative) abilities.

Research hypothesis. Different elements of sensory-emotional experience, activated in the process of semantic description of vague visual figures, will be differently associated with categorical and generative abilities.

Methods

Participants

We studied 102 older adolescents ages 15-16 years.

Procedure

The research program included the following methods:

1) "*Description of vague visual figures,*" a modification of the E.Yu. Artemyeva method (Artemyeva, 1980; 1999).

Respondents performed two tasks when presented with vague visual figures. First, they had to answer the question: "What is it? What does this object look like?" (The respondent wrote down one or several answers). Then immediately, the respondent answered the following question: "What properties are inherent in this object, according to your impression?" (Respondents wrote down one sign or a list of signs). The following were the stimulus patterns (vague visual figures).

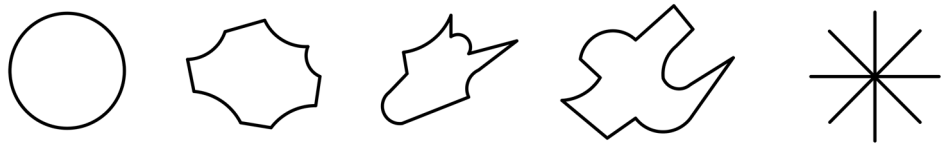

Figure 1. A set of vague visual figures

We identified the following indicators while assessing the respondents' visual meanings (first task):

1) the number of meanings;
2) the number of meanings of a geometric type (*circle, ball, polygon, geometric figure, or eight triangles*);

3) the number of meanings of a subject-descriptive type (visual meaning as a direct projection of the shape of the figure: *the sun, ball, carpet, maple leaf, mask, dog's head, cactus, hook, snowflake, or star*);
4) the number of meanings of a subject-contextual type (the meaning built on a broad, meaningful interpretation of the visual figures:*a black hole, a well, a piece of leather from a boot, a slice of cheese, a ghost, ancient weapons, a samurai, metro lines, or a schedule of functions*).

According to the instructions, the respondents, after listing the possible meanings of each figure, named a number of features by which, from their point of view, this figure can be described. The respondents named different signs that represent different modalities of experience. Based on the analysis of the protocols, we identified seven types of semantic signs which characterized different modalities of personal mental experience (second task):

I. Exteroceptive modality (distant and contact), including:
1. Visual signs (*colorful, bright, small, blue, huge, round, sparkles*, etc.);
2. Tactile signs (*elastic, cold, soft, rough, smooth, scratchy, wet, heavy, hard*, etc.);
3. Auditory signs (*loud, noisy, sounding, rattling*, etc.);
4. Taste signs (*bitter, sour*, etc.) and olfactory symptoms (*pleasant smell*, etc.) (These characteristics were found in the protocols in each case in our sample. Therefore, we did not take this type of signs into account when processing our data).

II. Proprioceptive modality:
5. Proprioceptive signs based on muscle sensations during movement, *i.e.*, changes in parts of one's body position (*running, racing, jumping, fast, tight, can explode, active, spin, fall,* etc.).

III. Apperceptive modality:
6. Apperceptive signs based on integration of sensory experience and the content of long-term semantic memory (*complex, untidy, fluid, rumpled, fragile, reliable, melts*, etc.).

IV. Emotional modality:
7. Emotionally evaluative signs (*kind, ugly, cheerful, sad, affectionate, gentle, intimidating, proud*, etc.).

Indicators: 1) the total number of semantic signs mentioned in the description of the five vague visual figures, as an indicator of the activation of sensory-emotional experience;

2) the number of each of the four types of semantic signs (Exteroceptive, Proprioceptive, Apperceptive, or Emotional-evaluative) as an indicator of the severity of the different modalities; and

3) the percentage ratio of the four types of semantic signs (Exteroceptive, Proprioceptive, Apperceptive, Emotional-evaluative) on the total number of the mentioned semantic features as an indicator of the degree of severity of different ways of semantic coding.

2) "*Generalization of three words*," a measure of categorical abilities (Kholodnaya, 2012; Kholodnaya et al., 2019).

Respondents searched for generic categories based on identifying a common essential trait between three complex concepts. We presented ten word triads, such as "*lighthouse, newspaper, bonfire*;" "*icon, map, decoration;*" "*gamma, beads, stairs*," etc.

Indicator: the sum of the scores for 10 triads of words as an indicator of categorical abilities. Evaluation criteria for each answer: 0 points - thematic generalization (theater, tourists, childhood, etc.); 1 point - analytical generalization (*built by a man, many details, can give light, long, etc.*) or formal generalizations without highlighting an essential feature (*labor, nature, decoration, artificial object, etc.*); 2 points - categorical generalization (*sources of information, structures, images, sequence, etc.*).

3) "*The conceptual synthesis*," a measure of generative abilities (Kholodnaya, 2012; Kholodnaya et al., 2019).

Respondents composed sentences combining three unrelated words based on generating their own context. We presented three word triads, such as "*shell, paper clip*, *thermometer*;" "*computer, tornado, pin*;" "*planet, hourglass, electrical outlet*."

Indicator: the sum of the scores for all completed sentences for the three triads of words as an indicator of conceptual ability. Evaluation criteria for each answer: 0 points — only two words out of three are connected, or a meaningless combination of words is formed; 1 point — the link is established on the basis of a simple listing of three words without specifying the links between them; 2 points — all three words are included in the description of a specific situation; 3 points — all three words are connected on the basis of cause-and-effect relationships, generalizing categories, metaphors, combining different contexts.

We use a standardized IBM SPSS software package (version 26) for data processing. Previously, we had normalized all indicators.

Results

Correlation Analysis

First of all, we analyzed the correlations (according to Spearman) between the types of visual meanings and the types of semantic signs, since the kind of visual meanings the respondents created during the first task determined their selection of semantic attributes: respectively, sensory and emotional experience activation. The results were as follows.

The total number of named visual meanings was associated with the total number of selected semantic signs ($r = 0.315$, $p = 0.001$). In turn, there were no associations between any type of semanticsigns and the number of geometric meanings. The number of subject-descriptive meanings was definitely associated with the number of Exteroceptive ($r = 0.265$, $p = 0.007$) and Proprioceptive ($r = 0.219$, $p = 0.03$) signs, while the number of subject-contextual meanings was associated with the number of Proprioceptive ($r = 0.230$, $p = 0.02$) and Emotional-evaluative ($r = 0.348$, $p = 0.000$) signs. These relationships relate to the core subject of our research, the process of constructing visual meanings (both their actualization and the allocation of their individual semantic features).

Next, we analyzed the relationship between indicators of the severity of different types of semantic signs and indicators of the formation of categorical and generative abilities.

According to the correlation analysis (according to Spearman), only indicators of generative abilities are definitively associated with all indicators of the severity of semantic signs without exception: the total number of signs ($r = 0.461$, $p = 0.000$); the number of Extraceptive signs ($r = 0.300$, $p = 0.002$), including the number of visual ($r = 0.249$, $p = 0.012$), tactile ($r = 0.250$, $p = 0.011$), or auditory ($r = 0.271$, $p = 0.006$) signs; the number of Proprioceptive signs ($r = 0.387$, $p = 0.000$); the number of Apperceptive signs ($r = 0.241$, $p = 0.015$); and the number of Emotional-evaluative signs ($r = 0.392$, $p = 0.000$). Categorical abilities have one weak connection with the number of Emotional-evaluative signs ($r = 0.215$, $p = 0.030$).

Factor Analysis (Principal Component Method; Varimax Rotation Method with Kaiser Normalization).

Table 1 shows a factor matrix. It includes indicators of categorical and generative abilities, as well as measures of the severity of Extraceptive, Proprioceptive, Apperceptive, and Emotional-evaluative signs. The KMO value is 0.679 and the significance level of the Bartlett sphericity criterion for both samples is $p = 0.000$. Eigenvalues of the factors are more than one; total dispersion is 57.0%.

Table 1

Factorization results (after rotation) of conceptual abilities and the main types of semantic signs

Components	1 factor (39.5%)	2 factor (17.5%)
Categorical abilities	–.025	.929
Generative abilities	.531	.551
Extraceptive signs	.560	.108
Proprioceptive signs	.782	–.130
Apperceptive signs	.690	.134
Emotional-evaluative signs	.632	.354

According to *Table 1*, although categorical and generative abilities interconnect (2 factors), nevertheless, all four types of semantic signs were associated with only one type of conceptual ability, namely the indicator of generative abilities (1 factor). Therefore, we can say that sensory-emotional, experience is activated in the process of semantic description of vague visual figures, and is associated primarily with conceptual generative abilities.

Cluster Analysis

The first variant of cluster analysis was associated with the identification of subgroups of respondents simultaneously according to two criteria: the level of formation and categorical and conceptual abilities (all indicators have a normal statistical distribution). *Table 2* presents the three clusters that stood out, and their characteristics.

Table 2

Descriptive characteristics of clusters identified by the criteria for categorical and generative abilities formation

Clusters	The number of subjects	Categorical abilities	Generative abilities
1	20	–0.52 ± 0.59	1.00 ± 0.57
2	58	–0.38 ± 0.72	–0.65 ± 0.50
3	24	1.34 ± 0.57	0.73 ± 1.00

Table 2 shows that cluster 2 is a subgroup of respondents with a low level of conceptual abilities (both categorical and generative). Cluster 3 is a subgroup of respondents with high-level conceptual abilities (both categorical and generative). Cluster 1 is a subgroup with an imbalance of conceptual abilities in the form of a pronounced predominance of generative abilities over categorical abilities. We compare these subgroups with each other in terms of measures of the severity of the main types of semantic attributes: Exteroceptive, Proprioceptive, Apperceptive, and Emotional-evaluative.

Respondents with a high level of conceptual abilities (cluster 3) identified more Apperceptive ($p = 0.05$) and Emotional-evaluative ($p = 0.007$) signs than respondents with low-level conceptual abilities (cluster 2). In other words, a higher level of conceptual abilities leads to a more pronounced activation of Apperceptive and Emotional-evaluative signs.

On the other hand, respondents with an imbalance of conceptual abilities (cluster 1), as compared with respondents with a low level of conceptual abilities (cluster 2), chose more Extraceptive ($p = 0.05$) and Emotional-evaluative ($p = 0.05$) signs. Consequently, activation of Extraceptive and Emotional-evaluative signs appears in the case of the predominance of generative abilities, combined with low-level categorical abilities.

The second version of the cluster analysis involved classifying the sample according to the severity criteria of all four main types of semantic signs: the percentages of Extraceptive, Proprioceptive, Apperceptive, and Emotional-evaluative (all indicators have normal distribution). The analysis allowed us to name three clusters; *Table 3* presents their characteristics.

Table 3

Descriptive characteristics of clusters, identified by the criteria for the percentage of four types of semantic signs

Clusters	% Extraceptive signs	% Proprioceptive signs	% Apperceptive signs	% Emotional-evaluative signs
1 (n=67)	0.55	–0.04	–0.12	0.34
2 (n=22)	–1.27	–0.51	–0.73	–0.79
3 (n=13)	–0.70	1.06	1.84	–0.45

According to *Table 3*, cluster 2 is a subgroup of respondents with low indicators of the severity of all types of semantic attributes. Respondents with the predominance of Exteroceptive and Emotional-evaluative signs belong to cluster 1. Cluster 3 consists of respondents with a predominance of Proprioceptive and Apperceptive signs. Then we compare subgroups among themselves in terms of their categorical and generative abilities.

We found significant differences in the indicator "level of formation of generative abilities" ($p = 0.000$) when comparing cluster 2 and cluster 1 (indicators of generative abilities are higher among respondents of cluster 1). At the same time, there were no differences in the indicator "level of formation of categorical abilities" when comparing cluster 2 and cluster 1.

Similarly, we noted significant differences in the indicator "level of formation of generative abilities" ($p = 0.003$), when comparing cluster 2 and cluster 3 (indicators of generative abilities are higher among respondents of cluster 3). However there were no differences in the indicator "level of formation of categorical abilities" when comparing cluster 2 and cluster 3.

Thus, according to the results of cluster analysis, we can draw the following conclusion: A higher level of conceptual abilities (both categorical and generative) is associated with a more pronounced activation of Apperceptive and Emotional-evaluative signs (the first version of cluster analysis). Nevertheless, generative abilities play a leading role in activating sensory and emotional experience in the process of semantic description of vague visual figures. A high level of generative abilities implies a higher severity of both Exteroceptive and Emotional-evaluative, as well as Proprioceptive and Apperceptive modalities in the composition of visual meanings (the second variant of cluster analysis). Judging by our data, categorical abilities are not a determining factor in activating an individual's sensory-emotional experience.

Network Analysis

We carried out a network analysis to confirm that the elements of sensory-emotional experience are associated with the level of formation of generative abilities. We used analysis of a weighted network of correlations (a weighted network of gene co-expression, WGCNA or network analysis) to cut the number of variables without losing the significant relationships evident in in-depth data analysis. The method allowed us to define modules (clusters), intermodal hubs, and network nodes on module membership, and find relationships between modules and compare topologies of different networks.

The network itself has the form of a graph composed of nodes connected by edges (connections between nodes) and indicating the "weights" of the edges of the network. The sign of the edge weight (positive or negative) indicates the type of interaction, and the absolute value of the edge weight indicates the strength of the connection between the nodes (Fruchterman et al., 1991; Newman, 2010; Opsahl, Agneessens & Skvoretz, 2010). The use of network analysis has shown its worth in

the analysis of indicators of the productivity of intellectual activity (Sipovskaya, 2019; Sipovskaya, 2020).

Figure 2 presents the linkage of elements of sensory-emotional experience with the level of formation of categorical and generative abilities through network modeling.

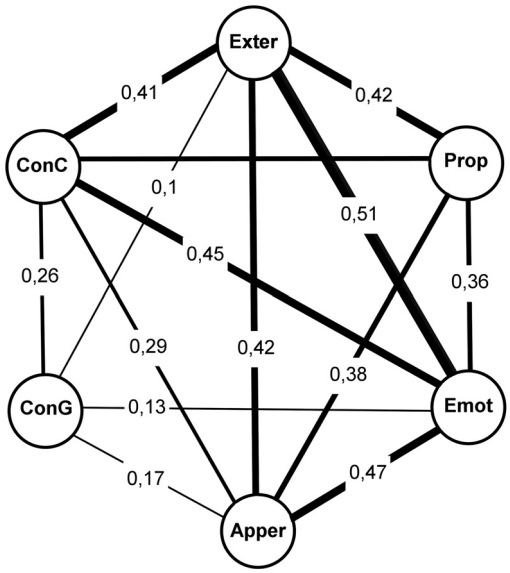

Figure 2. Modeling the structure of conceptual experience (elements of sensory-emotional experience in a system of relations with categorical and generative abilities)

Note. ConC = categorical abilities; ConG = generative abilities; Exter = Exteroceptive signs; Apper ± Apperceptive signs; Emot = Emotional-evaluative signs; Prop = Proprioceptive signs.

Figure 2 shows us that generative abilities are associated with all four types of semantic attributes. It is noteworthy that Extraceptive (0.41) and Emotional-evaluative (0.45) signs have the most robust connections with conceptual generative abilities. In turn, there are three types of semantic signs associated with categorical conceptual abilities. However, all three connections are weak, not reaching an acceptable level of significance (0.10; 0.13; 0.17).

Thus, the results of network analysis confirm that, on the one hand, the level of formation of conceptual abilities (both categorical and generative) is associated with their measure of participation in the process of semantic description of vague visual figures, and many elements of sensory and emotional experience. On the other hand, we may consider only conceptual generative abilities as the leading factor in the activation of sensory-emotional experience in this type of intellectual activity.

Discussion

According to different types of data processing — correlation, factorial, cluster, and network analysis — conceptual generative abilities, unlike categorical conceptual abilities, involve elements of sensory-emotional experience in the process of semantic description of vague visual figures.

The question arises: Why were only generative abilities associated with the activation of sensory-emotional experience? We emphasize that it is important not to confuse generative (conceptual) abilities with general abilities, which are traditionally described in terms of IQ indicators.

We define generative abilities operationally as the ability to create new mental contexts when constructing "impossible connections" between three concepts that differ in meaning. Accordingly, we can turn to the embodied simulation hypothesis to explain the unique role of generative abilities in the activation of sensory-emotional experience. Simulation is the creation of mental products (in the form of personal constructs, representations of certain situations, mental actions, etc.) in the absence of external stimulation. In other words, the embodied simulation hypothesis states that meaning is what a person creates in their mind based on their own mental experience, including the activation of its sensory and emotional components. "Meaning, according to the accomplished simulation hypothesis, isn't just abstract mental symbols; it's a creative process, where people construct virtual experiences — implemented simulations — in their mind's eye" (Bergen, 2012, p. 22). It is not surprising that generative abilities, according to various forms of our data analysis, are directly related to the activation of sensory and emotional experience.

In other words, we are talking about the specific quality of intelligence called mental modeling (simulation) and associated with the level of formation of conceptual (primarily generative) abilities, *i.e.*, the creation — in the absence of an external stimulus — of mental constructions ("mental images" and "mental actions"), the mental "material" of which is sensory and emotional impressions. No wonder that it is generative abilities that are associated with the intensity and variety of elements of sensory and emotional experience - a kind of construct that can create the meanings of vague visual images.

Finally, the main question: What is the source of these sensory-emotional impressions, and what mental mechanism is responsible for their activation?

In our opinion, the source that generates and regulates the influx of sensory-emotional impressions into intellectual activity (in our case, into the process of construction of visual meanings) is generative structures as mental units of personal conceptual experience. Generative structures are integral cognitive formations that contain a system of multilevel information-processing mechanisms. Generative structures are integral cognitive formations that contain a system of multilevel information-processing mechanisms. They include effective means of sensory, motor, and emotional coding, visualization, placement in semantic networks, categoriza-

tion, generation of new mental contents, etc. (Kholodnaya, 2012). A higher degree of formation of generative structures leads to a higher level of conceptual abilities and, so, there will be more elements of sensory and emotional experience in conceptual representations.

Thus, mental modeling (simulation) has an embodied character not in the sense that it is determined "bottom-up" by bodily states or the corresponding activity of certain brain zones. On the contrary, the functioning of generative structures determines how conceptual representations are embodied "from the top." Since in conceptual structures, as they are formed, the experience of the interaction of the body (including the brain) with its environment is accumulated, generalized and integrated, which later appears in various effects of embodied cognition.

Conclusion

An analysis of how activation of elements of sensory-emotional experience in the semantic description of vague visual figures relates to the level of formation of categorical and generative abilities, allowed us to draw the following conclusions: 1) Generative abilities play the leading role in the degree of severity and degree of diversity of different modalities in visual meanings composition; and 2) Generative abilities characterize the highest level of organization of personal conceptual experience, which, due to the integral nature of conceptual (generative) structures, takes on a multimodal quality.

Limitations

Two factors may limit the generalizability of our results. First, the specifics of the sample:Older adolescents are experiencing the peak of development of their conceptual abilities at this age. Accordingly, it is necessary to check the severity of this effect — the multi-directional role of categorical and generative abilities — in an adult sample. Second, the specifics of intellectual activity in the form of formulating visual meanings. The question arises as to whether the same effect would be evident if the task involved verbal meanings.

Ethics Statement

The ethical aspects of the study were discussed and approved at a meeting of the Laboratory of Psychology of Abilities and Mental Resources. V.N. Druzhinin, Institute of Psychology, Russian Academy of Sciences (Protocol No. 1, January 2016)

Informed Consent from the Participants' Legal Guardians

Participants' legal guardians provided written informed consent to participate in this study.

Author Contributions

Kholodnaya M.A.: development of a research program, processing of protocols, application of traditional statistical methods of data processing, preparation of the Problem Statement and Discussion of Results sections. Sipovskaya Ya.I.: conducting a survey of students according to the program, processing protocols, applying the method of neural network analysis of results, preparing the Problem Statement section".

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SOCIAL PSYCHOLOGY

News About Terrorism and Attitudes Toward Countries: The Role of Mortality Salience and Intergroup Threat

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Background. Media reports on armed fights or terror attacks introduce reminders of death into people's daily lives. When people feel non-specific threats (mortality salience) or specific threats (intergroup threats), they may demonstrate unfavorable attitudes toward national outgroups. The issue is mostly analyzed today in line with Terror Management Theory and Intergroup Threat Theory.

Objective. To examine such threats in the Russian context, and the impact of mortality salience (MS) on attitudes toward national outgroups that induced different levels of perceived intergroup threat.

Design. In two studies, participants watched films and completed questionnaires about social distance, social thermometer, and trust toward "more or less threatening" countries. In Study 1, 120 Russian students were assigned to six groups via experimental design: 3 (MS: terrorist attacks in Europe, terrorist attacks in Russia, or a control group watching a video about dental treatment) x 2 (country: Ukraine and Belarus). In Study 2, 122 participants were similarly divided into six groups, evaluating attitudes toward the USA and China.

Results. Study 1 showed that MS mostly increased unfavorable attitudes toward a country perceived as more threatening (Ukraine) than toward one perceived as less threatening (Belarus). Study 2 indicated the same effect on attitudes toward both more (the USA) and less (China) threatening outgroups.

Conclusion. The results identified contradictory tendencies in MS effect, in line with Terror Management Theory and Intergroup Threat Theory. The findings could be used in improving relationships from an international perspective.

Keywords: mortality salience; intergroup threat; attitudes toward countries; Terror Management Theory; Intergroup Threat Theory

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Introduction

The mass media influence our perception of the world in the context of social meanings (Altheide, 2007). Today, in "the culture of fear" (wars, conflicts, terror attacks), researchers have found a significant role for correspondent discourse in the media via expectation of danger and symbolic awareness of threat in everyday life (Skoll, 2016). The term "terrorism" is frequently identified as a "threat to group existence", a "threat to one's way of life", an "ideological instrument of control", or a "form of communication" (Skoll, 2016; Skoll & Korstanje, 2013). People perceive terrorist attacks in exaggerated ways around the world that are mostly covered in the media (Howie, 2012). News about terrorism includes common aspects, e.g., a bloody incident, information about the terrorist organization (targets, portraits), number of victims, counterterrorism politics, and global outcomes of terrorism (Skoll, 2016; Skoll, & Korstanje, 2013). News about terrorist attacks might increase support for military policies and unfavorable attitudes toward groups associated with terrorist "agenda" and frames (e.g., support of Iraq War, Syrian conflict) (Das, Bushman, Bezemer, Kerkhof, & Vermeulen, 2009; Echebarria-Echabe & Fernández-Guede, 2006; Korstanje, 2019).

The effect of terrorism news might be linked with a higher level of threat through reminders of death (non-specific threat) and perceived threat from a particular outgroup (specific threat) (Das et al., 2009; Jang, 2019; Pan, Zhou, & Hayes, 2017). People encounter a specific threat in the case of actual danger from a particular outgroup in the realistic or symbolic perspectives that, as a consequence, impact their attitudes toward this community (Stephan, Ybarra, & Rios, 2015). Pan, Zhou, and Hayes (2017) found that TV news with death-related content activated negative judgments on the immigration issue when immigrant perpetrators were negatively illustrated in the news.

A non-specific threat appears as a result of situational stimuli (e.g., information about terror attacks or pictures with destroyed buildings) and also precedes the evaluation of different objects through thoughts about mortality or about an unpredictable end of life (Jang, 2019; Landau et al., 2004; Vail, Arndt, Motyl, & Pyszczynski, 2012). For instance, death reminders from terrorism news in Western countries increased unfavorable attitudes toward Islamic migrants (Ahmad, 2015; Landau et al., 2004).

In numerous studies, researchers have examined the effect of terrorism news on specific groups portrayed in the news content as potentially "evil" without analysis of neutral groups (Das, Bushman, Bezemer, Kerkhof, & Vermeulen, 2009). For example, after 9/11, researchers in the USA frequently analyzed different forms of discrimination against Arabs and Muslims (Ahmad, 2015; Das et al., 2009; Landau et al., 2004). Terrorism news might also increase unfavorable attitudes toward any outgroup, regardless of news content or the viewer's socio-cultural background, when the news reports confront consumers with their mortality. For instance, news about 9/11 increased discrimination not only among Europeans toward Arabs but also among Arabs toward Europeans. Therefore, the research question is whether terrorism news influences attitudes toward any outgroups or only those that appear threatening.

The term "existential threat" as used in the psychological literature has the central meaning "perceived threat to survival" (from physical annihilation to a threat to one's way of life) in personal and social perspectives (Hirschberger, Ein-Dor, Leidner, &

Saguy, 2016). Notably, the perception of an existential threat may not be linked with objective causes. Some studies conceptualized the existential threat to be rooted in the personal fear of death (Pyszczynski, Solomon, & Greenberg, 2003), whereas others defined it as a collective-level threat to the in-group's existence (Riek, Mania, & Gaertner, 2006; Wohl & Branscombe, 2009).

To define these types of threat, researchers suggest two psychological theories, Intergroup Threat Theory (ITT) (Stephan, Ybarra, & Rios, 2015) and Terror Management Theory (TMT) (Greenberg, Pyszczynski, & Solomon, 1986). The ITT defines specific perceived threats as a basic cause of attitudes toward particular outgroups, whereas the TMT focuses on non-specific threats that worsen attitudes toward different groups. Previous studies have shown that both specific and non-specific threats independently influence attitudes toward outgroups (Burke, Martens, & Faucher, 2010; Stephan et al., 2015). To shed light on the relationships between these types of threat, the goal of the current study was to examine the effect of mortality salience (MS) on attitudes toward outgroups inducing different levels of intergroup threat.

Mortality Salience as a Source of Perceived Threat

Terror Management Theory posits that people have an instinct of self-preservation and awareness of the inevitability of death (Solomon, Greenberg, & Pyszczynski, 1991). A wide range of similar adaptive mechanisms is represented in plenty of animal species, but only humans have the ability for abstract thinking that enables them to grasp the inevitability of death (Solomon, Greenberg, & Pyszczynski, 1991). The contradiction between the instinct of self-preservation and the inevitability of death causes "paralyzing fear" (Solomon et al., 1991). It has been suggested that dealing with this fear is a dual process. The current model indicates a sequential process of proximal and distal defenses following an encounter with death-related information (Greenberg, Arndt, Simon, Pyszczynski, & Solomon, 2000). Proximal defense is activated to remove the death-related thoughts from conscious awareness and reduce the negative affect (Greenberg et al., 2000). After proximal suppression, distal defense actualizes a cultural anxiety buffer including self-esteem (beliefs that one's behavior corresponds to certain cultural values and standards) and one's cultural worldview (an idea of reality that indicates the meaning, purpose, and importance of human life, standards by which human behavior can be assessed, and hope that adherence to these rules and values will empower people to be immortalized) (Pyszczynski, Solomon, & Greenberg, 2015).

To verify the correctness of a worldview, a person has to focus on the attitudes of others: either an individual or a social group. Those who share a person's worldview increase that person's confidence in its accuracy, while those with different positions reduce this assurance. Thus, people tend to express more positive attitudes toward others who confirm their views and are more aggressive toward dissimilar others. It has been found that reminders of death increase this tendency (Burke et al., 2010). Specifically, psychological studies have shown that if reminded about death, people express more negative attitudes toward sexual, religious, racial, ethnic, and national outgroups (Greenberg & Kosloff, 2008). For instance, White participants express more negative attitudes toward African-Americans (Bradley, Kennison, Burke, &

Chaney, 2012); students at American university toward Jews (Cohen, Harber, Jussim, & Bhasin, 2009); Israeli participants toward Iran (Hirschberger & Ein-Dor, 2006); Scots toward the English (Castano, 2004); Germans toward Turks (Pyszczynski, Solomon, & Greenberg, 2003); Italians toward Germans (Castano, Yzerbyt, Paladino, & Sacchi, 2002); Europeans toward Arabs and migrants (Das,et. al., 2009; Pan et al., 2017); Arabs toward Europeans (Das et al., 2009); and Nigerian students toward the Hausa people (Ezeh, Mefoh, Nwonyi, & Aliche, 2017).

Previous studies of TMT analyzed the role of pre-existing beliefs in the context of intergroup relations (e.g., political conservatism, right-wing authoritarianism, social dominance orientation, values). For example, Greenberg, Simon, Pyszczynski, Solomon, and Chatel (1992) found that only conservatives under MS conditions showed more unfavorable attitudes toward others. Similarly, right-wing Israelis demonstrated support for militarism against those they believe "violate" their worldview (Hirschberger & Ein-Dor, 2006). At the same time, representation of human values under the MS condition led to reduction of anti-Arab prejudice (Motyl et al., 2011). When TMT did not consider the pre-existing attitudes toward outgroups, there is empirical support to expect a general "conservative shift" (reminders of death intensified intergroup hostility) (Jost, 2019). This contradiction raised questions about the role of cultural worldview in Terror Management Theory and System Justification Theory. In this study, we considered the pre-existing level of perceived intergroup threat from different countries.

Researchers in the TMT framework also focus on the personal death condition without detailed analysis of collective threats and consider these threats interchangeable (Hirschberger et al., 2016). At the same time, TMT posits that collective identity might reduce the paralyzing fear of death (Pyszczynski et al., 2015), although the threat of death can intensify death-related thoughts (Schimel, Hayes, Williams, & Jahrig, 2007). In the Russian context, people avoid direct questions about personal death that researchers have frequently used in experimental procedures (e.g., Levada-Center, 2018). Therefore, in the current study we focused on terrorism news (without information about potential "evil") as the mortality salience manipulation.

TMT also indicates the significant role of cognitive defense mechanisms in mediating the impact of terrorism news on outgroup prejudice that has been difficult to examine and interpret (e.g., Das et al. 2009). In previous studies, researchers did not control the activation of death fear in an experimental procedure that induced additional questions about MS manipulation (Burke et al. 2010). An additional scale of the fear of death might actualize the mortality salience effect in the control group (Pyszczynski et al., 2015). Therefore, in the current research, we tried to control the experimental manipulation (terrorism news) through a word-completion task and the level of negative affect.

Interaction Between Mortality Salience and Intergroup Threat

Intergroup Threat Theory proposes that perception of outgroups through realistic or symbolic threats determines attitudes toward them (Stephan et al., 2015). A perceived realistic threat is linked to physical and material harm; this type of threat is more likely than a perceived symbolic threat to induce prejudices against perceived

dangerous and competitive outgroups (Stephan et al., 2015). People who perceive a realistic threat believe that outgroup members might harm the ingroup's resources or economic welfare. For instance, the 9/11 teerrorist attack intensified the economic crisis in 2001 and as a result fostered a perception of a realistic threat from Mexican immigrants (Hitlan, Carrillo, Zárate, & Aikman, 2007). A perceived symbolic threat is associated with changes in values and way of life (Stephan et al., 2015). People who perceived a symbolic threat assumed that outgroup members might introduce different cultural standards and destroy the group's way of life. Stephan, Renfro, Esses, Stephan, and Martin (2005) say that both types of threat increase unfavorable attitudes toward outgroups. For instance, Americans who encountered information about Rwandan immigrants that posed both realistic and symbolic threats expressed more unfavorable attitudes toward those immigrants (Stephan et al., 2005).

The effect of perceived intergroup threat may increase the impact of mortality salience on attitudes toward national outgroups. Previous studies have shown that after reminders of death, American students demonstrated more negative attitudes toward Israel but not to India (Cohen et al., 2009), and toward illegal aliens from Mexico City but not from Vancouver (Bassett & Connelly, 2011). This difference might be linked with pre-existing views toward the mentioned groups; in other words, the participants might have previously perceived citizens of India and Canada as less threatening than those of Israel and Mexico; however, the researchers did not pretest the target groups. Therefore, in terms of the terror management perspective, we proposed that reminders of death will mostly reinforce unfavorable attitudes toward more threatening outgroups (**research hypothesis**).

Overview of Research

The present research integrates findings from Terror Management Theory and Intergroup Threat Theory to shed light on the MS effect on attitudes toward outgroups. The goal of the two experimental studies was to determine whether reminders of death cause unfavorable attitudes toward countries perceived as more threatening, in comparison with less threatening ones. In the experimental design we focused on two factors, mortality salience and perceived threat (less and more threatening countries). Moreover, national outgroups might be considered not only with respect to intergroup threat, but also to intergroup similarity. Intergroup similarity is the extent to which individuals consider the outgroup as similar to their own (Stephan et al., 2005). In previous studies, researchers did not examine the objective or perceived similarity as additional factors. In the present study, we tried to take into account the objective similarity (e.g., traditions, language, roots) and conducted two independent studies, with an analysis of attitudes toward culturally similar and dissimilar countries.

To actualize reminders of death, we focused on terrorism news reports. The specifics of news with death-related content might illustrate different effects on attitudes toward national outgroups. Interestingly, Perloff (2016) assumed that territorially close threats caused greater prejudice against "national outgroups" than distant threats. Das and colleagues (2009) found that news about terrorist attacks in the USA did not increase prejudices against Muslims among Dutch study participants, but

news about crime in the Netherlands led to a negative view of Arabs as a national outgroup. However, in previous studies, researchers did not experimentally compare the effect of physically close and distant threats on attitudes toward countries. To examine the difference between close and distant threats, we reminded participants about close threats (news about terrorist attacks in Russia) or distant threats (news about terrorist attacks in Europe). The content of the video did not include any information about the countries that were the targets of the participants' attitudes. After experimental manipulation, participants expressed their attitudes toward countries that might be distinguished by the level of intergroup threat in different cultural perspectives (similar and dissimilar). In both studies, we proposed to evaluate attitudes toward two national groups (more and less threatening), relations with which have been discussed in the Russian media.

Study 1 tested our hypothesis in a culturally similar context, making use of countries with whom Russia has had similar values, traditions, and language (the East Slavic language group), and a long history of co-existence within a common state, the Soviet Union (Ukraine and Belarus). Following the collapse of the Soviet Union, relations between Russia and the other two countries developed in different ways. According to a survey conducted by Levada-Center, Belarus ranked first on the list of friendly countries: 46% of respondents considered Belarus as a friend of Russia (Levada-Center, 2017), whereas Ukraine ranked second on the list of unfriendly countries: 50% of respondents considered Ukraine an enemy of Russia. Thus, these countries were considered culturally similar to Russia, but were differentiated in the level of perceived threat (Belarus–friend, Ukraine–enemy).

Study 2 examined attitudes toward culturally dissimilar countries: China and the USA. According to a Levada-Center study (2017), China ranked second on the list of friendly countries: 39% of respondents considered China a friend of Russia; the USA ranked first on the list of unfriendly countries: 69% of respondents considered the USA an enemy of Russia. Thus, these countries were considered culturally dissimilar to Russia, but differentiated in the level of threat (China–friend, USA–enemy).

STUDY 1

Methods

Participants

Participants were 120 students (76 women; ages 18-30, $M = 21.06$, $SD = 2.28$) from different departments of the Higher School of Economics (HSE) and the State Academic University for the Humanities (SAUH), who participated in exchange for course credits. The number of students from the different universities was the same in the different experimental conditions. The data were collected from November 2017 to February 2018. Participants were randomly assigned to one of the conditions of a between-group design: 3 (mortality salience: terrorist attacks in Europe, terrorist attacks in Russia, or dental treatment) x 2 (type of outgroup: more or less threatening countries).

To determine the required number of participants in our studies, we conducted an a priori power analysis. In line with Burke, Martens, and Fancher's (2013) meta-

analysis related to the MS effect on cultural worldview and self-esteem, the mean effect size was 0.35. We transformed the current r-value into the f-value (0.37), using Psychometrica software to analyze the relevant number of participants corresponding to our experimental design and specifics of data analysis (MANOVA) (Psychometrica, 2019). A priori power analysis by G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) showed that a sample size of 102 (with around 17 participants in each experimental condition) was appropriate to represent the previously mentioned effect-size (F = .0.37) with sufficient power (1 – ß > .80).

We chose a student sample for two reasons: (1) previous studies showed that MS effects were significantly higher for college students than for other participants (Burke et al., 2010); and (2) the availability of additional motivation via bonuses and similar conditions.

Procedure

Participants were asked to take part in a study on individual worldviews that consisted of two parts. The first part was hosted on the Google website and was represented as a study about how different countries are perceived by Russian citizens. Participants were randomly assigned to evaluate the perceived threat from either Belarus (N = 60) or Ukraine (N = 60). At the end of the first session, they received an identification number for the second session.

The second session was held a week after the first and included a face-to-face procedure that lasted about 30 minutes. After giving their informed consent, participants watched one of the three videos (terror attacks in Europe, terror attacks in Russia, or dental treatment), answered questions about it, and completed control measures to test the MS manipulation. The dependent variables were participants' attitudes toward Belarussians or Ukrainians (feeling thermometer, group trust, and social distance). Participants were required to evaluate the same country in both the first and second sessions. Finally, participants were given a debriefing, in which they received information about the actual aim of the research and watched a cartoon intended to induce positive emotions.

Pretesting of target countries. To determine how these countries were perceived by the participants in our study, we used a questionnaire about perceived intergroup threat. This measure included two items about perceptions of realistic threat ("[Name of country]'s military development poses a threat to the interests of Russia", and "[Name of country]'s economic development poses a threat to the economy of Russia"), and two items about symbolic threats ("[Name of country] is a threat to Russian culture", and "[Name of country] is a threat to Russian values and norms") (Stephan, Ybarra, Martinez, Schwarzwald, & Tur-Kaspa, 1998). The analysis showed that all statements formed one scale of "intergroup threat" (a = .91). Participants might agree or disagree with statements about Ukraine and Belarus along a 5-point scale (from 1 = *completely disagree* to 5 = *completely agree*).

To test the perceived threats from Ukraine and Belarus, we used the independent t-test. The results showed that participants perceived a greater threat ($t(118) = -5.81$, $p < .001$, Cohen's $d = 1.057$) from Ukraine (M = 2.84, SD = 1.19) than from Belarus (M = 1.76, SD = .82).

Mortality salience manipulation. In previous studies, MS has usually been manipulated by two open-ended questions concerning death (Rosenblatt, Greenberg, Solomon, Pyszczynski, & Lyon, 1989). We used a modified version of the MS procedure, in which respondents watched a video about death or a frightening event, and then imagined themselves in those situations. The changes in our procedure were because of specifics of the Russian context: in brief, people try to avoid direct questions about death (Levada-Center, 2018).

In the current study, MS was manipulated by videos of terrorist attacks in Europe (experimental group 1)/terrorist attacks in Russia (experimental group 2), or dental treatment (control condition). In the first experimental group, participants watched video reportage of terrorist attacks in Spain, France, Belgium, and the UK, which occurred between 2015 and 2017. In the second experimental group, participants watched reportage of terrorist attacks in four Russian cities, which occurred between 2004 and 2017. In the dental treatment (control) condition, participants watched video reportage of dental treatment that illustrated caries therapy and dental implantations that had negative consequences.

Each stimulus consisted of four videos from the news programs of Russian federal media channels and lasted 10 minutes. To remind participants about their own death, we asked them to imagine themselves as a victim of terrorist attacks or as a patient at a dental clinic and to describe their thoughts and feelings.

Following the MS manipulation, all participants completed a 20-item Russian version of the Positive and Negative Affect Schedule (PANAS), which evaluated both negative (10) and positive (10) emotions (Osin, 2012; Watson, Clark, & Tellegen, 1988). Participants identified the extent to which they were immediately feeling these emotions on a scale of 1 (*very slightly*) to 5 (*extremely*). To test the effect of experimental manipulations, we used only the subscale of negative emotions.

Participants then completed a set of 10-word fragments to indicate death-related thoughts (Greenberg, Pyszczynski, Solomon, Simon, & Breus, 1994). Five of these fragments might be completed with either a death-related or a neutral word (e.g., *gr*o*b — gr*i*b* [*coffin — mushroom*]), whereas the other five fragments could be completed only in one way, resulting in words unrelated to death (e.g., *ig*r*a [play*]). The number of death-related target words was regarded as the index of MS actualization.

Dependent measures. Three indicators — outgroup liking, outgroup trust, and readiness to interact — were used to measure attitudes toward national outgroups.

Feeling thermometer. To measure liking, participants had to indicate their feelings toward Belarusians or Ukrainians on a 100-point scale (0 = *cold,* 100 = *warm*) (Nelson, 2008).

Group trust. Participants rated their level of trust toward Belarusians or Ukrainians (1 = *totally distrust,* 10 = *totally trust).*

Social distance. To measure readiness to interact, participants reported their desire to communicate with Belarusians and Ukrainians as a family member, friend, boss, subordinate, and neighbor (Gulevich, Sarieva, & Prusova, 2015). The scale included five (Cronbach's a = .92) 5-point Likert-scale items with 1 = *completely disagree* and 5 = *completely agree,* lower scores indicating greater social distance and higher scores lower social distance.

Results

Manipulation Check

The Kruskal-Wallis test showed that the manipulation worked. Participants in all conditions demonstrated the same level of negative affect ($M_{exp1} = 2.19$, $M_{exp2} = 2.43$, $M_{control} = 2.20$, $H = .289$, $p = .865$). However, they chose more death-related words in the MS conditions than in the one for dental treatment ($M_{exp1} = 2.18$, $M_{exp2} = 2.58$, $M_{control} = 1.27$, $H = 23.374$, $p < .001$). The distant and close MS conditions did not differ from one another.

Main Results

To analyze the data, we used the multivariate linear model (SPSS 23.0.0). The results are shown in *Table 1*.

Table 1

The effect of mortality salience and type of outgroup on attitudes toward Ukraine and Belarus

IV	DV	SS	df	MS	F	p	h^2
Mortality salience	Social thermometer	32,46.05	2	1,623.03	3.50	.033	.058
	Group trust	3.02	2	1.51	.24	.784	.004
	Social distance	1.37	2	.68	.71	.495	.012
Type of outgroup	Social thermometer	19,304.03	1	19,304.03	41.63	<.001	.268
	Group trust	110.21	1	110.22	17.79	<.001	.135
	Social distance	4.96	1	4.96	5.13	.025	.043
Mortality salience × type of outgroup	Social thermometer	6,212.02	2	3,106.01	6.70	.002	.105
	Group trust	19.52	2	9.76	1.58	.211	.027
	Social distance	2.57	2	1.29	1.33	.269	.023
Error	Social thermometer	52,859.60	114	463.68			
	Group trust	706.05	114	6.19			
	Social distance	110.25	114	.97			

The results revealed a significant effect of type of outgroup on liking ($F(1, 118) = 41.63$, $p < .001$, $h^2 = .268$), trust ($F(1, 118) = 17.79$, $p < .001$, $h^2 = .135$), and readiness to interact with the outgroups ($F(1, 118) = 5.13$, $p = .025$, $h^2 = .043$). Indeed, participants showed significantly more positive attitudes toward Belarusians ($M_{liking} = 73.23$, $SD_{liking} = 22.17$; $M_{trust} = 6.92$, $SD_{trust} = 2.68$; $M_{interaction} = 4.22$, $SD_{interaction} = .86$) than toward Ukrainians ($M_{liking} = 47.87$, $SD_{liking} = 23.77$; $M_{trust} = 5.00$, $SD_{trust} = 2.28$; $M_{interaction} = 3.82$, $SD_{interaction} = 1.09$).

Mortality salience influenced liking of outgroups ($F(1, 118) = 3.50$, $p = .033$, $h^2 = .058$). A post hoc analysis comparing the attitudes toward Ukrainians and Belarusians between conditions revealed significantly lower liking of national outgroups

after watching terrorist attacks in Europe (M = 55.15, SD = 27.31) than after seeing dental treatment (M = 67.58, SD = 23.74). However, there was no difference between the terrorist attacks in Russia (M = 58.93, SD = 26.46) and the dental treatment condition.

Finally, there was interaction between mortality salience and type of country with respect to liking of the outgroup ($F(2,117) = 6.70$, $p = .002$, $h^2 = .105$). A post hoc analysis indicated that after watching terrorist attacks in Russia (M = 38.35, SD = 17.96) and in European countries (M = 40.85, SD = 21.53), participants expressed less liking only toward Ukrainians than after watching dental treatment (M = 64.40, SD = 23.08).

The findings from Study 1 supported the hypothesis that mortality salience had a greater impact on attitudes toward a more threatening country than toward a less threatening one. This might be related to specifics of the target countries, since Ukraine and Belarus are culturally similar to Russia. This closeness might influence the interaction between mortality salience and the perceived threat from the outgroup. Therefore, in Study 2 we analyzed the impact of mortality salience on attitudes toward countries that are dissimilar in cultural and historical perspectives.

STUDY 2

Methods

Participants

One hundred and twenty-two students (64 women; ages 18–30, M = 21.61, SD = 2.32) from different departments of the Higher School of Economics (HSE) and the State Academic University for the Humanities (SAUH) took part in this study, in exchange for course credits. The data were collected between December 2017 and February 2018.

Procedure

Participants followed a similar procedure as in Study 1, but with different target countries. In this case, participants expressed their attitudes toward two territorially and culturally distant countries, China and the USA. To test the type of outgroups, we compared participants` preliminary evaluations of the perceived threat (a = .88) from China and the USA. An independent t-test showed that participants perceived a greater threat ($t(120) = -3.52$, $p = .001$, Cohen's $d = .638$) from the USA (M = 3.07, SD = 1.15) than from China (M = 2.38, SD = 1.01).

Results

Manipulation Check

The Kruskal-Wallis test showed that the MS manipulation worked. Participants in all conditions demonstrated the same level of negative affect ($M_{exp1} = 2.46$, $M_{exp2} = 2.38$, $M_{control} = 2.19$, $H = .859$, $p = .651$). However, they chose more death-related words in the distant and close mortality salience conditions than in the one for dental treatment ($M_{exp1} = 2.66$, $M_{exp2} = 3.05$, $M_{control} = .83$, $H = 55.694$, $p < .001$). The distant and close mortality salience conditions did not differ from one another.

Main Results

The data were analyzed in the same way as in Study 1, through the multivariate linear model (SPSS 23.0.0). The results are shown in Table 2.

Table 2

The effect of mortality salience and type of outgroup on attitudes toward China and the United States

IV	DV	SS	df	MS	F	P	h^2
Mortality salience	Social thermometer	3,841.09	2	1,920.55	5.00	.008	.079
	Group trust	72.63	2	36.31	8.44	.000	.127
	Social distance	.76	2	.38	.41	.663	.007
Type of outgroup	Social thermometer	7,745.14	1	7,745.14	20.15	<.001	.148
	Group trust	94.72	1	94.72	22.01	<.001	.159
	Social distance	.11	1	.11	.12	.727	.001
Mortality salience × type of outgroup	Social thermometer	422.24	2	211.12	.55	.579	.009
	Group trust	4.90	2	2.45	.57	.568	.010
	Social distance	.45	2	.22	.24	.785	.004
Error	Social thermometer	44,592.72	116	384.42			
	Group trust	499.16	116	4.30			
	Social distance	106.38	116	.92			

The results indicate that the type of outgroup affected liking ($F(1, 120) = 20.15$, $p < .001$, $h^2 = .148$) and trust ($F(1, 120) = 22.01$, $p < .001$, $h^2 = .159$) toward Americans and Chinese. Participants showed significantly greater liking and trust toward Chinese ($M_{liking} = 62.81$, $SD_{liking} = 19.76$; $M_{trust} = 5.26$, $SD_{trust} = 2.47$) than toward Americans ($M_{liking} = 47.02$, $SD_{liking} = 20.60$; $M_{trust} = 3.52$, $SD_{trust} = 1.86$). However, there was no significant difference between the readiness to interact with Chinese ($M_{interaction} = 3.55$, $SD_{interaction} = .84$) and Americans ($M_{interaction} = 3.61$, $SD_{interaction} = 1.05$).

Mortality salience impacted liking ($F(1, 118) = 3.50$, $p = .033$, $h^2 = .058$) and trust ($F(1, 120) = 8.44$, $p < .001$, $h^2 = .127$) toward national outgroups. A post hoc analysis comparing the attitudes toward Americans and Chinese between conditions revealed significantly lower liking and trust after watching terror attacks in Europe ($M_{liking} = 56.14$, $SD_{liking} = 21.46$; $M_{trust} = 4.74$, $SD_{trust} = 2.47$) than after watching dental treatment ($M_{liking} = 65.08$, $SD_{liking} = 25.08$; $M_{trust} = 5.82$, $SD_{trust} = 2.75$). However, there was no difference between the terrorist attacks in Russia ($M_{liking} = 53.42$, $SD_{liking} = 14.94$; $M_{trust} = 4.05$, $SD_{trust} = 1.63$) and dental treatment conditions.

Finally, there was no significant interaction between mortality salience and type of country. The independent analysis of each country showed that videos of ter-

rorist attacks in Europe influenced the liking of Chinese ($F(1, 40) = 4.66$, $p = .037$, $h^2 = .107$; $M_{exp1} = 57.95$, $SD_{exp1} = 18.54$; $M_{control} = 72.25$, $SD_{control} = 23.68$) and trust toward both Americans ($F(1, 38) = 6.10$, $p = .018$, $h^2 = .138$; $M_{exp1} = 2.80$, $SD_{exp1} = 1.40$; $M_{control} = 4.35$, $SD_{control} = 2.43$) and Chinese ($F(1, 40) = 6.33$, $p = .016$, $h^2 = .140$; $M_{exp1} = 4.57$, $SD_{exp1} = 2.06$; $M_{control} = 6.60$, $SD_{control} = 3.03$). Participants expressed marginally less liking and trust after terror in Europe toward more and less threatening countries.

Videos of terrorist attacks in Russia impacted liking ($F(1, 40) = 5.15$, $p = .029$, $h^2 = .117$; $M_{exp2} = 58.67$, $SD_{exp2} = 13.54$; $M_{control} = 72.25$, $SD_{control} = 23.68$) and trust ($F(1, 40) = 6.40$, $p = .016$, $h^2 = .141$; $M_{exp2} = 4.67$, $SD_{exp2} = 1.71$; $M_{control} = 6.60$, $SD_{control} = 3.03$) only toward Chinese. Participants expressed less liking toward Chinese after information about terror in Russia. In general, mortality salience had the same effect on attitudes toward more and less threatening groups, which contradicted the research hypothesis.

Discussion

In this study, we analyzed the effect of the interaction between mortality salience and intergroup threat on attitudes toward national outgroups. We assumed that reminders of death would mostly influence attitudes toward outgroups perceived as more threatening in comparison to those perceived as less threatening. The results allowed us to identify some trends that appeared in attitudes toward similar (Ukraine, Belarus) and dissimilar (China, USA) countries. We found that attitudes toward different countries are influenced by the perceived intergroup threat. Participants showed less positive attitudes toward more threatening countries (Ukraine, USA) than to less threatening ones (Belarus, China), which corresponds with Intergroup Threat Theory.

The intergroup threat had a greater impact on cognitive and emotional components of the attitudes than on behavioral ones. In particular, participants expressed less liking and trust toward citizens of more threatening countries (Ukraine and the USA) than toward less threatening ones (Belarus and China). Differences in social distance were found between Belarus and Ukraine only. In the present case, liking and trust might reflect personal views, while readiness to interact with outgroups could be limited by external factors (such as the low probability of communication, language barriers, social norms, etc.).

The results showed that mortality salience influenced attitudes toward national outgroups. After reminders of death, participants expressed more unfavorable attitudes toward foreign countries than in the control condition. However, a comparison of the results of Study 1 and Study 2 revealed that the MS effect might be influenced by two factors, intergroup threat and intergroup similarity. Our results suggested that people tended to show changes in liking toward culturally similar outgroups (Ukraine), whereas in the case of dissimilar outgroups (the USA and China), we observed this tendency both for liking and trust.

Based on the results, close and distant death reminders have different impacts on attitudes toward outgroups. On the whole, the reminder of death by terrorist attacks

in European countries had a greater effect on attitudes toward other countries than did terrorist attacks in Russia. In the current case, MS manipulation might activate a certain level of comparison among respondents. The information about events in their own country induced participants to think about different groups living there, whereas information about events in foreign countries activated thoughts about different nations. These thoughts influenced attitudes toward the correspondent outgroups: in the first case, these groups were members of national outgroups who lived in the country (e.g., migrants or inhabitants of other regions), and in the second case they were citizens of foreign countries.

Conclusion

The current research identified the role of mortality salience induced by terrorism news on attitudes toward more or less threatening countries. Reminders of death mostly predicted attitudes toward groups perceived as more threatening and culturally dissimilar in the Russian socio-political context. The evidence from Study 1 (culturally similar outgroups) supports the hypothesis that MS intensified unfavorable attitudes toward more threatening outgroups, whereas in Study 2 (culturally dissimilar outgroups), this tendency was observed toward both less and more threatening outgroups. These findings shed light on the intergroup threat as a factor and indicated the specifics of the mortality salience effect. Further studies should analyze groups with different levels of intergroup threat and perceived similarity, as well as consider ideological variables (social dominance orientation and right-wing authoritarianism) and social context in the long-term perspective.

Limitations

Our research had several limitations. First, we systematically varied only the perceived intergroup threat, without a detailed analysis of perceived similarities between groups. Our assumption about the perception of greater cultural similarity between Russia and Ukraine or Belarus than with China or the USA was not supported by the measures we used. The USA and China are culturally different countries and are considered by Russians to be members of "Western" and "Eastern" civilizations, respectively. To analyze the relative importance of perceived similarity and perceived threat, further research is needed.

Second, our research measured attitudes toward outgroups that induced a weak or medium sense of threat among respondents. We did not consider groups that would have induced a greater sense of threat. The current perspective might be explained by the type of participants, which in our research was students from Moscow universities, where participants study in an international environment, in which they might have "friendly" interactions with the target groups and consider terrorist attacks in other countries as relevant stimuli. Sociological surveys in Russia have shown that younger people and those with higher education express more positive attitudes toward other ethnic and national groups than do older people and those with lower educational levels (Levada-Center, 2015). To exclude this limitation, we need to conduct further research with respondents from other socio-demographic groups.

Third, our results suggest that mortality salience had no impact on attitudes toward Belarus, which is probably considered as a culturally similar and non-threatening country. This raises a research question for further study: whether MS influences only attitudes toward those who are perceived as a "threatening/dissimilar" outgroup, without any effect on evaluations of non-threating countries. To analyze this limitation, in the future we need to compare the effect of MS on attitudes toward counties that are similar to Belarus.

Finally, we used a modified version of the MS procedure, which included both viewing the death of others and thinking about one's own death. In previous papers, some authors combined these types of threat (internal and external). For example, Burke and colleagues (2010) did not indicate any differences in the impact of questions about one's own death and viewing of a video showing the death of others. However, in some cases, researchers distinguished mainly between "internal" and "external" forms of threat, specifically that the type of threat might have different effects on attitudes and behavior (Onraet, Van Hiel, Dhont, & Pattyn, 2013). To shed light on these contradictions, future studies might focus on independent analysis of MS manipulations through questions about one's own death or the deaths of other people.

Ethics Statement

All participants gave informed consent in the study that included information about the study, the opportunity to get out from this procedure if they would be not interested, and requirements about age (over 18 years). After the experimental procedure, participants were debriefed by cartoons that induced positive emotions and information about the actual goals of the study.

Author Contributions

I.P. and O.G. conceived of the idea of the research. I.P. conducted the experimental procedure and verified the analytical methods. All authors wrote the paper, discussed the results and future directions of the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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The Relationship Between Value Orientations and Personal Readiness for Activity in Youth From Russia, Kazakhstan and Latvia

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Background. The development of high-quality human capital is an important objective that involves value orientations, cultural dimensions and psychological characteristics of activity. This article presents a cross-cultural comparison of value orientations and psychological parameters of activity among youth from Russia, Kazakhstan, and Latvia.

Objective. The study addressed three questions: (1) Are there values and attitudes related to the readiness for activity among youth in the three countries? (2) Are there any differences between values and parameters of the psychological system of activity in the Russian, Kazakhstani and Latvian samples? (3) What values and attitudes predict the youth's readiness for activity in each country?

Design. University students from Russia, Kazakhstan and Latvia were invited to participate in the study. The study sample was selected according to age, sex and period of living in the country. Value orientations, cultural dimensions and attitudes were measured by the Values Survey Module, World Values Survey questionnaire, The Subjective Evaluation of Basic Values Realisability. Personality Research Form, Quality of Life Enjoyment and Satisfaction Questionnaire, Subjective Happiness Scale, Self-Organisation of Activity Questionnaire, Differential Test of Reflexivity, and Satisfaction with Life Scale questionnaires were applied to evaluate the psychological parameters of activity. To analyse the relationship between value orientations and psychological parameters of activity, we used analysis of variance, Pearson's correlation coefficient and stepwise linear regression.

Results. The cross-cultural variance was established for most values and cultural dimensions in the Russian, Kazakhstani, and Latvian samples, but Personal readiness for activity only differed on the tendency level between the Kazakhstani and Latvian samples. Different values and attitudes accounted for near 57% of the Personal readiness for activity index in Russia and Latvia, but just less than 29% in Kazakhstan.

Conclusion. The activity of university students from Russia depends on their need for achievement and level of happiness. In the Kazakhstani and Latvian samples, the most important factor was the quality of life enjoyment and satisfaction index.

Keywords: value orientations; cultural dimensions; psychological system of activity; post-Soviet countries, personal readiness for activity

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Introduction

Traditionally, the definition of social progress and human capital as its part has been based on economic terms (a so-called GDP-oriented approach). However, a more people-oriented approach has emerged amongst scholars over the last decades. There are a growing number of published studies that focus on high-quality human capital. These aim at exploring social progress index (Porter, 2013), social capital (Kwon, Heflin & Ruef, 2013; Leyden & Link, 2015), personal potential (Leontiev, 2011), professional self-determination (Alimbayeva, Baimukanova, Sabirova, Karipbaev & Tamabayeva, 2018) and others. Thus, addressing the issue of youth's value orientations, cultural dimensions and psychological characteristics of activity in the context of their personal and professional development seems to be relevant to the modern world's challenges.

Cultural dimensions are supposed to contribute to our better understanding of the interplay between personal and environmental aspects when analysing the problem of high-quality human resource development (Atamanova, Bogomaz & Filippova, 2019). Evidence from the various literature is that one's beliefs and evaluations about diversity do affect one's perceptions and behaviour (Bell, Connerley & Cocchiara, 2009; Mor Barak, 2014). Also, a positive approach to diversity leads to better outcomes (Homan, van Knippenberg, Van Kleef & De Dreu, 2007, Lauring & Selmer, 2013). Various measurement models of national culture have been created over the past decades; the development of theoretical models went from identifying a list of parameters by which one can compare different cultures to identifying factors of a higher level. These factors represent cultural values, "the principles and fundamental convictions which act as general guides to behaviour, the standards by which particular actions are judged to be good or desirable" (Halstead & Taylor, 2000, p. 169). In other words, each value guides our behaviour and could regulate our activity and readiness for it. The most dominant models of cultural dimensions, which gained recognition and popularity, are the following: Hofstede's (1983), Schwartz' (1994), and Inglehart's (1997) models.

The studies conducted highlighted the role of young people's basic values and their subjective evaluation of possibilities to realise these values in their sociocultural environments (Bogomaz, Kozlova & Atamanova, 2015). Bogomaz et al. (2015) also showed that the higher a young person's personal potential, the more possibilities they revealed in their local settings for their personal and professional development. Baumann and Winzar (2017) point out that the extent to which values drive behaviour is a function of the circumstances in which individuals find themselves and the relative importance of competing values in particular circumstances. Decades of research have shown that the relationship between attitudes and behaviour is complicated (Ajzen, 1988; Glasman & Albarracín, 2006), so an intermediary linking value and behaviour could be a psychological parameter characterising one's activity. Such a parameter for integrating one's value orientations, cultural dimensions and psychological characteristics of activity could be one's personal readiness for activity (Atamanova et al., 2019). Our studies show that the index of personal readiness for activity depends on the innovativeness index, traditional values, openness

to experience, index of motivation, and maintaining: the individual's adherence to the values of survival negatively affects the manifestation of personal readiness for activity (Buravleva & Bogomaz, 2020). Thus, personal readiness for activity seems to be a universal characteristic and it could accompany both innovative and traditional activity. Also, personal readiness for activity correlates with emotional intelligence (Bogomaz, Boyko & Yashina, 2019).

Accordingly, it is captivating to explore cultural dimensions of countries that were recently a single unit. The collapse of the Soviet Union in 1991 generated a unique situation when 15 countries simultaneously started their pathways to building independent national communities (Atamanova et al., 2019). The 30 years of post-Soviet development in these countries were full of political, cultural, and economic transformations that brought many changes to the way of life and the population's mentality. Since all the former Soviet Republics removed themselves from the USSR, they may have been strongly influenced by the influx of western culture. The effect of major political changes on the higher education of post-Soviet states and youth's values were explored in studies by Yakavets (2016), Azimbayeva (2017), Fedotova (2017), and Mykhailenko, Blayone, Usca, Kvasovskyi & Desyatnyuk (2020). However, cultural and psychological differences are not particularly well researched because these changes are very slow due to the significance of local cultural values. However, we believe that enough time has passed since the collapse of the Soviet Union to see cultural and psychological differences among young people living in various post-Soviet countries.

Today's young generation in the former Soviet Union countries is an indicator of the social and economic alterations that have occurred since the turbulent turn of the century. Youth is known to be the age category most sensitive to change, so it represents a major research interest in the context of the future trends of social development. A deeper understanding of the cultural context requires a research focus on what is going on in the countries. However, youth's personal and professional development intertwines with each country's high-quality human capital from a long-term perspective.

Our research includes youth from three ex-Soviet Union countries with different economic and political pathways to building independent national communities: Russia, Kazakhstan, and Latvia. Also noticeable is the geographical differences of these countries: Kazakhstan is in Asia, Latvia is in Europe, and Russia is in both Asia and Europe.

Our objectives were to test hypotheses of cross-cultural differences in value orientations and readiness for activity among the Russian, Latvian, and Kazakhstani samples made up of university students. This would allow a differentiated approach to discovering the relationship between these individual personality characteristics and students' personal and professional development activities. The study addressed three questions: (1) Are there values and attitudes related to the readiness for activity among youth in the three countries? (2) Are there any differences between values and parameters of the psychological system of activity in the Russian, Kazakhstani and Latvian samples? (3) What values and attitudes predict youth's readiness for activity in each of the countries?

Methods

We used several existing or specially developed scales to analyse value orientations and attitudes in these three countries and (2) psychological parameters of activity. Value orientations and attitudes included indicators such as traditional values versus secular-rational values (T/S-RV), the need for achievement and affiliation, subjective evaluation of possibilities for basic values realisability in the local settings, quality of life enjoyment and satisfaction and subjective happiness, and cultural values, namely Hofstede's six dimensions. Psychological parameters of activity include purposefulness, planning, systemic reflection and satisfaction with life, and the personal readiness for activity index, which is the average of the four parameters mentioned. In order to estimate all these psychological characteristics, the study participants were asked to fill out several questionnaires. The internal consistency coefficients (Cronbach's alpha) for each dimension are presented for all the subsamples to be analysed and the total sample, respectively, in Table 1. Cronbach's alphas ranged from .91 to .65; such scores are considered to be acceptable values (Taber, 2018).

1. Values Survey Module (VSM 2013) by Hofstede (Hofstede & Minkov, 2013). This consists of 24 items with a 5-point Likert scale response format, ranging from "*of utmost importance*" to "*of very little or no importance*". VSM 2013 Hofstede's six dimensions of culture values entailed the independent variable values. The dependent variables included the Power distance index (PDI), Individualism index (IDV), Masculinity index (MAS), Uncertainty avoidance index (UAI), Long-term orientation index (LTO), and Indulgence versus restraint index (IVR). A reliability test for the VSM 2013 should be based on the country mean scores; however, the number of countries is insufficient in our case. According to Hofstede and Minkov (2013), the reliability of the VSM at the country level is taken for granted, and can indirectly be shown through the validity of the scores. To estimate this, we performed correlation analysis between value orientations, attitudes and psychological parameters of activity, which showed a satisfactory level of consistency (Table 3).

2. World Values Survey questionnaire (WVS) by Inglehart (Inglehart & Welzel, 2005), modified by Khabibulin (2015). The scale consists of 13 items with a 7-point Likert scale response format, ranging from "*totally disagree*" to "*absolutely agree*". The scale includes two axes: Traditional values versus Secular-rational values (T/S-RV) and Survival values versus Self-expression values (S/S-EV). In our study, we only used the T/S-RV dimension since the Cronbach's alpha values for the S/S-EV scale were inadequate for one of the subsamples.

3. The Subjective Evaluation of Basic Values Realisability (SEBVR) technique developed by Bogomaz (for more details, see Bogomaz. 2014; Atamanova et al., 2019; Filenko, Atamanova, Bogomaz, 2020) for examining one's subjective evaluation of possibilities for basic values realisability in the local settings. The Subjective Evaluation of Basic Values Realisability technique is a 20-item instrument based on the semantic differential method originated by Osgood and analogous to the Noetic Orientations Test. The task is to evaluate each bipolar set using a 7-point Likert-like scale (3-2-1-0-1-2-3). For this study, four Metavalues of professional self-realisation (MPrS), Metavalue of public self-realisation (MPuS), Metavalue of vital self-realisation (MVS) and Metavalue of existential self-realisation (MES)) and the SEBVR index were used (see Filenko, Atamanova, Bogomaz, 2020).

4. The Personality Research Form (PRF) developed by Jackson (1984), in Kondakov's modification (1998), is a 6-item questionnaire using a 5-point response scale, ranging from "*strongly disagree*" to "*strongly agree*". This version of the PRF estimates two subscales: Need for achievement and Need for affiliation.

5. A short version of the Quality of Life Enjoyment and Satisfaction Questionnaire (Q-LES-Q) is a self-report instrument by Ritsner and colleagues (2005) in Rasskazova's adaptation (2012). The questionnaire consists of 17 items with a 5-point response scale from "*hardly ever*" to "*constantly*". The Q-LES-Q includes five measures: Physical health, Subjective feelings, Leisure time activities, Social relationships, and the Q-LES-Q index.

6. The Subjective Happiness Scale (SHS) was constructed by Lyubomirsky and Lepper (1999) and adapted by Leontiev and Osin (2000). It was designed to assess a person's current psychological state. The questionnaire is a 4-item measure using a 5-point response scale from "*totally disagree*" to "*absolutely agree*". However, we used only three items according to the recommendation from Leontiev (Osin & Leontiev, 2020).

7. The Self-Organisation of Activity Questionnaire was developed by Mandrikova (2010) to evaluate the maturity of tactical planning and strategic goal-setting skills. The questionnaire was extended from the basis of the Time Structure Questionnaire – TSQ. The Self-Organization of Activity Questionnaire consists of 25 items. For our study, we used only two subscales: Purposefulness (one's ability to concentrate on a goal) and Planning (one's involvement in tactical planning according to certain principles). The items were evaluated by a 5-point Likert-like scale ranging from "*completely disagree*" to "*completely agree*".

8. The Differential Test of Reflexivity (DTR) by Leontiev and Osin (2014) is a 30-item questionnaire using a 4-point response scale, operationalising Leontiev's 3-component model of reflexive processes. According to the model, systemic reflection (a tendency to look at oneself within the context of situations and life in general) is a productive form of reflection conducive to dialogue with the world. We used only one subscale modified for our study (7 items) — systemic reflection. Our study applied a 5-point Likert-like scale to evaluate the items.

9. The Satisfaction with Life Scale (SWLS), developed by Diener, Emmons, Larsen and Griffin (1985) and adapted by Leontiev and Osin (2008), has a good reliability level with satisfaction with life. This 5-item scale is assessed according to a 5-point scale depending on the agreement-disagreement with the statement.

It should be noted that the Self-Organisation of Activity Questionnaire and Differential Test of Reflexivity in a modified version (the 5-point Likert-like scale was applied), as described above, as well as the Satisfaction with Life Scale were used to evaluate the study participants' personal readiness for activity index as an integrative parameter of the psychological system of activity. The personal readiness for activity index is the average of the following indicators: Purposefulness, Planning, Systemic reflection and Life satisfaction, as mentioned above. These transformations were made to develop a research tool adequate to the objective of characterising one's psychological system of activity via an integrative psychological parameter, namely personal readiness for activity (Atamanova & Bogomaz, 2018; Atamanova et al., 2019).

Table 1

Cronbach's alpha coefficients for study variables

Study variables	Russia	Kazakhstan	Latvia	Total sample
T/S-RV	.67	.65	.67	.68
Need for achievement	.68	.65	.63	.66
Need for affiliation	.76	.67	.83	.75
SEBVR index	.88	.87	.88	.88
MPrS	.77	.65	.68	.73
MPuS	.66	.65	.67	.66
MVS	.70	.73	.84	.73
MES	.80	.75	.72	.78
Q-LES-Q index	.88	.91	.88	.89
Physical health	.82	.72	.81	.79
Subjective feelings	.84	.84	.84	.82
Leisure time activities	.75	.68	.68	.67
Social relationships	.76	.76	.69	.68
Subjective Happiness	.85	.82	.81	.84
Purposefulness	.83	.82	.72	.79
Planning	.88	.82	.85	.86
Systemic reflection	.78	.79	.69	.77
Satisfaction with life	.77	.83	.84	.81
Personal readiness for activity index	.84	.88	.78	.86

Note. T/S-RV = Traditional values versus Secular-rational values. SEBVR = Subjective Evaluation of Basic Values Realisability. MPrS = Metavalue of professional self-realization. MPuS = Metavalue of public self-realization. MVS = Metavalue of vital self-realization. MES = Metavalue of existential self-realization. Q-LES-Q = Quality of Life Enjoyment and Satisfaction Questionnaire.

Participants

The study was conducted from 2018 to 2019. The initial sample for establishing the cross-cultural variance consisted of 818 people (477 women, 352 men), aged from 18 to 35 (18.32(2.39) M(SD)). Of these, 550 people participated in the study in Russia; 192 in Kazakhstan; 76 in Latvia. The groups differed significantly in age and sex. To compare the indicators, student age and sex were selected from this sample (18–26 age range).

The final sample (*Table 2*) for comparing the factor structure invariance included 601 people (330 women, 271 men) from Russia (n = 344), Kazakhstan (n = 192), and Latvia (n = 65). The mean age of respondents was 20.33 ± 2.20 years (Russia = 20.18 years; Kazakhstan = 20.44 years; Latvia = 20.85 years) and 54.9% were women (Russia = 57.6%; Kazakhstan = 49.5% ; Latvia = 53.8%). The samples did not differ significantly in age ($\chi^2(2) = 7.01$, $p = 0.06$) and sex ($\chi^2 = 2.866$, $df = 2$, $p = 0.239$).

All the respondents have lived in their respective country for more than five years. The average period of living in their countries was 17.6±4.8 years (Russia = 17.7 years;

Kazakhstan = 16.7 years; Latvia = 19.4 years). In this study, the birth nation does not exclude the respondents, as they might have lived there only for a short period or perhaps were born when their parents stayed in that particular nation and never lived there. The study participants were majoring in various subjects, but this aspect was not in question in this study.

Table 2

Demographic characteristics of the Russian, Kazakhstani and Latvian samples

	Russia (n = 344)	**Kazakhstan (n = 192)**	**Latvia (n = 65)**
Age (Mean(SD)	20.18 (1.66)	20.44 (2.96)	20.85 (2.01)
Sex (M/F)	146/198	96/96	30/35
Period of living in the country	6–24 years	5–23 years	5–26 years

Procedure

The present study was designed based on a snowball sampling technique. The study participants were asked to complete a series of questionnaires, their participation in the study was voluntary. The paper-and-pencil forms were offered in Russian. The university students from Kazakhstan and Latvia who participated in the study could understand the Russian language.

Analysis

The data collected was then statistically treated applying the IBM SPSS Statistics 23. Descriptive analysis and analysis of variance (ANOVA, the F-test criterion), Pearson's correlation coefficient and stepwise linear regression were used to compare the subsamples. Correlation analysis was performed to determine a significant relationship between value orientations and activity dimensions. In addition, analysis of variance was done to check if there are any significant differences between the three countries among value orientations and activity dimensions. Finally, regression analysis was performed for the personal readiness for activity index in the countries under study, and the six dependent variables: Traditional values versus Secular-rational values, Need for achievement, Need for affiliation, the SEBVR index, the Q-LES-Q index, Subjective happiness, as well as the respondents' period of living in their countries. Regression analysis was carried out separately for each subsample under the study. The idea was that psychological variables involved in the study could fully characterise young people's psychological system of activity, when viewed as predictors of their personal readiness for activity index.

Results

We conducted descriptive statistics (mean and standard deviation) and correlation analysis between value orientations and Personal readiness for activity index for the total sample (n = 601). The results show that out of 13 value orientations, 9 are significantly related to Personal readiness for activity index (see *Table 3*). In general,

Table 3

Means (M), Standard Deviations (SD), and Correlations

Values	M(SD)	1	2	3	4	5	6	7	9	10	11	12	13
PDI	50.0(18.18)												
IDV	52.2(13.62)	–.067											
MAS	42.4(16.04)	.181**	–.164**										
UAI	47.4(16.91)	.157**	.014	.071									
LTO	57.9(15.64)	.120*	–.217**	.072	.063								
IVR	60.2(13.09)	–.111*	.184**	–.126*	–.213**	–.098							
T/S-RV	4.3(0.98)	.089	–.215**	–.035	–.035	.307**	–.017						
Need for achievement	4(0.67)	.031	–.019	.020	–.054	.131*	.068	.210**					
Need for affiliation	4(0.81)	.049	–.022	–.042	–.042	.058	.069	.295**	.431**				
SEBVR index	5.5(1.05)	.054	–.106*	–.021	–.016	.192**	–.009	.238**	.220**	.207**			
Q-LES-Q index	15.6(3.30)	–.024	.009	.017	–.206**	.062	.080	.207**	.231**	.303**	.314**		
Subjective happiness	10.8(2.71)	–.036	–.078	–.087	–.281**	.076	.164**	.331**	.231**	.241**	.281**	.439**	
Personal readiness for activity index	3.6(0.53)	–.002	–.006	–.098	–.116*	.126*	.161**	.371**	.382**	.403**	.204**	.287**	.404**

*Note. PDI = Power distance index. IDV = Individualism index. MAS = Masculinity index. UAI = Uncertainty avoidance index. LTO = Long-term orientation index. IVR = Indulgence versus restraint index. T/S-RV = Traditional values versus Secular-rational values. * — p < .01; ** — p < .001.*

Table 4

Analysis of means (M), standard deviations (SD) and variance across countries

Values	Russia M(SD)	Kazakhstan M(SD)	Latvia M(SD)	ANOVA				
				Main effect F; *p* value		Bonferroni post hoc		
						Russia VS Kazakhstan	Russia VS Latvia	Kazakhstan VS Latvia
PDI	50.41(18.12)	48.67(18.42)	52.03(17.83)	.855	.426	.834	1.000	.813
IDV	53.57(13.7)	49.74(13.16)	51.98(13.75)	4.674	**.010**	**.007**	1.000	.711
MAS	43.37(17.07)	41.71(14.51)	44.20(14.72)	.907	.404	.632	1.000	1.000
UAI	47.92(17.17)	44.77(15.51)	52.00(18.41)	5.648	**.004**	.096	.138	**.004**
LTO	56.14(15.84)	62.22(13.75)	54.06(17.23)	11.586	**.000**	**0.000**	1.000	**.001**
IVR	60.50(13.73	59.35(12.08)	60.92(12.55)	.479	.620	1.000	1.000	1.000
T/S-RV	4.07(0.86)	4.72(1.03)	4.02(0.83)	40.473	**.000**	**0.000**	1.000	**0.000**
Need for achievement	4.00(0.66)	4.14(0.64)	3.88(0.63)	6.452	**.002**	**.011**	.524	**.006**
Need for affiliation	4.02(0.82)	4.10(0.76)	3.74(0.89)	4.863	**.008**	1.000	**.018**	**.007**
SEBVR index	5.29(1.15)	5.88(0.79)	5.87(0.79)	23.050	**.000**	**.000**	**.004**	1.000
MPrS	5.47(1.36)	5.95(1.00)	5.97(1.34)	14.414	**.000**	**.000**	**.000**	.761
MPuS	4.64(1.26)	5.28(1.08)	5.05(1.34)	20.812	**.000**	**.000**	**.002**	1.000
MVS	5.77(1.28)	6.21(1.06)	6.09(1.53)	10.402	**.000**	**.000**	**.008**	1.000
MES	5.35(1.36)	5.60(0.79)	5.71(1.42)	19.291	**.000**	**.000**	**.006**	1.000

Table 4 (*continued*)

Values	Russia M(SD)	Kazakhstan M(SD)	Latvia M(SD)	ANOVA				
				Main effect F; *p* value		Bonferroni post hoc		
						Russia VS Kazakhstan	Russia VS Latvia	Kazakhstan VS Latvia
Q-LES-Q index	15.19(4.0)	16.43(2.24)	15.43(2.35)	18.601	**.000**	**.000**	**.020**	**.000**
Physical health	13.18(3.62)	14.70(2.84)	13.25(3.81)	17.520	**.000**	**.000**	1.000	**.000**
Subjective feelings	19.24(3.76)	20.47(3.56)	19.03(4.05)	11.872	**.000**	**.000**	1.000	**.002**
Leisure time activities	10.66(2.40)	11.13(2.03)	10.60(2.25)	4.542	**.011**	**.014**	1.000	.115
Social relationships	19.13(3.76)	19.40(3.40)	18.86(3.37)	1.177	.309	.651	1.000	.554
Subjective happiness	10.40(2.67)	11.67(2.63)	9.98(2.51)	17.897	**.000**	**.000**	.484	**.000**
Purposefulness	3.91(0.72)	4.11(0.64)	4.01(0.61)	.55	.577	**0.012**	0.882	1.000
Planning	3.31(0.96)	3.37(0.87)	3.27(0.92)	.37	.688	1.000	1.000	1.000
Systemic reflection	3.95(0.60)	3.89(0.56)	3.89(0.48)	.55	.577	0.986	1.000	1.000
Satisfaction with life	3.27(0.74)	3.48(0.79)	2.97(0.80)	11.39	**.000**	**0.016**	**0.018**	**0.000**
Personal readiness for activity index	3.63(0.53)	3.71(0.53)	3.53(0.48)	3.039	**.049**	.386	.386	.052

Note. PDI = Power distance index. IDV = Individualism index. MAS = Masculinity index. UAI = Uncertainty avoidance index. LTO = Long-term orientation index. IVR = Indulgence versus restraint index. T/S-RV = Traditional values versus Secular-rational values. SEBVR = Subjective Evaluation of Basic Values Realisability. MPrS = Metavalue of professional self-realisation. MPuS = Metavalue of public self-realisation. MVS = Metavalue of vital self-realisation. MES = Metavalue of existential self-realisation. Q-LES-Q = Quality of Life Enjoyment and Satisfaction Questionnaire.

our findings focus on the relationship between Personal readiness for activity index and Uncertainty avoidance index, Long-term orientation index, Indulgence versus restraint index, Traditional values versus Secular-rational values, Need for achievement, Need for affiliation, SEBVR index, Q-LES-Q index, and Subjective happiness. Power distance index, Individualism index, and Masculinity index were not found to be related to Personal readiness for activity index. However, this relationship could be different in countries yet to be analysed, and more detailed results could be seen in regression analysis.

Table 4 shows the means, standard deviations, and range for all the variables used in the analysis, grouped across Russia, Kazakhstan, and Latvia. For example, in cultural dimensions, the Individualism index score of Russia is significantly higher than that of Kazakhstan ($p = 0.007$). While considering the Uncertainty avoidance score of Kazakhstan, it is found to be significantly lower than that of Latvia ($p = 0.004$). Moreover, the contrast pattern can be seen in Russia ($p = 0.00001$) and Latvia ($p = 0.001$), and both have a lower Long-term orientation index than Kazakhstan.

The Traditional values versus Secular-rational values indicator is significantly higher in the case of Kazakhstan compared to Latvia ($p = 0.000001$) and Russia ($p = 0.000000000001$). Kazakhstan also has a higher Need for achievement dimension than both Russia ($p = 0.011$) and Latvia ($p = 0.006$). However, Latvian youth had a significantly lower Need for affiliation dimension than youth in Kazakhstan ($p = 0.007$) and Russia ($p = 0.018$). All basic metavalues, such as Metavalue of professional selfrealisation, Metavalue of public self-realisation, Metavalue of vital self-realisation and Metavalue of existential self-realisation, are significantly lower in Russia than in Latvia ($p = 0.004$ for the SEBVR index) and Kazakhstan ($p = 0.00004$ for the SEBVR index). The quality of life enjoyment and satisfaction index in Russia is significantly lower than in Kazakhstan ($p = 0.00006$) and Latvia ($p = 0.02$) and significantly higher in Kazakhstan than in both Russia and Latvia ($p = 0.0001$).

The parameters of the psychological system of activity show that Purposefulness is significantly lower in Russia than in Kazakhstan ($p = 0.012$). Satisfaction with life in Latvia is significantly lower than in Kazakhstan ($p = 0.00001$) and Russia ($p = 0.018$) and significantly higher in Kazakhstan than in both Russia and Latvia ($p = 0.016$). The score of the Personal readiness for activity index is higher for youth from Kazakhstan compared to Latvia on a tendency level ($p = 0.052$).

Stepwise linear regression was conducted to identify which value orientations could be significant predictors of Personal readiness for activity index in each country. The Russian sample collinearity tests confirmed the independence of predictor variables (the tolerance range = 0.80 to 0.96, the VIF range = 1.0 to 1.2), and the assumption of independent errors of residuals was met (the Durbin-Watson value was 1.94) in all four models. The Kazakhstani sample collinearity tests confirmed the independence of predictor variables (the tolerance range = 0.78 to 0.93, the VIF range = 1.28 to 1.1), and the assumption of independent errors of residuals was met (the Durbin-Watson value was 2.08) in all four models. The Latvian sample collinearity tests confirmed the independence of predictor variables (the tolerance range = 0.90 to 0.95, the VIF range = 1.05 to 1.5), and the assumption of independent errors of residuals was met (the Durbin-Watson value was 2.39) in all two models.

Table 5

Cross-cultural stepwise multiple-regression analyses between the Personal readiness for activity index as a dependent variable and values and attitudes

Model	Predictor variable	b	SE	Beta	p	Adjusted R2 (p)
Russian sample						
Model I	Need for achievement	.371	.039	.465	.000	.214 (<.000)
	Constant	2.144	.157		.000	
Model II	Need for achievement	.307	.036	.385	.000	.344 (<.000)
	Subjective happiness	.075	.009	.371	.000	
	Constant	1.615	.157		.000	
Model III	Need for achievement	.299	.035	.374	.000	.379 (<.000)
	Subjective happiness	.061	.010	.302	.000	
	T/S-RV	.118	.029	.190	.000	
	Constant	1.315	.170			
Model IV	Need for achievement	.267	.037	.334	.000	.391(<.011)
	Subjective happiness	.060	.010	.294	.000	
	T/S-RV	.101	.029	.163	.001	
	Need for affiliation	.080	.031	.123	.011	
	Constant	1.209	.174		.000	
Kazakhstani sample						
Model I	Need for affiliation	.293	.047	.411	.000	.165 (<.000)
	Constant	2.508	.197		.000	
Model II	Need for affiliation	.239	.047	.335	.000	.233 (<.000)
	T/S-RV	.144	.034	.278	.000	
	Constant	2.041	.219		.000	
Model III	Need for affiliation	.167	.050	.234	.001	.285 (.000)
	T/S-RV	.130	.033	.252	.000	
	Q-LES-Q index	.231	.062	.256	.000	
	Constant	1.542	.250		.000	
Latvian sample						
Model I	Q-LES-Q index	.602	.093	.638	.000	.398(<.000)
	Constant	1.490	.317		.000	
Model II	Q-LES-Q index	.514	.081	.546	.000	.565(<.000)
	Need for affiliation	.223	.045	.425	.004	
	Constant	.953	.290		.000	

Note. T/S-RV = Traditional values versus Secular-rational values. Q-LES-Q = Quality of Life Enjoyment and Satisfaction Questionnaire.

Table 5 demonstrates the overall significance of value orientations and attitudes in Personal readiness for activity across cultures. The need for affiliation is just one significant predictor of Personal readiness for activity index for all samples. The Russian sample regression model ($F(1, 315) = 53.05$, $p < 0.000$, $R2 = 0.391$, R2 Adjusted = 0.383) showed that Need for achievement, Subjective happiness, Traditional values versus Secular-rational values and Need for affiliation were significant predictors of Personal readiness for activity index, accounting for 38% of the variance. Similarly, the Kazakhstani sample regression model also showed that Traditional values versus Secular-rational values (T/S-RV), Need for affiliation and, in addition, the Quality of Life Enjoyment and Satisfaction index (Q-LES-Q index) accounted for 29% of the variance in mean scores for Personal readiness for activity index ($F(1, 184) = 25{,}70$, $p < 0.000$, $R2 = 0.294$, R2 Adjusted = 0.285). The Latvian sample regression model showed that the Quality of Life Enjoyment and Satisfaction index (Q-LES-Q index), Need for affiliation accounted for 57% of variance in the indicators concerned ($F(1, 60) = 41{,}32$, $p < 0.000$, $R2 = 0.579$, R2 Adjusted = 0.565).

Discussion

Cross-cultural comparison of university student samples showed that most differences in the countries in question were between Kazakhstan vs Latvia and Russia in both value orientations and attitudes and Personal readiness for activity index. The youth from Kazakhstan differs significantly in the Long-term orientation index (the highest score) and Uncertainty avoidance index (the lowest score) compared to the youth from Russia and Latvia. In other words, Kazakhstan youth follow strict behavioural codes, rules, and laws, whereas Russian and Latvian youth face fewer regulations and reveal more acceptance of different opinions. Kazakhstan youth, to a larger extent, have the present- and past-looking attribute, whereas Russian and Latvian youth demonstrate more the forward-looking attribute. Our data suggests a long-term orientation of Kazakhstan youth, which is consistent with the results of Minkov et al. (2018). Our study found significant differences in the Individualism versus collectivism dimensions between Kazakhstan and Russian youth. Russian youth have looser ties and emphasise self-interest and 'I' consciousness, whereas Kazakhstan youth, to a greater extent, have strong social bonding and emphasise group harmony and 'We' consciousness. The results obtained were compared with the ones previously argued that Kazakhstan shared many attributes common to collective cultures (Karibayeva & Kunanbayeva, 2016, Latova, 2016). This demonstrates the differences between collectivistic societies, where cognitive consistency is less important and conforming to situational pressures is more important than in individualistic societies (Suh, 2002; Triandis, 2001). Our conclusion contradicts Temirbekova, Latovb, Latovac & Temirbekovd (2014) who studied 626 students from Russia, Kyrgyzstan, Kazakhstan and Ukraine. The authors revealed that Russian students had the highest power distance, and Kazakhstan students stand out as more individualistic than other countries. Differences can be associated with both the characteristics of the sample and the timing of the study. Russian-speaking young

people majoring in different fields took part in our study. In the study from Temirbekova et al. (2014), the study participants majored in business administration. Last but not least, more than five years passed between these two studies, which could affect value orientations.

Kazakhstan youth also differ significantly from Russian and Latvian youth in the Traditional vs Secular-rational values indicator that depicts a continuum where the traditional side is associated with the importance of existential security, traditional family ties, and the strong presence of religion and hierarchy. Residents from Latvia more often choose secular-rational values, and residents of Kazakhstan, traditional values, Russian people occupy an intermediate position between them within the Traditional values versus Secular-rational values continuum.

Furthermore, the differences between Kazakhstan vs Latvia and Russia connected with personal well-being, such as the quality of life enjoyment and satisfaction scales (the total index and the physical health, subjective feelings, and leisure time activities scales), subjective happiness and satisfaction with life. This highlights the importance of collectivist and traditional values and feelings of happiness and well-being among the youth of Kazakhstan.

In addition, higher scores in purposefulness and personal readiness for activity index in youth from Kazakhstan may also connect with their adherence to traditional values compared to those in Russian and Latvian youth. Such value orientations may result in a desire to follow a certain algorithm to achieve one's purposes.

The study participants from Russia and Latvia have more pronounced individualism dimensions and secular-rational values, but these samples may differ in their motivation. Russian youth seem to be more focused on personal achievements and social support, and they appreciate putting in hard work to achieve goals and the attention of others. Latvian youth showed a higher subjective evaluation of possibilities for realising their basic values in their local settings in the case of Metavalue of professional self-realisation and Metavalue of existential self-realisation. This may signal their greater desire to rely on themselves and a more realistic view of their opportunities.

In general, our data reports on the reasonable links between the Personal readiness for activity index and cultural dimensions, value orientations and psychological indicators, such as Uncertainty avoidance index, Long-term orientation index, Indulgence versus restraint index, Traditional values versus Secular-rational values, Need for achievement, Need for affiliation, SEBVR index, Q-LES-Q index, and Subjective happiness. This could mean that active young people feel happier and more satisfied than passive people. A predisposition to secular-rational values, a desire for affiliation and achievement, a long-term perspective, hardiness and mindfulness characterises them. The mechanisms underlying the relationship between well-being dimensions and personality ones in the context of one's readiness for activity involve psychological factors. One possible explanation is that happy and successful individuals have more freedom to determine their own life pathways and make choices (Diener, Diener & Diener, 1995). Attribution of success in life to one's own actions may also contribute to higher levels of well-being (Diener et al., 1995). This is partially consistent

with our results; Kazakhstan youth have a more pronounced feeling of happiness and well-being and a higher degree of personal readiness for activity.

We tried to answer the question of what cultural dimensions, value orientations and psychological characteristics could be predictors of personal readiness for activity in Russian, Latvian, and Kazakhstan youth. There was only one dimension: the need for affiliation was common across all countries as a predictor of young people's personal readiness for activity. However, in all samples, the need for affiliation described a small part of the variance in the mean scores for the Personal readiness for activity index. Personal readiness for activity in Russian students depends on their desire for achievement and level of happiness. In the Kazakhstani and Latvian samples, the most important input was provided by the Quality-of-Life Enjoyment and Satisfaction index. The Russian sample differed more from the samples of Kazakhstan and Latvia, which have more similarities.

Conclusion

1. Cultural dimensions, traditional versus secular-rational values, need for achievement and affiliation, feelings of happiness and well-being have medium and high correlations with personal readiness for activity.
2. Cross-cultural variance was established for most values and cultural dimensions in the Russian, Kazakhstani, and Latvian samples. The cross-cultural similarity was established in the psychological system of activity for the three countries; personal readiness for activity was different on a tendency level.
3. Need for affiliation is common in all countries as a predictor of young people's personal readiness for activity, but it describes a small part of the variance. The Russian university students' personal readiness for activity depends on their need for achievement and level of happiness. In the Kazakhstani and Latvian samples, the most important input was provided by the Quality-of-Life Enjoyment and Satisfaction index.

To sum up the study outcomes, it should be noted that the study focus was on examining the relationships between value orientations, attitudes and the psychological system of activity in young people in post-Soviet countries. To reveal cross-cultural differences, if any, in psychological variables in question and relationships between them, three samples of youth (Russia, Kazakhstan and Latvia) who do not differ in age or gender were involved in the study concerning the period they had lived in the countries. Our research continues the tradition of cross-cultural studies investigating cultural diversity in the post-Soviet space (Minkov et al., 2018; Becker et al., 2018) and expands the research by considering youth as a platform representing social progress, human capital and socio-economic and political development (Lebedeva & Tatarko, 2019; Atamanova et al., 2019). We have found that value orientations affect personal readiness for activity. However, there are more differences in these relationships than similarities between youth from Russia, Kazakhstan and Latvia. It is important to consider the cross-cultural value differences in the context of youth's personal and professional development.

Limitations

One of the limitations of this study is that all the participants were Russian-speaking young people. Differences probably exist in value orientations and parameters of the psychological system of activity among Kazakhstan and Latvian youth who do not speak the Russian language. The second limitation concerns the generalisability of the findings because of the study design (a snowball sampling technique was applied). In order to achieve more robust results in cross-cultural research, the selected samples should include participants from a wider range of social and regional groups.

Ethics Statement

The study followed the ethical guidelines of the institutional ethics review board, and it did not require special ethical approval because research procedures had no more than minimal risk.

Author Contributions

Sergey Bogomaz and Inna Atamanova conceived of the idea. Baizhol Karipbayev, Tatyana Filippova, Diana Zagulova, and Inna Atamanova collected the data. Ekaterina Perikova performed the computations and prepared the original draft. Inna Atamanova performed review and editing of the manuscript. All authors discussed the results of the study and contributed to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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PERSONALITY PSYCHOLOGY

Free Will as a Paradox: Empirical Evaluation of the Construct of Everyday Consciousness

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Background. Free will belongs to the category of phenomena that are actively discussed in scientific discourse but are neither verified nor proven false. Free will is studied in philosophy, neuroscience, and psychology. We discuss this pluralism, multiplicity of perceptions, and the parties' arguments in the theoretical part of this article. We approach the existing polemics from the point of view of a person who is in the moment of making a decision and taking responsibility for it. The usual paradoxes are mitigated if we consider free will through the concepts underlying everyday consciousness.

Objective. Our aim is to introduce into the discussion of free will an understanding of its nature as a construct of everyday consciousness, one which acts as a factor in increasing the personal maturity of vital decisions. We also discuss the arguments of the various meta-positions in the dispute about free will.

Design. Our empirical research was designed as a modification of the experiments on imposed attitudes. The sample consisted of 340 people ages 30–50 years.

Results. The level of maturity of actions by the subjects who received the set for determinism was lower than that of the subjects who received the set for free will (U 5133; $p = 0.014$).

Conclusion. Our study showed that the stronger a person's belief in free will, the more personally mature that person's choices — actions — are; and that the more active that belief in free will, the more effective are their efforts to overcome social pressure.

Keywords:
free will; belief in free will; neuroscience; deed (action); decision making; personality; free will as illusion.

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Introduction

The idea of free will has a long history of discussion which stems from philosophy, but philosophers still do not agree on what free will means. Thus it would be misleading to specify a strict definition of free will since, in the philosophical works devoted to this notion, there is probably no single concept of it (*The Stanford Encyclopedia of Philosophy*).

However, the lack of a common understanding of basic terms is a fairly frequent phenomenon for the sciences. Here the paradox is that not only is the status of the concept a matter for debate, but the very existence of free will as a subject of research remains unclear. On the one hand, this concept, speculative by nature, could remain the prerogative of philosophy: it has no ontological referent, and is not perceived sensorily; it is neither verified nor proven false. On the other hand, the idea is used in many different sciences, probably due to its exceptional social significance.

Free will, defined as "the idea or belief that individual people have volition and the capacity to choose their own courses of action without being fully determined by internal or external forces" (*The Cambridge Dictionary of Psychology*, p. 211–212), is traditionally opposed to rigid determinism, which considers free will nothing more than a subjective illusion. In contrast to determinism, the fundamental nature of the concept of free will is revealed in social practice, both from the side of the actor (whether a person has the right to decide), and from the side of society (whether the person bears responsibility for his/her actions). In this light, the abundance of studies on the attribution of responsibility for offenses is understandable (Nestor, 2018; Anderson, & Kiehl, 2020; Genschow, Rigoni, Hawickhorst, Aschermann, & Brass, 2020; Pundik, 2020), but free will itself has remained outside the scope of research.

The most determined — and most resonant — attempts to deny the existence of free will are made in neuroscience. Many authors (Bargh, 2008; Montague, 2008; Cashmore, 2010; Filevich, Kühn, & Haggard, 2013; Klucharev, 2017) defend the idea of lack of free will. However, even in that camp there is far from unanimity (Bode, Murawski, Soon, Bode, Stahl, & Smith, 2014).

The substitution of a phenomenon caused by terminological coincidence is also very destructive: will-defined as a decision-making process — is mixed up with will — seen as a resource for achieving a set goal. For example, Gailliot, Baumeister, DeWall, Maner, Plant, Tice, Brewer, and Schmeichel (2007) experimentally investigated free will as the source of self-control and concluded that it is a limited resource and, therefore, can deplete. Job, Walton, Bernecker, and Dweck (2013) questioned the depletion effect. As a result, the debate has not been about volition, but about will as an effort to overcome obstacles.

It has already become commonplace to say that "there remains wide-ranging disagreement and confusion" over the concept of free will; that psychologists are exploring "self-control, rational choice, planning, and initiative;" and that "philosophers still debate whether humans truly have free will" (Baumeister, & Monroe, 2014, p. 2). Attempts to substantiate the middle position that person's decisions are both free and causally conditioned have not yet gone beyond linear ideas.

The unceasing debate over the very existence of free will indicates the need to understand its ontological status as a phenomenon. The **objective** of this current work is

to discuss ways to solve this problem: to bring into the discussion an understanding of free will as a construct of everyday consciousness, which acts as a factor in increasing the personal maturity of vital decisions, and to discuss the arguments of the meta-position in the dispute about free will.

Brain — No Will, No Freedom?

Representatives of the popular and powerful area of neuroscience, which describes mental processes in terms of neural processes, take the extreme position. Based on the natural science tradition, they actually reduce the psyche to brain activity. Nevertheless, we are interested in the trends and the range of arguments they use, which we will briefly outline.

Experiments by B. Libet are often taken as a starting point in reviews. The author himself spoke about the results he obtained with research precision: "Freely voluntary acts are preceded by a specific electrical change in the brain (the "readiness potential" or RP) that begins 550 ms before the act. Human subjects became aware of intention to act 350–400 ms after RP starts, but 200 ms before the motor act" (Libet, 1999, p. 47).

This experimental result was interpreted as evidence of a person's lack of free will (Tancredi, 2007; Wegner, 2002). V. Ramachandran (2003) in the Reith Lectures said: "All the richness of our mental life — all our feelings, our emotions, our thoughts, our ambitions, our love life, our religious sentiments and even what each of us regards us his own intimate private self — is simply the activity of these little specks of jelly in your head, in your brain."

The extreme nature of such judgments is easily revealed. Noting the complexity of making arbitrary decisions, L. Deecke identifies three types: What to do, How to do, and When to do.

"After the 'what to do' and the 'how to do' questions are solved, all that is left to be decided is the 'when to do', *i.e.,* to decide the right moment to start the action. This is the task of the frontomesial cortex, including the SMA. The 'when to do' is the final question in the motivational chain and is so close to the start of the movement — and time-locked to it — that it can be recorded by the RP[1] paradigm, while the other two decisions ('what to do' and 'how to do') cannot be directly investigated by our experimental paradigm" (Deecke, 1996, p. 59-60).

The distinction proposed by Deecke makes it possible to evaluate Libet's method in a different way: the experimental design prescribed what the subjects should do and how to do it (move a finger), limiting their decision only to a simple "when." Libet thus reduced the humans' nature as subjects of volition in two ways, not only by limiting them operationally, but also leaving the motivational and value components outside his research. Yet, these are the components which, in fact, constitute the nature of free will! The experimental hardware creates a scientific aura which masks a serious **methodological error**.

A number of physiologists are quite aware of this. D. Ploog, a researcher on the neurobiological foundations of the behavior of great apes, writes that the problem of

[1] RP — readiness potential.

will in the aspect of neuroscience is considered "most often with surprising naivete" (Ploog, 2012, p. 439). The author adheres to the principle of causality for the entire spectrum of natural sciences but assures us that the chain of causality "in brain research ends in the immediate past. The principle of cause and effect can only be applied to the past, and not to future events" (*ibid.*). A similar position is taken by the neurophysiologist and primatologist R. Sapolsky, who limits the deterministic influence on the part of neural structures to *one second* (Sapolsky, 2017, p. 26-77).

We should note that there are signs that natural scientists implicitly recognize their basic methodological error. Firstly, interpretations are gradually becoming more cautious and less unambiguous; for example, instead of "neural localization," the term "neural correlate" is now used (Polák, & Marvan, 2018; Koch, Massimini, Boly, & Tononi, 2016). Secondly, in improving their experiments, supporters of the natural science paradigm have begun to provide subjects with more and more freedom, bringing laboratory conditions closer to natural ones (Perez, Mukamel, Tankus, Rosenblatt, Yeshurun, & Fried, 2015). Thirdly, hoping to get experimental designs that are free from criticism, a number of researchers have turned to simpler processes, sometimes expanding their understanding of volition so much that they go beyond the phenomenon of free will. One such focus is the study of "perceptual decisions" (Bode et al., 2014).

Libet's idea has also been developed to the point that, although the individual's decision is allegedly being prepared without the participation of consciousness, once having realized it, the subject can stop its implementation. The subjects of the experiment "were able to exert a veto within the interval of 100 to 200 msec. before the pre-set time to act" (Libet, 1999, p. 51). Here the author of the acclaimed experiments moved from neurophysiology to behavioral phenomena: "All of us, not just experimental subjects, have experienced our vetoing a spontaneous urge to perform some act" (*ibid.*). But "vetoing" means freely realizing one's will, taking responsibility.

There are some very discouraging results (almost in Deecke's terms): "The RP is predictive with regards to the whether and the when, if a known task is performed, but not with regards to the what of the action" (Brass, & Haggard, 2008). It doesn't get any clearer than that. There is an obvious recognition of the limitation on the part of the natural science paradigm, the methodological core of which, within neuroscience, is the model of "computer metaphor."

Probably the controversy over interpretations comes to a dead end because "we are looking in the wrong place": it is difficult to find free will in the body, where it most likely cannot exist. This is where the real paradox comes in! After all, none of the adherents of the deterministic paradigm think of looking for the content of a text written in a word processor on the level of distribution of electronic processes in computer boards, or in the structural elements of a matrix. However, it is this paradoxical logic that is practiced in relation to the brain.

Is the Soul Free?

Distancing ourselves from biological reductionism to consider the problem of the existence of free will, we move on to an alternative logic, a philosophical understanding of the indicated phenomenon. This alternative consists not so much in re-interpreting

the facts as in the choice of basic assumptions. R. Smith (2015), a historian of science, is sure that ascribing free will to neural processes is a categorical mistake, since the language of free will is a psychosocial category and an attribute of people; agency is not something attributable to brains or bodies. The study of agency is hence the study of how people attribute freedom, obligation, and responsibility.

But philosophers also cannot ignore Libet's experiments. Professor A. Mele sees no reason why these experiments should make us doubt the existence of free will. Mele (2006) distinguishes between urges, intentions, and decisions, and divides the latter into distal (related to the future) and proximal (related to the present). This distinction allows him to more accurately analyze experiments: 1) Nothing warrants Libet's claim that, starting around -550 ms, type II RPs are correlated with decisions or intentions rather than with, for example, urges strong enough; 2) B. Libet investigated only the proximal section of a decision, thus leaving the distal decision to participate in the experiment at all outside the scope of his research. "Brain activity preceding conscious decisions reflects the decision process rather than its outcome. Furthermore, the decision process is configured by conditional intentions that participants form at the beginning of the experiment" (Brass, Furstenberg, & Mele, 2019).

Although the philosopher N. Elzein believes that there are compelling reasons to embrace free will skepticism, "these reasons have little to do with the presence of unconscious precursors to the decisions we make" (Elzein, 2020, p. 16).

One of the most influential libertarians today, R. Kane (1994), defines free will as the ability to be the absolute creator and engine of one's own goals and intentions. The physical mechanism for the realization of free will as freedom of choice could be quantum effects in the brain. The decision will not be random, if the situation of quantum uncertainty in the brain corresponds to the situation of psychological struggle when the agent is torn between conflicting motives. It is worth emphasizing that Kane continues to search for physical mechanisms of free will, as if there is a direct connection between them and free will.

Thus, we continue to track the dispute between supporters and opponents of the existence of free will, begun by ancient philosophers, the essence of which was formulated in an extremely condensed form by I. Kant in his third antinomy: there is freedom in the world — there is no freedom in the world, but only causality reigns. The very presence of antinomy — the contradiction between two equally provable statements about a subject — testifies, it seems, to the fundamental unverifiability of the statements. Kant "concludes that freedom is based not on knowledge, but on belief. So, he puts belief above knowledge" (Kalinina, 2009, p. 256).

The **paradox** of the problem of free will is that, despite the formulation of the antinomy on the *epistemological* plane, attempts have been made to solve the problem on the plane of *ontology* for 200 years.

S. Harris (2012) argues that "free will is actually more than an illusion (or less)." Hence, either our desires are conditioned by previous experience, and we are not responsible for them, or they are chance-dependent, and we are not responsible for them either. However, this illusion has an active potential (both constructive and destructive). Therefore, to S. Harris's formula "more than an illusion," we add a paraphrase: ... we embody our desires into life activity, **turning the illusion into reality**.

Thus, the research question of free will is not solved *with the help of belief*, but it is *thanks to it* that free will is constituted. Free will is generated by the very act of believing in it.

Free Will is Generated by the Person

We intend to test the lateral (it would be excessive to call it alternative) logic for solving the problem of free will. Namely, additional opportunities open up when we distinguish between the viewpoints from which this problem is considered. From the *standpoint of a researcher*, the question of free will, as already discussed, is the subject of a hypothesis, and thus the question can remain unanswered for an indefinitely long time. But from the *standpoint of a participant in real social practice*, the problem of the presence/absence of free will needs to be solved almost immediately: making a decision and bearing responsibility for it before the community — performing a deed!

Therefore, in both the academic conceptualization and laypersons' understanding, the concept of free will is not a magical metaphysical notion, but rather a reference to choice, agency, and unconstrained action (Feldman, 2017).

The transition from the position of the researcher to the position of the (real life) actor necessarily moves us into the sphere of psychology. Note how G. Feldman formulated the definition of the construct under discussion: "The belief in free will is a generalized lay-belief regarding the capacity for human choice — "Do I (and others) have a choice, and if so, can I (and others) freely choose to do otherwise?" As a belief, it captures a mental representation by a person who believes there's a link between an object, in this case humans, and an attribute, in this case "free will," or the capacity for choice" (Feldman, 2017, p. 4). Note the grammatical formulation use of the first person ("I"), which reflects the change in position from an observer (third person) to a doer (first person).

But here, too, there is reason to be surprised: Social and psychological studies of free will are conducted as if this freedom of choice is influenced exclusively by social pressure. A typical example of such research is the experimental imposition of alternative beliefs on subjects, testing the presence or absence of free will.

In 2008, K. Vohs and J. Schooler (2008) investigated the relationship between the belief in free will and human behavior. This and subsequent studies by social psychologists have revealed interesting effects, as follows:

Attenuated free will beliefs led to:

- Less self-knowledge, such that participants reported feeling more alienated from their true selves and experienced lowered perceptions of authenticity while making moral decisions (Seto, & Hicks, 2016).
- Increased aggression and decreased willingness to help others (Baumeister, Masicampo, & DeWall, 2009).
- Reduced gratitude for help both in the real past and in a hypothetical scenario (MacKenzie, Vohs, & Baumeister, 2014).
- Participants' being more passive, exhibiting a reduction in intentional engagement (Lynn, Van Dessel, & Brass, 2013).

- Heightened conformity and copying of the opinions of others (Alquist, Ainsworth, & Baumeister, 2013).
- Perceived meaninglessness. Reducing self-awareness to the goal of reducing existential conflict (i.e., conflict related to psychological and philosophical values), thus making conformity the regulatory goal (Moynihan, Igou, & van Tilburg, 2018).

Vice versa, *belief in free will* is linked to feelings of belonging and subjective significance (Moynihan, Igou, & van Tilburg, 2017), the sense of freedom to act, and the conviction that we are the authors of our actions and are actively engaged with the world (Seto, & Hicks, 2016).

There is a strong indication that belief in free will is positively associated with *greater personal maturity* (an empirical verification of this interpretation is presented below). Conversely, belief in determinism when making decisions reduces a *person's personality potential*.

Perhaps the strongest concomitant of belief in free will is the sense of agency. This is substantiated in detail in the work of G. Feldman, where the key idea is as follows: "The belief in free will is different from other constructs in that it conceptualizes agency as being about the capacity for choice" (Feldman, 2017, p. 5). Here the importance of choice lies in the fact that it is a fundamental factor in understanding the human psyche and a defining feature of human existence.

However, the question remains as to how the construct of "free will" and belief in free will does its constructive work, and what processes it activates to increase a person's personality potential. In his work, G. Feldman (2017), who views the essence of free will through the concept of choice[2], turned to the phenomenology of performing actions. This is not by accident, since it is not enough to believe in a construct; you also have to act in accordance with your belief, *i.e.,* make choices. The author paid special attention to a person overcoming constraints in making choices. Actually, it is this overcoming of causal determinants that makes the will free, affirming a person's subjectivity.

In terms of cultural-historical psychology, the construct "belief in free will" is a cultural tool (psychological tool), "a means of internal activity aimed at mastering oneself" (Vygotsky, 1978, p. 55), and of a person's self-creation as a personality which needs self-confirmation, self-realization, and self-actualization. "Free will should be understood not as a philosophical, theological, or biological property of all human action, but rather as a way of operating within culture" (Baumeister, & Monroe, 2014, p. 10).

Indeed, in order to be able to exist in his culture, a person needs to have a psychological tool that allows him or herself to show autonomy in relation to hereditary and environmental factors. K. Dąbrowski calls free will the "third factor": "Its activity is autonomous in relation to the first factor (hereditary) and the second (environmental) factor. It consists in a selective attitude with regard to the properties of one's own character and temperament, as well as to environmental influences" (Dąbrowski, 1973, p. 80).

[2] The term "choice" appears 49 times in the work under discussion.

When making a personal choice (deciding to act), biological determinism and social demands are recognized as possible constraints, but are accepted or rejected by means of the construct "belief in free will." The more active a person's belief in free will, the more free his will is, both from predetermined biological processes and from the pressure of social prescriptions.

In turn, free will as a social construct is also necessary for society itself to ensure that a person takes personal responsibility for the results of his or her own choices and deeds.

Research hypotheses:

1. A free will attitude contributes to an increase in the personal maturity of a person's actions. A deterministic attitude contributes to a decrease in the maturity of actions.
2. The work of the personality is expressed through overcoming social pressure.

Methods

Our sample was comprised of 340 people, ages 30–50: 178 (52%) were women and 162 (48%) were men. They were divided into the following groups:

- Group with a deterministic attitude: 113 people, of whom 56 (49.6%) were women, and 57 (50.4%) were men.
- Group with a free will attitude: 112 people, of whom 61 (54.5%) were women and 51 (45.5%) were men.
- Control group: 115 people, of whom 61 (53%) were women and 54 (47%) were men.

Procedure

Data collection was carried out via the Internet. The respondents' participation was voluntary and not paid. Before starting work, the subjects received the following message: "Purpose of the study: to find out how people make important decisions for themselves. Please be free in your choices; there are no right or wrong answers. We guarantee that all data will be used only for scientific research purposes in an anonymous form."

The first group of subjects (having being presented with a deterministic interpretation — no free will) read excerpts from a book by S. Harris (10 quotes). For example: "Our wills are simply not of our own making. Thoughts and intentions emerge from background causes of which we are unaware and over which we exert no conscious control. We do not have the freedom we think we have."

Instructions: "Sam Harris is a PhD in Cognitive Neuroscience and a renowned American publicist and popularizer of science. Below are quotes from his best-selling book *Free Will*, translated into many languages. Read the quotes, comprehend, and evaluate your attitude toward them, where: 1 = definitely disagree; 2 = disagree; 3 = not sure; 4 = agree; 5 = definitely agree."

The second group (having being presented with a nondeterministic interpretation — free will exists) read excerpts from a book by V. Frankl (10 quotes). For

example: "Man is not fully conditioned and determined but rather determines himself by whether he gives in to conditions or stands up to them. Man does not simply exist but always decides what his existence will be, what he will become in the next moment."

Instructions: "Viktor Frankl is an Austrian psychiatrist, psychologist, and neurologist, the creator of logotherapy. Frankl is the author of books that have undergone a fabulous number of reprints in dozens of languages around the world. Below are quotes from his book *Man's Search for Meaning*. Read the quotes, comprehend, and evaluate your attitude toward them, where: 1 = definitely disagree; 2 = disagree; 3 = not sure; 4 = agree; 5 = definitely agree."

All the quotes had a vivid emotional and semantic form of expression and unambiguously reflected the author's position regarding the "free will" construct.

The third control group filled out the P. Oleś "Internal Dialogical Activity Scale" adapted by D. Astretsov and D. Leontiev (2015).

In addition, members of all three groups were asked to make a decision in five difficult life situations which required action.

The stimulus material was constructed based on theoretical ideas about the action; five real life situations were formulated, each of which contained a certain choice of conflicting values that required resolution (see details in Dotsenko, Startseva, & Pchelina, 2020). Each situation had six ready-made solutions offered and one open answer, which would involve a personal decision by the subject (which would be subject to expert judgment on the part of researchers about its degree of personal maturity). The level of maturity was assessed in accordance with the types of action decided upon (Dotsenko, 2009; Dotsenko, Startseva, Pchelina, Karaberova, & Ivantsova, 2020) and received a score from 0 to 8, where 0 was the refusal to make a decision and take any action (refusal to perform a deed), and 8 was a creative solution that supported two or more values at once (the most mature act). To translate meaningful choices into figures, standardized coding was used and, in controversial cases, five expert judgments were solicited.

The results were processed using the SPSS Statistics20, STATISTICA10 software.

Results and Discussion

As we can see in *Figure 1*, the level of maturity of action by the control group is approximately equidistant from the other two. The level of maturity of actions by the subjects who received the set for no-free-will statement is lower than the level of maturity of actions by the subjects who received the set for free will (Mann-Whitney U test 5133; $p = 0.014$). Therefore, we are entitled to conclude that the statements influenced the formation of the subjects' attitude, thereby supporting hypothesis 1.

However, the subjects were asked not only to read excerpts from books, but also to express their *attitude* toward the quotations: to accept or reject the messaging. We did not impose a ready-made attitude, but provided an opportunity for the subject to declare (take!) **their position** in relation to the idea of free will. The experimental task served as a model of a real life situation: 1) the subjects were gently pressured in

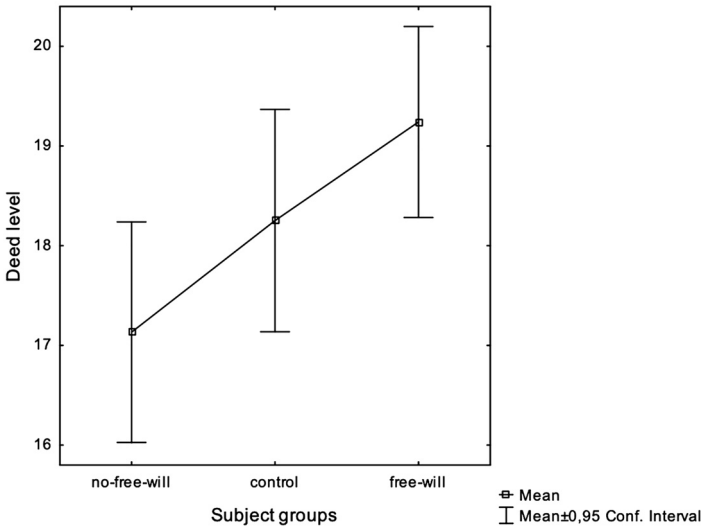

Figure 1. Indicators of the maturity of actions by persons with different beliefs in free will in the three groups of subjects

favor of free-will or no-free-will; but 2) they were able to take and express their own positions by scaling their agreement/disagreement with the proposed statements.

Therefore, it is reasonable to pose the following research question: Did all the subjects agree with the statements proposed to them (attitudes towards no-free-will or free will), and what were the levels of actions of those who agreed versus those who protested?

We got the general picture (shown in *Figure 1*), and there were shifts. Now we are not interested in all the subjects, but only those who actively resisted the pressure of "authorities," and those who (almost) completely agreed with the proposed theses, in other words, our attention is drawn to "tails" of distributions.

Table 1

Groups of subjects depending on the attitude to the proposed excerpts from books (sets)

Set Position	free-will	no-free-will
Expressing agreement	"free-will" (+)	"no-free-will" (+)
Expressing disagreement	"free-will" (-)	"no-free-will" (-)

To obtain these fractional groups, we used the filter *Mean* ± *Standard deviation*. Subjects *Min.* ≤ *n* < Mean – *Stv. Dev*. by the parameter of belief in free will formed the "free-will" (–) group, and by the parameter of no-free-will, the group "no-free-will" (–). Subjects *Mean* + *Stv. Dev.* > *n* ≥ *Max*. by corresponding parameters were divided into the groups "free-will" (+), and "no-free-will" (+).

The effects of the subjects' attitudes toward the proposed sets are clearly visible in *Figure 2*. The positive attitudes toward both the idea of no-free-will and the idea

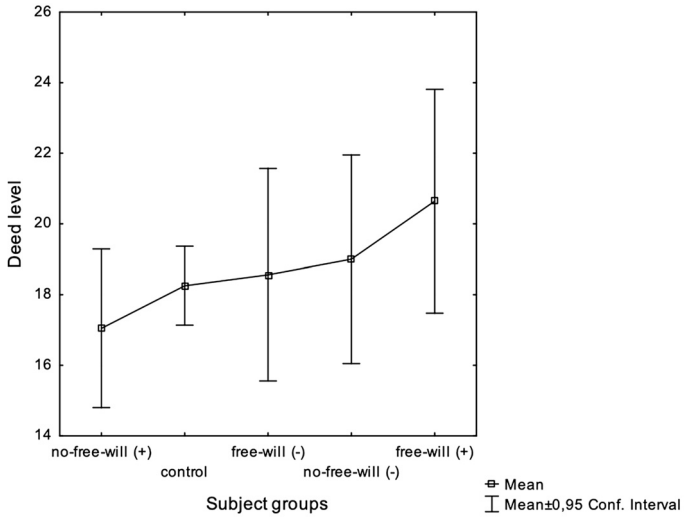

Figure 2. Indicators of the maturity of deeds in persons with different beliefs in free will in the three groups of subjects

of free will, measured by the maturity of their actions, were the most polarized. The level of maturity in the subgroup "free-will" (+) was higher than in the subgroup "no-free-will" (+) at U 90.5, p = 0.041 (the level of significance has become somewhat worse, due to the smaller size of the subgroups).

Disagreement with the experimental sets moved groups of subjects to opposite poles, which is quite meaningful and theoretically expected. So, the "free-will" (-) group is almost equalized with the control, and "no-free-will" (-) is noticeably approaching the free-will pole. This is a very striking result: **the work of the individual overcomes the pressure of the authorities** to whose statements the participants of the experimental groups were exposed. The attitude toward the construct of "free will" is a means by which a person asserts his/her subjectivity. Efforts to overcome the press of circumstances reveal the essence of personal work: the subjects who objected to the set for no-free-will ["no-free-will" (-)], showed a high level of personal maturity of their actions. Consequently, our second hypothesis found its empirical proof.

Thus, belief in free will, its incompleteness (limitedness) or absence, as a person's value-based position, found its embodiment in the level of personal maturity of his/her actions. And the more the belief in free will was actualized, the more mature personal choices were made.

Conclusion

Understanding the results we obtained opens up the possibility of supporting the following ideas.

Biological reductionism stops us from finding free will. The abundance of efforts to reduce the phenomenon of free will to biological processes — with a wide

range of conflicting results — allows us to make two plausible explanations. First, during such reduction, the phenomenon in its essence disappears; biologization kills freedom, which corresponds exactly to the deterministic nature of biological processes. Second, free will cannot be the subject of an ontological approach; it is a phenomenon of an epistemological plan.

A Social Construct is a psychological tool. Free will as an epistemological reality is a social construct that has the properties of a cultural means (historically conditioned environment). Society uses this means to convince its members to believe in their ability to be free to choose a line of behavior, as well as to encourage a person to take responsibility for the results of their choices.

The determining action of the "third factor." Humanity has developed a broad repertoire of means to overcome biological limitations, and go beyond their direct action. One of these means is belief. A person has the ability to accept or reject existing constraints (with an arbitrarily chosen degree of freedom), both biological and social. A mature personality uses the construct of free will as a tool for his/her further personal development and self-actualization (actualization of their essential qualities).

The paradox of free will, revealed in scientific discourse, is solved by each individual person in everyday activities, but with varying degrees of success and personal maturity.

Limitations

The main limitation of this study was the restriction of the sample's age to 30-50 years. Therefore, we do not claim applicability of our results to other age groups. Further studies involving people ages 18-30 and older than 50 years can clarify the relationship between the belief in free will and the level of maturity of actions. We will also be able to compare the levels of people's subjectivity, and their ability to overcome the pressure of authorities in subjects of different age groups.

Ethics Statement

All study participants were informed about the purpose of the study, as well as that the data will only be used for scientific purposes in an anonymous form. All subjects participated voluntarily.

Author Contributions

The research idea was created jointly by the co-authors. E.D. paid a bit more attention to theory, and O.P. designed and conducted empirical research. The co-authors performed the analysis of the results and work on the text with equal input. Both authors contributed equally to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Coping and Co-creation: One Attempt and One Route to Well-Being. Part 1. Conceptual Framework

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Background. All life strives to be well, but not all life is well. This suggests that cognition aimed at improving and protecting well-being might share a common core across all life forms: core cognition

Objective. In this first of a two-part theoretical article, we systematically specify the evolutionary core cognition of well-being from the perspective of general living agents. In Part 2 we apply this to identity development and the theoretical approaches to well-being. This first part aims to identify the strategies and conditions for the creation and protection of generalized well-being and describes associated behavioral ontologies.

Results. We defined a set of key terms that, together, specify core cognition. This set comprises quite naturally concepts like agency, behavior, need satisfaction, intelligence, authority, power, and wisdom, which are all derived from the defining properties of life. We derived coping and co-creation as two essentially different, but complementary, behavioral ontologies. Copingis for survival and targeted problem solving and aims to end the need for its activation. Co-creation is for thriving and problem prevention and aims to perpetuate its activation. Co-creation can explain the growth of the biosphere. While both strategies are essential, the successful interplay of their strengths leads to the dominance of one of them: co-creation. Absence of success leads to a dominance of coping: a coping-trap and a strong urge to curtail behavioral diversity. We summarize the key terms of core cognition and the ontologies in two tables with defined terms.

Keywords:
well-being;
agency;
cognition;
coping;
co-creation;
intelligence;
power;
authority

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Introduction

In this theory paper, we rigorously formulate the evolutionary roots of well-being from first principles, namely the basic demands of being and remaining alive. We identify two strategies and associated behavioral ontologies to create and protect the conditions for well-being of humans and other life-forms. Given editorial constraints and the breadth of the topic, we have separated this paper into two parts.

In Section 1 of Part 1 we derive core cognition from first principles as the necessary foundational cognition shared by all of life in the service of being (well). This section ends in a summary table of the defining terms of core cognition. The second half of Part 1 describes the opposing and complementary properties of cognition for survival (coping) and cognition for flourishing (co-creation). This section is summarized in *Table 2*, in which we oppose and contrast the key terms of both modes of cognition as separate ontologies.

Part 2 applies the developed framework. First, we shed a fresh explanatory light on the structure of identity by connecting it to coping and co-creation (in) adequacy. Second, we apply core cognition insights on a metatheoretical level. We contrast the theory of ontological security, as a near perfect example of the coping mode's (only) route to well-being, to the "theory" of psychological safety. This is a typical example of the co-creation mode's route to flourishing, Third, we extend the overview tables.

In the current paper we define a few dozen Core Cognition concepts **in boldface**. If these concepts pertain to core cognition in general, their definition is included in *Table 1*. If the concept, or a specific variant of it, pertains to either coping or co-creation, it is listed in *Table 2*. Together, the separate sets of concepts form behavioral ontologies for coping and co-creation. *Table 2* is organized such that concepts with complementary roles in coping and co-creation are matched. The tables and figures form a summary of this paper.

Section 1 — Core Cognition

Is well-being unique to humans, or animals, or does it pertain to life in general? We argue that well-being is a foundational concept that can best be understood as pertaining to all living entities, through a shared motivation for survival and thriving. In this section we define a set of key terms defining **core cognition** (Andringa, van den Bosch, & Wijermans, 2015): the foundational cognition shared by all life to secure its continued existence and flourishing. In Part 2, we show that core cognition allows us to unify a number of well-known — but still unconnected — phenomena in psychology, such as the structure of identity and how the concepts of security and safety lead, respectively, to states of pathological normality or healthy personal and interpersonal development.

Being by Doing

A living entity is different from a dead entity because it self-maintains this difference. **To live** entails self-maintaining and self-constructing a "far from equilibrium state". The work of Prigogine (1973) showed that, for thermodynamic reasons, such

an inherently unstable system can only be maintained via a continual throughput of matter and energy (e.g., food and oxygen). **Death** coincides with the moment self-maintenance stops. From this moment on, the formerly living entity moves towards equilibrium and becomes an integral and eventually indistinguishable part of the environment.

A living entity "is" — exists — because it "does": it **satisfies its needs** by maintaining the throughput of matter and energy by "*adaptively regulating its coupling with its environment so that it sustains itself*" (Andringa et al., 2015; Barandiaran, Di Paolo, & Rohde, 2009 p. 8). An autonomous organization that does this is called a "living agent" or an **agent** for short (Barandiaran et al., 2009). Note that we refer to an agent when the text pertains to life in general and is part of core cognition. Where we specifically refer to humans we use the term "person". The term "individual" can refer to both, depending on context.

Life is precarious (Di Paolo, 2009), in the sense that it must be maintained actively in a world that is often not conducive to self-maintenance and where both action and inaction can have high viability consequences (including death). We refer to **behavior** as agent-initiated context-appropriate activities with expected future utility that counteract this precariousness and minimize the probability of death. Behavior is always aimed at remaining as viable as possible, since harm — viability reduction — can more easily end a low-viability than a high-viability existence.

A pattern of behaviors that effectively optimizes viability leads to **flourishing**, while a pattern of ineffective or misguided behaviors leads first to **languishing** and eventually to death. Life is "being by doing" the right things (Froese & Ziemke 2009, p. 473). **Viability** is a holistic measure of the success or failure of "doing the right things", since it is defined as the probabilistic distance from death: the higher the agent's **viability**, the lower the probability of the discontinuation of life. A walrus that falls off a cliff may be perfectly healthy, but it has zero viability, since it will die the moment it hits the ground. While healthy, it is in mortal and inescapable danger, and hence unviable. In general, **threat** signifies a perceived reduction of context-appropriate behavioral options that allow the agent to survive. Maximizing viability (flourishing) and minimizing danger (survival) constitute basic motivations of life. In fact, we call any system **cognitive** when its behavior is governed by the norms of the system's own continued existence and flourishing (Di Paolo & Thompson, 2014). This is also a reformulation of "being by doing".

Cognition for Survival and Thriving

Agency entails **cognition**: behavior selection for survival (avoiding death) and thriving (Barandiaran et al., 2009) (optimizing viability of self and habitat). We have argued that cognition for survival is quite different from cognition for thriving (Andringa et al., 2015). Cognition for survival is aimed at solving problems, where a **problem** is any perceived threat to agent viability, interpreted as a pressing need that activates **reactive behavior**. We called this form of cognition **coping**. In humans, (fluid) intelligence is a measure of problem-solving and task-completion capacity and manifests coping. The objective of coping is ending/solving the problems that activated the coping mode, so ideally coping is a temporary state. We refer to the problem-solving

ability, including successful test and task completion ability (Gottfredson, 1997; van der Maas, Kan, & Borsboom, 2014), as **intelligence**.

However, when the agent's problem solving is inadequate and problems are not solved and are potentially worsened or increased, the perceived viability threat remains activated and the agent is trapped in the coping mode of behavior. A **coping trap** keeps the agent in continued threatened viability, and hence in behaviors aimed at short-term self-protection in suboptimal states that are far from flourishing. Maslow (1968) calls this deficiency (D) cognition, since it is ultimately activated by unfulfilled needs. It is a sign that the intelligence of the agent failed to end (solve) problem states.

While the coping mode of behavior is for survival, the co-creation mode is for flourishing. Successful coping leads to solved problems and satisfied needs, and hence to its deactivation. Therefore, co-creation is the default mode of cognition and coping is — ideally — only a temporary fallback to deal with a problematic situation. Continued activation is the success measure of the co-creation mode and avoiding problems (or dealing with them before they become pressing) is, therefore, the main objective of co-creation. It is essentially proactive behavior (thus not just "proactive coping", since successful coping leads to its deactivation). Maslow (1968) refers to co-creation as being (B) cognition, and we described it as pervasive optimization and "generalized wisdom", for reasons which will become apparent. The objective of co-creation is pro-actively producing indirect viability benefits through self-guided habitat contributions that improve the conditions for future agentic existence.

This is known as **stigmergy**: building on the constructive traces of past behaviors left in the environment (Doyle & Marsh, 2013; Gloag et al., 2013; Heylighen, 2016b; 2016a) and that, in the aggregate, gradually increase habitat viability. This expresses **authority** as a shaping force in the habitat (Marsh & Onof, 2008), via influencing others through habitat contributions. **Habitat** is defined as the environment from which agents can derive all they need to survive (and thrive) and to which they contribute to ensure long-term viability of the self and others.

Habitat viability is a measure of the potential of the habitat to satisfy the conditions for agentic existence (i.e., satisfied agentic needs). For example, a habitat can be deficient in the sense that its inhabitants continually have unfulfilled needs (and hence are in the coping mode). The habitat can also be rich, so that pressing needs can easily be satisfied and co-creative contributions can perpetuate and enhance habitat viability.

The **biosphere** grew from fragile and localized to robust and extensive, so we know beyond doubt that life on Earth is, in the aggregate, a constructive force. It is the co-creation mode's contributions to habitat viability that explain this. In fact, the biosphere can be seen as the outcome of stigmergy: the sum total of all agentic traces left in the environment since the origin of life (Andringa et al., 2015). Co-creation and generalized wisdom as the main cognitive ability drive the biosphere's growth and gradually increase its **carrying capacity:** the sum total of all life activity in the biosphere. This makes co-creation the most authoritative influence on Earth. Coping is also an important authoritative influence, but it is limited to setting up and maintaining the conditions for pressing need satisfaction.

Table 1
Core cognition: key terms

Core cognition key concepts with definition	
Core cognition	The cognition shared by all of life.
To live	Self-maintaining being different from the environment.
Death	End of self-maintained difference from the environment.
Need satisfaction	Acquiring and executing the necessities (food and energy) for life (self-maintaining being different from the environment).
Agent	"An autonomous organization that adaptively regulates its coupling with its environment and contributes to sustaining itself as a consequence." (Barandiaran et al., 2009, p. 1).
Behavior	Agent-initiated and context-appropriate activities with expected future utility that counteract life's precariousness and maximize agent and habitat viability.
A need	Something that, when satisfied, protects or increases agent viability.
Viability	Probabilistic distance from death (i.e., discontinued agency).
Agent viability	Agent probabilistic distance to death. To persist, all life needs to optimize viability.
Threat	A perceived reduction of context-appropriate behavioral options to include only those that allow the agent to survive.
Agency	The ability, or a measure of the ability, to self-maintain viability (through need satisfaction) for survival and thriving.
Cognition	The ability to select behavior in the service of the agent's continued existence and flourishing.
Coping and co-creation	Two complementary forms of cognition. Coping is in the service of continued existence and flourishing in the service of flourishing. Successful coping leads to the discontinuation of its activation and promotes co-creation. (These two forms of cognition are opposed in Table 2).
Stigmergy	Building on the constructive traces that past behaviors have left in the environment (increasing habitat viability).
Authority	Expressing stigmergy.

Table 1 (*continued*)

Core cognition key concepts with definition	
Habitat	The environment from which agents can derive all they need to survive (and thrive) and to which they contribute to ensure long-term viability (of self and others). Note that we use the term "habitat" to include other agents, but to exclude the agent. Hence, we can speak of agent + habitat to refer to the whole of existence relevant to the agent.
Habitat viability	A measure of the degree to which the habitat can satisfy the conditions for agentic existence (i.e., satisfies its needs).
Biosphere	The sum total of all agentic traces left in the environment. Since the biosphere grew from fragile and small, to robust and extensive, we can conclude that life is a net constructive force and co-creation has been dominant.
Carrying capacity	A measure of the sum total of the life activities that a habitat can sustain.
Original perspective	A perspective on the world originating as the yet-undeveloped ability to separate individual viability from the combined viability of self and habitat, which allowed primitive life to optimize the whole, while addressing selfish needs and creating the conditions for more agentic life.
Well-being	The process of co-creation leading to high-viability agents, increased habitat viability, and long-term protection of the conditions on which existence depends. Note that this is a process, not a state or the evaluation of a state.
Motivation	Being ready to respond in a context appropriate manner.
Behavioral repertoire	The set of all context appropriate behaviors the agent has access to. Appraisal activates context-appropriate subsets of the repertoire.
Learning	The process to extend the behavioral repertoire and tune the effectivity of individual behaviors to the context
Worldview	The set of all that an agent takes as reliable (true) enough to base behavior on
Appraisal	A worldview-based motivational response to the perceived viability consequences of the present that activates context appropriate behavioral options
Core affect	Mood-level action readiness based on the appraisal of indicators of (un)safety and situationally appropriate activation of behaviors, expressed as motivations to avoid or end (coping) or motivations to perpetuate or to aim for (co-creation)
Resilience	"[T]he capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker et al., 2004)

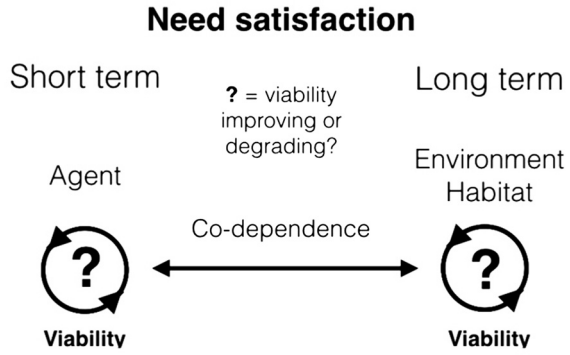

Figure 1. Life's demand: maintaining and increasing viability of self and habitat (based on Andringa & Angyal, 2019). Pervasive optimization of agent and habitat viability leads to increased carrying capacity and more life.

Figure 1 presents the co-dependence of acting agents on their habitat. The habitat comprises the aggregate of agentic activities, but is not an actor itself. Hence, a viable habitat is composed of the sum total of previous co-creative agentic traces that form a resource to satisfy the conditions on which current agentic existence depends. This entails that, signified by the question marks, agents should be aware not only of their own viability, but also of habitat viability. In fact, we have argued (Andringa et al., 2015) that early, primitive life forms were not yet able to separate the self from the co-dependence of self and habitat. This leads to an **original perspective** on the combined viability of agent and habitat, which allowed their primitive cognition to optimize the whole, while addressing selfish needs and co-create ever better conditions for agentic life. This can be termed **pervasive optimization** and it expresses an emergent purpose of life on Earth to produce more life. Albert Schweitzer (1998) formulated a slightly weaker version of this: "I am life that wills to live in the midst of life that wills to live."

Well-Being and Adequacy

Pervasive optimization is the driver of **well-being**. We propose that successful well-being, with a focus on "being" and hence interpreted as a verb, can best be understood as a co-creation process leading to high-viability agents, increased habitat viability, and long-term protection and extension of the conditions on which existence depends.

The two modes of behavior have quite different impacts on the habitat and, by extension, the biosphere. The coping mode is aimed at protecting and improving agent viability with whatever means the agent has access to. Since the objective is avoiding death, the motivation is high, which entails that habitat resources can be sacrificed for self-preservation purposes. **Inadequacy** can be defined as the tendency to self-create, prolong, or worsen problems that keep an agent in the coping mode. When a habitat is dominated by inadequate agents, as is characteristic of a social level coping

trap, habitat viability cannot be maintained, let alone increased. From the perspective of coping, life is at best a zero-sum game.

Alternatively, **adequacy** can be defined as the ability to avoid problems or end them quickly so that coping is effective and rare. Now co-creation is prevalent so that habitat viability is protected, carrying capacity increases, and long-term need satisfaction is secured. Co-creation is, as the term suggests, a *more than zero-sum game*. This is, as argued above, the true basis of well-being. Due to its lack of "co-creation", coping *protects* lower levels of well-being and, at best, resolves (or otherwise takes care of) viability threats (in the sense of removing symptoms of low well-being), while co-creation allows both agent and habitat flourishing.

The inadequacy/adequacy dimension might underlie the proposed single dimension of psychopathology termed p (Caspi & Moffit, 2018; Lahey et al., 2012). This has been conceptualized as "a continuum between adaptive and maladaptive functioning", "successful versus unsuccessful functioning", a disposition for negative emotionality or impulsive responsivity to emotion, and unrealistic thoughts that manifest in extreme cases as delusions and hallucinations (Smith et al., 2020). All descriptions fit with our interpretation of inadequacy as the tendency to self-create, prolong, or worsen problems, and adequacy as the ability to avoid problems or end them quickly.

Welzel and Inglehart (2010) argue, from the perspective of cultural evolution, that "feelings of agency are linked to human well-being through a sequence of adaptive mechanisms that promote human development, once existential conditions become permissive", which is a formulation of the dynamics of *Figure 1*. They argue that "greater agency involves higher adaptability because for individuals as well as societies, agency means the power to act purposely to their advantage". This uses the concept of agency as a *measure* of the ability to self-maintain viability, which is related to adequacy.

Behavioral Repertoire and Worldview

Living agents, per definition, need to express behavior to perpetuate their existence. And with every intentional action, the agent implicitly relies on the set of all that it takes as reliable enough (i.e., true enough in the sense of reflecting reality as it is) to base behavior on. We refer to this set as the agent's **worldview**. A worldview should be a stable basis, as well as developing over time because it is informed by the individual's learning history. An agent's worldview informs its appraisal of the immediate environment. This may be an appraisal of its viability state: whether the habitat is safe or not, or whether it judges the current situation as manageable, too complex, or opportunity filled.

These are basic appraisals shared by all of life that seem to be reflected in the psychological concept of core affect (Russell, 2003). Core affect is a mood-level construct that combines the axis unpleasurable/pleasurable with an arousal axis spanning deactivated to maximally activated. Core affect is intimately and bidirectionally linked to appraisal (Kuppens, Champagne, & Tuerlinckx, 2012; van den Bosch, Welch, & Andringa, 2018); and refers directly to whether one is free to act or forced to respond: whether one can co-create proactively or has to cope reactively. Hence **appraisal** is a worldview-based motivational response to the perceived viability consequences of

the present state of the world. It is motivational, but not yet action. As such, appraisal resembles Frijda's (1986) emotion definition as "action readiness". Which fits with the notion that all cognition is essentially anticipatory:

> Cognitive systems anticipate future events when selecting actions, they subsequently learn from what actually happens when they do act, and thereby they modify subsequent expectations and, in the process, they change how the world is perceived and what actions are possible. Cognitive systems do all of this autonomously. (Vernon, 2010, p. 89)

The anticipation of the development of the world (comprised of self and environment) refers back to what we earlier introduced as the "original perspective" on the combined viability of agent and habitat, which allowed the first life forms to optimize the whole, while addressing selfish needs and creating ever better conditions for more agentic life. Core affect is a term adopted from psychology (Russell, 2003), which we here generalize to all of life. Core affect is a relation to the world as a whole and not a relation to something specific in that world. Like moods, core affect does not have (or need) the intentionality (directedness) of emotions and it is, unlike emotions, continually present to self-report (van den Bosch et al., 2018).

The human worldview is, of course, filled with explicit and shared beliefs, opinions, facts, and ideas interpreted with and filtered by experiential knowledge. This worldview informs whether a situation is appraised as dangerous (whether avoidance or approach is appropriate). This holds also for a general agent: when the agent judges the situation as safe, it can express unconstrained natural behaviors, since it has to satisfy few constraints. If the situation is safe and opportunity-filled, the agent can be interested and learn, but if the situation imposes many constraints, the agent tries to end these by establishing control. And in a deficient environment the agent is devoid of opportunities (which in humans may correspond to boredom or, in case of lost opportunities, to sadness). Core affect then is expressed as motivations to avoid or end (coping) or motivations to perpetuate or to aim for (co-creation). We have depicted this in *Figure 2*.

Appraisal of reality refers to the behavioral consequences of the current state of the world and it is a form of basic meaning-giving that activates a subset of context appropriate behavioral options (van den Bosch et al., 2018). This leads to **motivation** as being ready to respond to the context appropriately. We define the set of all possible behaviors — appraisal- and worldview-dependent — as the **behavioral repertoire**. The richer the behavioral repertoire, the more diverse context-appropriate behaviors the agent can exhibit. The more effective its behavioral repertoire, the more effective the agent becomes in realizing intended outcomes and the more adequate the agent is. Conversely, the less effective the context-activated behaviors, the more inadequate the agent is. **Learning** either reduces the ineffectiveness of behaviors or it expands the behavioral repertoire.

Expanding the repertoire results from an individual discovery path through a representative sample of different environments and participative learning opportunities. Broadening is effortful and potentially risky, but ultimately rewarding. Fredrickson's (2005) "broaden-and-build" theory fits here by proposing that positive emotions — indicating the absence of problems and hence co-creation — help to

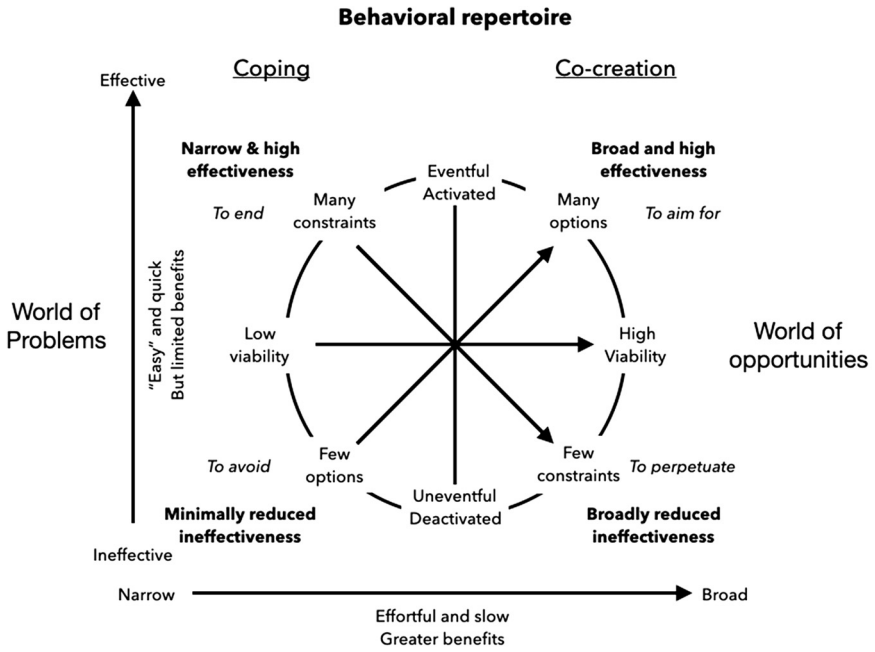

Figure 2. Behavioral repertoire. The concepts around the circle refer to appraisal and the verbs in italic to basic motivations. The descriptions in bold and the outer axes refer to the structure of behavioral (in)effectiveness.

extend the scope of behavioral options. This type of learning leads to individual skills that are, through the individual discovery path, difficult to share. This is manifest in humans as implicit or tacit knowledge (Patterson, Pierce, Bell, & Klein, 2010) and well-developed agency.

Reducing the *ineffectiveness* of behaviors is essential in problematic (coping) situations. This may entail adopting, through **social mimicry**, the behaviors of (seemingly) more successful, healthy, or otherwise attractive agents. The adoption of presumed effective behaviors manifests shared knowledge. Mimicry is a quick fix and works wherever and as long as the adopted behaviors are effective. As a dominant learning strategy, mimicry leads to a coordinated situation of sameness and oneness. Coordinated agents make their adequacy conditional upon the narrow set of situations where the mimicked behaviors work. These agents may be intolerant to others who frustrate sameness and oneness. They may express this intolerance by selecting behaviors that enforce social mimicry on non-mimickers. The more they feel threatened, the more they feel an urge to restore the conditions for adequacy and the more intolerant to diversity they are. In humans this is expressed as the authoritarian dynamic (Stenner, 2005).

Core Cognition: Key Terms

This discourse leads to a selection of core cognition's key concepts and their definition, which is presented in *Table 1*.

Section 2 — Coping and Co-Creation

This section addresses the quite different and complementary features of coping and co-creation. We need both, because successful coping maximizes time for co-creation. The complementarity of the two modes, as two separate ontologies that disagree on many aspects, might be the root of life's **resilience.** Where resilience is defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker, Holling, Carpenter, & Kinzig, 2004). We originate resilience in the agent's ability to anticipate and predict.

Anticipation and Predictability

Coping and co-creation are abilities in psychology, skills, and tacit knowledge (Patterson et al., 2010) expressed as behavior in response and appropriate to how the agent appraises its habitat context. Of course, agent-initiated actions change the habitat state to which other agents may respond, which, in turn, changes the habitat state. Since the habitat may change even without direct agentic influences, agents exist in an evolving world in which they must position themselves to protect and enhance self and habitat viability. To exist in such an environment, the agent needs anticipatory models (Vernon, 2010) of the state of the self and the habitat. It must update these actively, and choose its behavior to realize benefits to the self and the habitat. In this open environment, even the best agent-generated model leads only to partial predictability. Coping and co-creation strategies increase partial predictability, but use different strategies and complementary logics.

Coping

Coping makes the world more predictable by reducing its complexity and creating systems (of agents or objects) with more predictable behavior, which bring threats-to-self under control — which requires energy, resources, and continual maintenance — and promote **security**. The coping mode's goal is to end perceived viability threats, and coping success entails the discontinued need for its activation. Hence, it is goal-oriented (like problem solving and task execution) and endowed with a sense of urgency to avoid (further) viability deterioration that justifies the exploitation of previously created viability. Any deviation from manageable order — unfamiliar events or deviant agent behavior — is seen as an unwanted intrusion to be counteracted. Hence, coping leads to an effortfully controlled environment that minimizes unpredictability and diversity. If the threat level — i.e., the expected negative viability impact — increases, so does the drive to suppress diversity.

Since coping is goal-oriented and intends to reduce complexity, it favors shared rules (in general, shared knowledge) and behavioral mimicry. The more agents follow the same rules with great precision, the more predictable agents and the habitat become. Coping promotes the spread and precise execution of a single set of behavioral rules, and endorses an urge to correct or suppress any unwanted diversity. This is a form of social mimicry (Chartrand & van Baaren, 2009), which might not only lead to the spread of effective behavior, but also to a *"degree of entanglement"* (Combs

& Kribner 2008, p. 264), emergent collective behavior (via mimicry or rules), and a group-level perspective.

In human societies, bureaucracy, the military, large corporations, and strict manifestations of religions and ideologies are examples of coping logic. Technology, from the very primitive to complex, like computers, depicts the best coping by producing precise outputs, as long as the physical environment (the tool and its necessary resources) and the user operate within very tight constraints; this entails trained behaviors.

Coordinated agentic behavior, such as social mimicry, is endorsed by agents who expect benefits from more sameness and oneness. Agents with similar needs share similar coordination benefits, but that is unlikely for agents with different needs or those with other (even potentially better) strategies. In fact, imposed external coordination might be detrimental. Differences in expected benefits lead to a separation into in-groups and out-groups. An **in-group** is a group of agents who express a degree of oneness and sameness through social mimicry and hence share adequacy limits, perceptions of what is beneficial, how to realize these benefits, and what endangers the realization of these benefits. **Out-groups** do not share these limits, either because they have other limits or because they are less limited. By violating sameness and oneness, out-groups frustrate coordinated coping in the eyes of in-groups. Note that out-groups might not even know they are assigned to the out-group and might not raise their defenses.

In-groups (as a manifestation of coping) see the risk of frustrated coordinated behavior as an existential threat, which justifies exploiting or suppressing out-groups and the habitat alike. Habitat and out-group exploitation may activate out-group resistance that makes goal achievement more difficult. So, the better the in-group is able to control out-groups and habitat, the more likely they are to realize the intended results. Due to its problem-solving nature, coping manifests "*the ability to realize intended outcomes*", which is Bertrand Russell's (1938) definition of **power.** Hence coping behaviors are a manifestation of power generalized to generic agents.

The coping mode's manifestation of authority is typically power based, in the sense that it sets up habitat conditions for reduced diversity, increased predictability of agent behavior to facilitate intended outcomes and to bring viability threats-to-self under control (**security**). This is known as coercive authority (as opposed to legitimate authority (Hofmann, Hartl, Gangl, Hartner-Tiefenthaler, & Kirchler, 2017). Coercive power generally (but not necessarily) leads to benefits for the in-group to the detriment of out-groups and the wider habitat: the zero-sum game that in humanity is associated with manifestations of authoritarianism (Stenner, 2005) and the tragedy of the commons (Hardin, 1968).

Co-creation

Co-creation does not reduce complexity; instead, it makes the world more predictable by promoting unconstrained natural behavior and easy need satisfaction through promoting and communicating efforts that facilitate and maintain habitat viability. This creates a safe environment where **safety** is defined as "a situation or state with *positive indicators* of the absence of viability threats" (van den Bosch et

al., 2018). This communicated absence of threats is a logical necessity, since absence can otherwise not be established. The positive indicators of safety — signs of unforced agentic behavior — allow agents in the habitat to co-create without having to be on alert for (unexpected) danger. This allows the uninterrupted functioning of a self-organizing network of interacting agents that satisfy needs most naturally, while minimizing negative impacts and promoting coexistence and even collaboration. Human friendships depend on this logic, and they have, like all co-creation processes, no stable outcome or goal other than providing a safe context for growth and flourishing.

This is the complement of coordinating other agents' behavior (which characterizes coping). Unconstrained natural behavior does not need guidance, since the agents do whatever comes naturally and return to this when constraints are lifted. This harmony between what is possible and what comes naturally stabilizes the habitat, leads to more communicated safety, and increases predictability through the reduction of interagent tension, which otherwise might activate coping as a fallback. Co-creating agents should become aware of the needs of others and what comes naturally to themselves, others with similar needs, others with different needs, and the wider habitat's dynamics. They have to optimize it all in the context of everything else and over all timescales (we referred to this as "pervasive optimization", Andringa et al., 2015), which is a direct reference to Sternberg's definition of wisdom:

> The application of tacit knowledge towards the application of a common good through a balance among intra-, inter-, and extra- personal interests to achieve a balance among adaptation to existing environments, shaping of existing environments, and a selection of new environments, over the long term as well as the short term. (Sternberg, 1998)

This definition is somewhat human-centered and can easily be generalized to all life, all agentic interests, all habitats, and all time-scales. And since tacit knowledge refers to skills, Sternberg's definition can be generalized to "the balancing skills to contribute to the biosphere". This is what we refer to as **generalized wisdom**.

Whereas the application of power generally (but not necessarily) produces benefits to an in-group at the detriment of out-groups, proper co-creation leads to broadly constructive benefits and is a more than a zero-sum game. As we argued, this has driven and arguably still drives biospheric growth. Note that many agents might still suffer; co-creation manifests broad net benefits, not the absence of harm or suffering. Typically co-creating agents form a **community,** a group of individuals who each freely and self-guidedly contributes whatever benefits their adequacy can bring.

Co-creating agents need to act on what comes naturally to agents and habitats. They must learn how to promote more natural behavior and prevent behavior leading to broadly detrimental consequences. The Daoist key term **Wu Wei**, reflects this, since it "*means something like 'act naturally,' 'effortless action,' or 'nonwillful action*' " (Littlejohn, 2003). Characteristically, it completely misses the urgency of coping strategies and the effort associated with exercising power. *Wu Wei* is also a way to be authoritative:

> ... individuals emerge authoritative and powerful as part and parcel of an interconnected web of forces. Therefore, a crucial back-and-forth tug between the self and the various

> influences and authorities surrounding it is woven in the very fabric of what it means to be a fully attained and empowered individual. (Brindley, 2010, pp. xxvii–xxviii)

Wu Wei is a quite different conception of authority, since it does not pertain to realizing specific intended results, but instead is aimed at pervasive optimization (Andringa et al., 2015) and becoming "a fully attained and empowered individual" as "part and parcel of an interconnected web of forces", or what Maslow (1954) refers to as self-actualization. It is this growth process that drives identity development (see Part 2), as much as it promotes general well-being.

Co-creation expresses and relies on highly skilled behaviors of many **responsible autonomous** individuals, who adapt to and use the possibilities of changing situations. As such it is not easy to maintain and somewhat fragile; the highest co-creative quality is difficult to maintain and generally transitory. This is quite different for coping, which relies on more basic strategies such as mimicry and rule-following, and which can be both stable and stultifying.

Two Ontologies

The complementary properties and behavioral logic of coping and co-creation lead often to opposing strategies. Both aim to increase habitat predictability. Coping does that by imposing behavioral constraints and habitat control to counteract adequacy limits. Co-creation instead promotes the creation of a never-stable network of behaviors that come naturally and unconstrained and that distribute the responsibility for habitat viability over all contributing agents. This implicitly assumes that participants are willing and able to alleviate their adequacy limits and grow in their ability to co-create.

Coping and co-creation are both essential, but successful coping is short-lasting and effective; it ends the cause of its activation and restores co-creation as the behavioral default. Unsuccessful coping is ineffective, and hence prolonged. And since the causes for its activation remain valid, it precludes co-creation. This entails that individuals who predominantly cope or co-create develop quite different worldviews, strategies, values, and identities. Hence, they might not be able to understand one another or to collaborate effectively.

Table 2 shows the two separate ontologies of coping and co-creation. It organizes and relates the concepts within each ontology through matching them to complementary concepts and/or roles in the other ontology. That we are able to do that on a consistent basis, suggests not only the structural complementarity of coping and co-creation, but also that we are uncovering some basic tenets of life and cognition.

We consider the selection, matching, and precise formulation of these concepts an ongoing process. Hence, its formulations will develop over time; the formulation in the table is our current best.

In Part 2 of this paper, we apply and extend the proposed framework to identity development and we apply it on a metatheoretical level to two approaches to general well-being: ontological security as a manifestation of coping, and psychological safety as a manifestation of co-creation. This leads to the extension of both tables and an improved definition of co-creation and the two ontologies that comprise it.

Table 2
Ontologies of survival and thriving

Ontology of survival (coping)		Ontology of thriving (co-creation)	
Languishing	Low-viability state as the outcome of a pattern of ineffective or misguided behaviors.	High-viability state as the outcome of a pattern of broadly effective behaviors.	Flourishing
Threat: behavioral constraints	Agent appraisal of viability threats, entailing a *reduction* of the set of context-appropriate behavioral options to include only those that allow the agent to survive.	Agent appraisal of the *absence* of viability threats, allowing self-guided exploration of opportunities that *enlarge* the set of context-appropriate behavioral options.	Safety: behavioral freedom
Problem	A perceived threat to agent viability that activates a pressing need and hence motivates reactive behavior.	A perceived possibility to improve (agent or habitat) viability and hence motivate proactive behavior and the expression of novel behaviors.	Opportunity
Coping	The reactive fallback mode of behavior aimed at protecting agent viability by *ending* problem states. Quick and effective deactivation of coping is the measure of success of the coping mode.	The proactive default mode of behavior aimed at producing indirect viability benefits through habitat contributions that improve the conditions for future agentic existence.	Co-creation
Reactive behavior	Behavior in response to perceived threats to viability.	Behavior aimed at setting up or protecting the conditions for co-creation.	Proactive behavior
Coping trap (Coping failure)	The continual or predominant activation of the coping mode of behavior through ineffective or counterproductive problem-solving strategies.	Prolonged or near-continual activation of co-creation.	Successful co-creation
Targeted optimization	Goal-oriented behaviors such as problem solving and task execution.	Optimizing the whole of agentic existence, while addressing selfish needs and creating ever better conditions for agentic life.	Pervasive optimization
Social mimicry	The adoption of behaviors of effective, healthy, or otherwise attractive agents leading to sameness and oneness.	Skilled contribution of self-deciding individuals who adapt and use opportunities to promote habitat flourishing.	Responsible autonomy

Table 1 (*continued*)

Ontology of survival (coping)		Ontology of thriving (co-creation)	
Learning to become less ineffective	Mimicry-based learning, where behaviors of effective, healthy, or otherwise attractive agents are copied and expressed and hence manifest shared knowledge.	The adoption of new behaviors via interactive engagement with different environments. Manifested as tacit knowledge	Learning as extending the behavioral repertoire
Main mode of cognition: intelligence	The ability to solve problems and fulfill goal-oriented tasks (to end states of pressing need).	The ability to avoid problems and co-create. (Also: The balancing skills to contribute to the biosphere).	Main mode of cognition: generalized wisdom
Inadequacy	The tendency to self-create, prolong, or worsen problems that keep on activating the coping mode. An inadequate agent is predominantly coping, but unsuccessful in ending the activators of coping.	The skill to avoid problems or end them quickly so that coping is rare and co-creation prevalent. An adequate agent is a predominant co-creator.	Adequacy
Coping adequacy	The skill to solve pressing problems (ending the need to cope) or to mitigate their impact through control of the environment and constraining agency (continuing coping).	The skill to avoid and end problems through harmonizing relations, (inter-agent) conflict mitigation, and promoting unconstrained innate behaviors.	Co-creation adequacy
In-group	A group of individuals sharing similar limits on adequacy (and worldview).	A group of individuals who each freely and self-guidedly contributes whatever benefit their adequacy offers.	Community
Out-group	Individuals who violate sameness and oneness and hence frustrate coordinated coping.		
Security	A situation or state where viability threats-to-self are brought under control.	A situation or state with positive indicators of the absence of viability threats.	Safety
Power	The ability to realize intended outcomes by effortfully shaping and controlling the habitat and the activities of the agents that comprise it. Exercising power is a way to be authoritative.	Effortless action expressing authority through harmonizing a diversity of agentic interests by promoting natural agentic dynamics and development.	Wu Wei

Conclusion

In this paper we proposed that human psychology is rooted in core cognition, the presumed cognition shared by all of life. We used the defining properties of life to propose fundamental terms in order to describe the key features of core cognition (see *Table 1*). Many of these terms had already been defined in the context of enactive cognition, psychology, or elsewhere; but had never been combined in a single framework.

We concluded that the main demand of life is to maintain and increase the viability of self and habitat. Pervasive optimization of the co-dependence of agent and habitat is the driver of individual and collective well-being. In the aggregate, this drives/stipulates biospheric growth (see *Figure 1*). In humans, this skill manifests as wisdom.

We defined cognition as the ability to select behavior in the service of the agent's continued existence and flourishing and we described the structure of behavioral (in) effectiveness in terms of both increasing the effectiveness and increasing the scope of the agent's behavioral repertoire (see *Figure 2*). This naturally coupled to core affect, the appraisal of the environment, and motivations.

We derived two complementary and often contradictory ontologies of behavior: co-creation and coping. Co-creation is the default mode that aims to perpetuate itself through preventing problem states by promoting unconstrained natural behavior and easy need satisfaction. Co-creation optimizes all in the context of everything else; it is the cognition for thriving. Coping is the fallback strategy intended to solve problems quickly and urgently by reducing complexity and promoting more predictable behaviors through imposing limits on behaviors and social mimicry. It is the cognition for survival.

An inadequate agent expresses the tendency to self-create, prolong, or worsen problems that keep on activating the coping mode. An inadequate agent remains predominantly in the coping mode, as they are unsuccessful in ending the activators of coping. Conversely, an adequate agent has the skills to avoid problems or end them quickly so that coping is rare, and co-creation prevalent. We suggested that the proposed p, as a single dimension of psychopathology, reflects inadequacy.

While we constructed the ontologies of coping and co-creation (see *Table 2*) we noticed that each entry on one ontology corresponded with a matching, but intrinsically disparate entry, in the other ontology. Since it is not directly obvious why this is the case, it warrants further investigations. Overall, we consider the selection, matching, and precise formulation of these concepts an ongoing process. Hence, conceptual formulations will develop over time; the formulation in the tables is our current best.

Author Contributions

Andringa and Denham conceived and discussed the paper. Andringa developed most of the theory.

Conflict of Interest

The authors declare no conflict of interest.

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Psychological and Electrophysiological Correlates of Word Learning Success

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Background. A rich vocabulary supports human achievements in socio-economic activities, education, and communication. It is therefore important to clarify the nature of language acquisition as a complex multidimensional process. However, both the psychological and neurophysiological mechanisms underpinning language learning, as well as the links between them, are still poorly understood.

Objective. This study aims to explore the psychological and neurophysiological correlates of successful word acquisition in a person's native language.

Design. Thirty adults read sentences with novel nouns, following which the participants' electroencephalograms were recorded during a word-reading task. Event-related potentials in response to novel words and alpha oscillation parameters (amplitude, variability, and long-range temporal correlation dynamics) were analyzed. Learning outcomes were assessed at the lexical and semantic levels. Psychological variables measured using Amthauer's test (verbal abilities), BIS/BAS scales (motivation), and the MSTAT-1 (ambiguity tolerance) and alpha oscillation parameters were factored.

Results. Better recognition of novel words was related to two factors which had high factor loadings for all measured alpha oscillation parameters, indicating the role of attention networks and respective neural activity for enabling information processing. More successful learners had lower P200 amplitude, which also suggests higher attention-system involvement. Another factor predicted better acquisition of word meanings for less ambiguity-tolerant students, while the factor which pooled logical conceptual thinking ability and persistence in goal-reaching, positively correlated with acquisition of both word forms and meanings.

Conclusion. The psychological factors predominantly correlated with word-learning success in semantic tasks, while neurophysiological variables were linked to performance in the recognition task.

Keywords: word learning; semantics; EEG; alpha oscillations; ERP; ambiguity tolerance; BIS/BAS scales

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Introduction

During their lifespans, human beings learn on average more than 40,000 words (Kuipers, Uminski, Green, Hughes, & Aglietti, 2017). Generally, word learning may be posited as including acquisition of novel word forms (phonological and/or orthographic), new meanings (both novel semantics and connections with previous semantic knowledge), and establishing links between them (Mkrtychian et al., 2019). The balance between these constituent parts depends on exact circumstances: for instance, learning a new meaning for familiar polysemic words does not include word form acquisition, whereas synonym or foreign word learning may only require connecting novel word forms to already familiar concepts, which have been previously established for the native language (L1).

While word-form learning has been investigated often, word-meaning acquisition remains largely understudied. In experimental settings, the connections between novel word forms and their meanings could be ascertained using pictures (Apfelbaum & McMurray, 2017; Bermúdez-Margaretto, Beltrán, Cuetos, & Domínguez, 2019); definitions (Bakker, Takashima, van Hell, Janzen, & McQueen, 2015; Liu & van Hell, 2020); or meaningful sentence contexts (Elgort, Brysbaert, Stevens, & Van Assche, 2018; Lauro, Schwartz, & Francis, 2020; Mestres-Missé, Rodriguez-Fornells, & Münte, 2007). In natural situations, new meanings are acquired either through explicit instruction or by inferring them from their contexts (Jenkins & Dixon, 1983); the latter (contextual acquisition) is prevalent for L1 learning (Nagy, Herman, & Anderson, 1985). There are at least two interconnected cognitive mechanisms of contextual learning: associative learning and hypothesis testing (Yu & Smith, 2012). These mechanisms allow the retrieval of correct word-referent pairings from ambiguous learning contexts.

Successful word learning eventually provides one with a rich vocabulary, which supports one's communication abilities and is key for achieving success in various social, educational, and professional fields. Any deficits which impede language learning negatively influence cognitive development and academic achievement. Therefore, it is important to investigate and understand the key factors determining success in novel word acquisition.

External Factors

The external factors of word learning success include the learning materials and methods used. The existing literature on learning conditions has generally focused on second language (L2) learning, probably because L1 is usually acquired in a natural, implicit way, whereas L2 usually needs an explicit learning strategy (in monolingual environments). Arguably, the same factors could be important in terms of L1 learning, for instance, when studying new professional or scientific terminology. Thus, the method of learning (implicit or explicit) could be one of the factors determining learning success (Dickinson et al., 2019; Sobczak & Gaskell, 2019).

Learning outcomes are also affected by the modality of stimulus presentation (Penney, 1989). The results, however, are task-dependent and related to the appropriateness of the specific modality to the task (Welch, DutionHurt, & Warren, 1986).

For instance, it has been demonstrated that spatial tasks involve the visual modality (*e.g.*, Bertelson & Radeau, 1981; Jack & Thurlow, 1973; Kitagawa & Ichihara, 2002), whereas auditory tasks rely on temporal judgment (*e.g.*, Fendrich & Corballis, 2001; Hansen & Cottrell, 2013; Welch et al., 1986).

Moreover, word learning outcomes are affected by the learners' activity — vocal (oral), subvocal (silent), or written repetition (Candry, Deconinck, & Eyckmans, 2018; Junttila & Ylinen, 2020). However, this effect is ambiguous and depends on other factors (Zamuner, Strahm, Morin-Lessard, & Page, 2018). Thus, the advantage of vocal over silent rehearsal was found only for phonologically unfamiliar (but not native-language similar) words (Kaushanskaya & Yoo, 2011).

Finally, many other psycholinguistic variables, such as word length and frequency, number of lexical neighbors, concreteness, emotional validity, and imageability may affect word learning (Ferré, Ventura, Comesaña, & Fraga, 2015). Thus, experimental procedures involve a variety of external factors that have a great impact on word learning success. This makes it difficult to compare the results of different studies and, consequently, highlights the necessity of simultaneous employment of both psychological and neurophysiological approaches in a single study.

Internal Factors

There is ample evidence of the influence of students' psychological features on their learning achievement; these include the level of concentration, attention allocation and maintenance, short-term and motor memory, thinking skills, cognitive control, etc. (Chen & Chen, 2015; Kostromina, Mkrtychian, Kurmakaeva, & Gnedykh, 2017; York, Gibson, & Rankin, 2015; Zohar & Dori, 2003). As for language learning in particular, it has been shown that cognitive flexibility (Ehrman & Oxford, 1995), attention allocation (Schmidt, 2012), and working memory capacity (Kroll, Michael, Tokowicz, & Dufour, 2002) allow students to be more effective in L2 learning.

Crucially, most psychological studies dedicated to novel word acquisition relate to L2 learning. Such studies have, for instance, indicated the role of motivation (Gardner, Lalonde, & Moorcroft, 1985; Gömleksiz, 2001; Karlak & Velki, 2015; Sheu, 2016); anxiety (see Teimouri, Goetze, & Plonsky, 2019, for meta-analysis); tolerance of ambiguity (Genç, 2016); and risk-taking (Yulan & Yuewu, 2020). Motivation has been called "one of the important aspects of second language acquisition" (Anjomshoa & Sadighi, 2015, p. 135). Ambiguity tolerance also appears to facilitate L2 learning (Ghanizadeh & Allahdadi, 2015) and has been associated with various language learning achievements, as demonstrated in grammar, dictation, and speaking test results (Chapelle & Roberts, 1986). The least ambiguity-tolerant learners have also been shown to use more language learning strategies (Sadeghi & Soleimani, 2016). On the other hand, a recent study showed that tolerance of ambiguity did not correlate with vocabulary knowledge but rather had a relationship with self-perceived achievement in L2 vocabulary learning (Başöz, 2015).

As for L1 acquisition studies, they mostly concern native vocabulary learning in childhood. These studies have revealed relationships between vocabulary acquisition and working memory (Verhagen & Leseman, 2016), attention, (Bastianello, Majo-

rano, & Burro, 2018) and other executive functions (White, Alexander, & Greenfield, 2017), as well as inference making (Kim, 2017) and thinking (Kostromina & Nagaeva, 2008). However, there is a lack of evidence of the influence of adult learners' individual differences on word acquisition in L1.

Neuropsychological Correlates

Along with the investigation of the psychological factors involved in language learning, there is a body of neurophysiological studies exploring the brain activity underpinning this process. Many of these were conducted using electroencephalography (EEG), one of the most popular and affordable methods for non-invasive assessment of brain activity. Due to its superb temporal resolution, an EEG is particularly well suited for studying the highly dynamic neural processes subserving the language function. Different electrophysiological measures which can be acquired using EEG are associated with specific psychological functions, and include event-related potentials (ERPs) (Kappenman & Luck, 2012) and oscillatory activity (Klimesch, 2012).

Since novel word learning assumes the acquisition of both new word forms and previously unfamiliar meanings, the ERP components of orthographic and semantic processing are of particular interest. The P200 (or P2) component with a frontocentral positive-going distribution is related to orthographic form recognition (Bermúdez-Margaretto, Beltrán, Shtyrov, Dominguez, & Cuetos, 2020), and its amplitude is correlated with word frequency (Y. Wang, Jiang, Huang, & Qiu, 2021). Moreover, a positive ERP around 200 ms is connected with a top-down control over attention (Morrison & Taler, 2020), and an increase in its amplitude is associated with a decrease in the level of attention (Cnudde et al., 2021).

Another important EEG marker for word processing is N400; this is the negative ERP traditionally associated with semantic processing (Kutas & Federmeier, 2011), which amplitude reduction indicates the integration of novel words into the lexico-semantic cognitive system. Interestingly, it has been shown that a rapidly developed N400 has frontal distribution, whereas, after a consolidation, it typically shifts into centro-parietal areas (Rasamimanana, Barbaroux, Colé, & Besson, 2020).

By measuring the oscillatory activity which is believed to reflect the functioning of large-scale neural networks, properties such as its frequency, amplitude, and the temporal dynamics of oscillatory patterns in specific frequency bands can be assessed. Alpha-band activity (oscillations in the 8-12 Hz range) is of particular interest since these oscillations reflect the general activation of the cerebral cortex and have been associated with many cognitive processes. The most important one is attention (Bastiaansen, Böcker, & Brunia, 2002; Klimesch, 1999), which, in turn, influences visual perception (Hanslmayr, Gross, Klimesch, & Shapiro, 2011), and consequently may affect the success of written word acquisition. Alpha-band oscillations reflect suppression of brain structures irrelevant to a specific task (Jensen & Mazaheri, 2010) and the selection of relevant information (Klimesch, 2012).

One particularly interesting measure of oscillatory dynamics is the so-called long-range temporal correlation (LRTC). This approach to quantifying oscillatory patterns

uses a type of autocorrelation analysis and has been successfully used to investigate a variety of important neural processes such as the excitation/inhibition ratio, system memory, and the efficiency of information transfer (Linkenkaer-Hansen, Nikouline, Palva, & Ilmoniemi, 2001; Linkenkaer-Hansen, Nikulin, Palva, Kaila, & Ilmoniemi, 2004; Linkenkaer-Hansen et al., 2007; Montez et al., 2009; Nikulin & Brismar, 2005; Palva et al., 2013; Smit, Linkenkaer-Hansen, & de Geus, 2013).

Objective

As reviewed above, there are multiple factors at play which potentially affect success in word acquisition. However, there is still a lack of research investigating the psychological and neurophysiological correlates of language learning in an integrative fashion, which could help elucidate language acquisition as a complex multidimensional process.

Our study aimed to investigate both the electrophysiological and psychological correlates of contextual learning of new nouns in the native language. We hypothesized that more and less successful word learners differ in their verbal intelligence, motivation, and tolerance of ambiguity, as well as in their brain responses to novel words in an attention-demanding task.

To explore word learning success thoroughly, we chose five tasks to assess different levels of lexical and semantic word processing. The stimulus preparation, and learning and testing procedures, were developed according to recommendations for neurophysiological studies of language learning and word acquisition (Blagovechtchenski et al., 2019). We used EEG, a non-invasive neuroimaging method with a high temporal resolution, which makes it most appropriate for studying dynamic cognitive processes (Erickson, Kappenman, & Luck, 2018). We assessed the parameters of alpha oscillations, as they provide an objective indicator of the state of attention networks (Klimesch, 2012). The main characteristics of these oscillations (amplitude, variability, and long-range temporal correlations) were analyzed and linked to novel word learning performance.

Since the level of alpha-range activity reflects the level of attention and visual alertness (Bastiaansen et al., 2002; Stothart & Kazanina, 2013; J. Wang, Conder, Blitzer, & Shinkareva, 2010), we anticipated that the amplitude of alpha oscillation would be negatively correlated with word learning success.

It has been shown that fluctuations of ongoing brain oscillations are linked to variability in behavioral responses, particularly, in visual stimulus detection (Zazio, Schreiber, Miniussi, & Bortoletto, 2020). A decrease of alpha power implies a more liberal detection criterion, whereas the opposite is true for its increase (Iemi & Busch, 2018; Iemi, Chaumon, Crouzet, & Busch, 2017). Thus, high variability of alpha oscillation may be linked to more variable responses to the same stimuli. This, in turn, suggests a negative correlation of such variability and behavioral accuracy in time-limited attention-demanding tasks such as Recognition and Lexical decision.

For ERPs to newly learnt words, we expect to see differences in P200 and N400 amplitudes between more and less successful word learners since, for the latter, new nouns may remain orthographically (P200) and semantically (N400) less familiar.

Methods

Participants

Thirty right-handed healthy volunteers (M_{age} = 23.4 year; range = 18–35 years; 53.33% females), all monolingual Russian speakers, participated in the study. All subjects gave their written informed consent and filled out a questionnaire about their demographic characteristics and health. The study protocol was approved by the Ethical Committee of Saint Petersburg University.

Stimuli

Novel words were simultaneously provided with both new word forms and novel meanings. To create novel word forms, four groups of 10 Russian nouns with the same structure (CVCCVCVC, where C is a consonant and V is a vowel) were chosen. The groups did not differ statistically in their lemma and last-syllable frequency. Novel word forms were created by mixing ultimate syllables within the group: for example, вурдалак ([vurdal'ak], eng. vampire) –> вурдакет* ([vurdak'et], a pseudoword). Thus, 40 novel word forms were produced. They were rotated across subjects in terms of their experimental role and were used as either novel words (concrete or abstract) or untrained fillers; moreover, novel word forms were assigned to the meanings in a counterbalanced fashion. Rare or obsolete objects (concrete semantics, 10 items) or abstract concepts borrowed from foreign cultures (10 items) were used for the novel meanings.

Learning Procedure

Each novel word was presented visually in five eight-word sentences (*Figure 1*), which gradually revealed its meaning from the described situational context. Every sentence was first presented word-by-word and then, to ensure understanding, com-

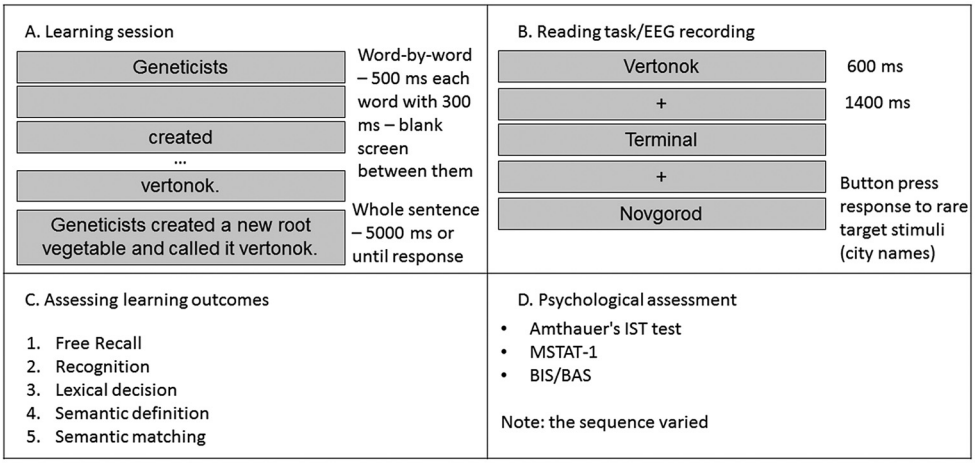

Figure 1. Experimental procedures: contextual learning session (A) was followed by EEG recording during a word reading task (B), behavioral assessment of learning success (C), and psychological assessment of the volunteers (D).

pletely on the computer screen. Participants had to read these sentences sitting in an acoustically and electrically shielded chamber and press a button after reading the whole sentence. Presentation of sentences was managed using NBS Presentation 20.0 software with a black Arial font (size 27) on grey background.

EEG Recording

The 128-channel active EEG actiCHamp setup and BrainVision Recorder, software (BrainProducts, GmbH, Gilching, Germany) were used to investigate the neurophysiological correlates of word learning. The electrodes were applied according to the extended 10–10 system (M1-ext montage by Easycap GmbH, Germany) with FCz as a reference channel, and one EOG electrode was placed under the left eye. 1 kHz sampling rate was used.

The EEG was recorded during a silent reading task. The participants' attention to the reading task was ensured by use of rare target stimuli (city names; 40 items, repeated twice) randomly dispersed among the main experimental stimuli; novel words (20 items, repeated 10 times); and untrained fillers (60 items, equally composed of real words and orthographically similar pseudowords, repeated 10 times). They were randomly presented (black Arial font (size 24), grey background, 600 ms per word, 1400-ms interstimulus interval with a fixation cross) with the instruction to read all stimuli carefully and press the button (response pad RB-740, Cedrus Corp., San Pedro, CA) with the left index finger each time a city name appeared on the screen.

EEG Analysis

Preprocessing. Custom-built scripts in MATLAB 6.0 (MathWorks Inc., Natick, MA) and the Berlin Brain-Computer Interface (BBCI) toolbox (https://github.com/bbci, GitHub) were used for EEG analysis. First, a band-pass filter between 1 and 45 Hz (2th-order Butterworth filters), down-sampling to 250 Hz sampling rate, and re-referencing to the common average reference, was applied to the raw EEG data. Then, the EEG data were visually inspected to remove artefacts, particularly those associated with muscle activity. Independent component analysis was performed and components associated with blinking and eye movement were removed.

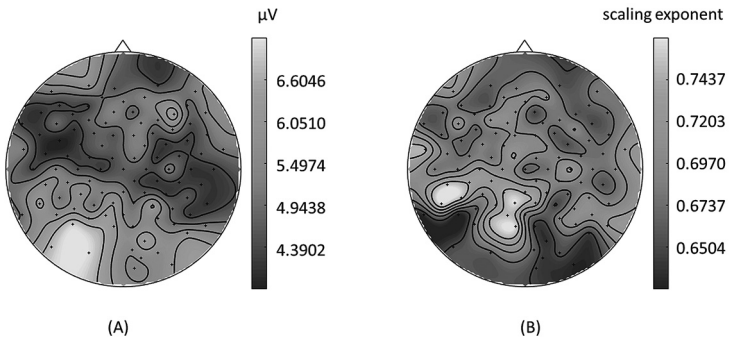

Figure 2. General distribution of amplitude of alpha rhythm (A) and its LRTC scaling exponent (B) averaged for all subjects and conditions

Alpha oscillation analysis. We estimated three parameters of alpha oscillations: amplitude, LRTC, and variability (coefficient of quartile variation, CQV).

Amplitude: The amplitude (extracted with 8–12 Hz band-pass Butterworth second-order filter) was computed using an analytic signal approach based on the Hilbert transform for each subject and each channel over the entire continuous recording. For each subject, all data from all channels were averaged, so we eventually had one mean value of alpha amplitude for each subject (*Figure 2A*).

LRTC: To estimate LRTC, we used detrended fluctuation analysis (DFA) of the amplitude envelope of alpha neuronal oscillations (Kantelhardt, Koscielny-Bunde, Rego, Havlin, & Bunde, 2001; Peng, Havlin, Stanley, & Goldberger, 1995). Note that LRTC refers to the correlation between different time points in EEG activity, not across different spatial locations. Technical details on the use of DFA for the estimation of LRTC in EEG signals can be found in Hardstone et al. (2012). Finally, we had one mean DFA exponent for each subject (*Figure 2B*).

CQV: The variability was estimated from the amplitude envelope of alpha oscillations extracted as described above. It was quantified with the coefficient of quartile variation (CQV), a descriptive statistic based on quartiles' information (Bonett, 2006):

$$CQV = (Q3-Q1)/(Q3+Q1) \qquad (1)$$

In (1), Q1 and Q3 denote the first (lower) and third (upper) quartiles of the data, respectively. Quartiles are the points that divide any ranked data set into four equal groups. Finally, we had one mean CQV coefficient for each subject.

ERP analysis. First, we segmented the preprocessed EEG recording into epochs from –200 ms before the stimulus event (with -200-0 ms interval used as the baseline) to 1000 ms after that. Second, standard deviation analysis was implemented for each segment using the Berlin BCI toolbox in MATLAB (https://github.com/bbci, GitHub). Since both of the expected ERP components (P200 and N400) could be detected above the fronto-central region, and the frontal and prefrontal cortex play a crucial role in the assimilation of new word forms (Eichenbaum, 2017; Plakke, Romanski, & Kikuchi, 2014), we analyzed ERPs measured above this region to assess their activity in the process of novel word learning. We used averaged ERPs from F1, F2, and Fz electrodes (ROI above frontal/prefrontal cortex) to quantify differences in ERP amplitudes between the groups (see below).

Learning Outcome Assessment

Five tasks were chosen to assess the success of learning: 1) Free Recall (performed before the EEG task to avoid the impact of the passive reading task in EEG on the novel word recall accuracy); 2) Recognition; 3) Lexical Decision; 4) Semantic Definition; and 5) Semantic Matching (*Table 1*). Microsoft Excel Spreadsheets were used for tasks 1 and 4, and NBS Presentation software for the others (with the same screen and text parameters as in the learning procedure above). The stimulus set and the presentation procedure for the Recognition and Lexical Decision tasks were the same as for the EEG reading task, with the exception that the latter also included target stimuli

(city names). The integrative variable General Success was calculated as the mean of z-scores of all task results (accuracy and quality, see *Table 1*).

Table 1

Assessing learning outcomes

№	Name	Presented stimuli	Task	Scoring
1	Free Recall	–	To recall all novel word forms without cues	Number of correctly recalled letters (letter strings with fewer than 3 correct letters per word were discarded)
2	Recognition	Novel words, fillers, and controls (words and pseudowords)	To press 'yes' or 'no' response key, depending on whether the stimulus was presented on the learning stage or not	Number of 'yes' answers to novel words
3	Lexical Decision	Novel words, fillers, and controls (words and pseudowords)	To press 'yes' or 'no' response key, depending on whether the stimulus was a meaningful word or not	Number of 'yes' answers to novel words
4	Semantic Definition	Word forms of novel nouns	To type the definition for each novel word	Quality of definition, assessed by four experts, and accuracy of definition — amount of definitions correctly corresponding to the word forms
5	Semantic Matching	Word forms of novel nouns and four options: one appropriate definition, two definitions corresponding to other novel words, and 'none of the above'	To choose the correct definition	Number of correct choices
6	Integrative variable General Success (calculated as the mean of z-scores of all tasks).			

Psychological Assessment

To evaluate conceptual thinking abilities, we used the second (Excluding the Word) and third (Analogies) subtests of the Russian version of Amthauer's IST test (Golovei & Rybalko, 2006). Tolerance of ambiguity was assessed using the MSTAT-I questionnaire (McLain, 1993). Osin (2010) had previously adapted this questionnaire for Russian students and determined the questionnaire's complex two-dimensional structure. For this study, the dimension of attitude toward ambiguous situations was chosen. Thus, we measured two variables - Preference for ambiguous situations (direct scales), and Acceptance/avoidance of ambiguous situations (inverted scales).

BIS/BAS scales were developed by Carver and White (1994) to measure two motivational systems: a behavioral inhibition system (BIS) corresponding to avoiding aversive outcomes, and a behavioral activation system (BAS) which, in turn, consists of three subscales: Fun-Seeking, Drive, and Reward Responsiveness. Fun-Seeking is associated with impulsivity, whereas other subscales are related to reward sensitivity and reaching goals. In this study, we used the Russian version of the BIS/BAS questionnaire adapted by Knyazev and colleagues (2004).

The psycho-diagnostic techniques were selected based on the existing literature. The two scales of Amthauer's test measure semantic conceptual abilities, which play a crucial role in academic success (Kholodnaya, Trifonova, Volkova, & Sipovskaya, 2019). BIS/BAS scales, in turn, measure two motivational systems that underlie human behavior and affect (Carver & White, 1994); this is important due to the role of motivation in language learning, as highlighted in the Introduction. MSTAT-1 was selected because of its present use of contextual learning, which requires readiness to act in ambiguous, unclear situations, such as an encounter with previously unknown words within short story-like sets of sentences. The latter resembles a situation when a child is faced with a new word, which is unfamiliar to them at both the word-form and meaning levels.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics 26.0 software. The reliability of BIS/BAS and MSTAT-1 was evaluated using Cronbach's alpha coefficient. High reliability was revealed for Preference of Ambiguous Situations (0.750), Acceptance/Avoidance of Ambiguous Situations (0.869), Drive (0.775), Reward Responsiveness (0.764), and BIS (0.767). However, Cronbach's alpha was low (0.241) for Fun-Seeking; therefore this subscale was excluded from further analysis.

To minimize the number of variables, psychological and alpha oscillation (amplitude, CQV, and LRTC) parameters were factored using the principal components method with varimax rotation (Kaiser, 1958). Then, correlations between the obtained components and the behavioral task results were calculated using the nonparametric Spearman Rho test.

For paired comparison between groups of subjects with different success levels, the sample was divided into two main groups: less successful learners (LSL), who scored General Success values less than $M - 0.25\sigma$ (17 people, 58.82% male), and more successful learners (MSL), who had General Success scores above $M + 0.25\sigma$ (10 people, 30% male); three participants with intermediate values were excluded from further analysis. The LSL and MSL groups were compared with Pearson $\chi 2$ and Fisher's exact tests for the nominative variable (Gender) and U Mann-Whitney for the others.

Between-group (MSL vs. LSL) comparison of ERP amplitudes, computed in 8-ms bins between 0 and 800 ms, was done using the Wilcoxon test for independent samples (two-tailed) implemented in the MATLAB environment. FDR correction for multiple comparison was implemented.

Results

Socio-demographic Characteristics

Comparison between the LSL and MSL groups showed that they did not differ statistically in Gender ($\chi 2 = 2.095$, p (Fisher's exact test) = 0.236), Age, and Handedness, but more successful word learners had more years of Education (*Table 2*).

Table 2

Socio-demographic characteristics (Mean ± SE or % of total N)

Variable	Sample N = 30	MSL N = 17	LSL N = 10	LSL/MSL comparison (U Mann-Whitney)	Correlation with General Success (Spearman's Rho)
Age	23.43± 0.74	23.10±0.62	23.76±2.73	Z = –0.45, p = 0.675	r = 0.006, p = 0.976
Handedness	70.83±4.52	71.91±8.60	69.64±18.06	Z = –0.23, p = 0.824	r = –0.105, p = 0.579
Education	14.88± 0.40	16.35±0.58	14.53±0.46	Z = –2.30, p = 0.023*	r = 0.306, p = 0.100

*Note. LSL = less successful learners. MSL = more successful learners. * $p \leq 0.05$*

Table 3

Factor analysis — Rotated component matrix

Variables	Factors				
	1	2	3	4	5
	Physiological Indicators of Low Attention Concentration	Tolerance of Ambiguity	Persistence in Conceptual Thinking	Reward/ Punishment Sensitivity	Cognitive Processing Neurodynamics
Amplitude of alpha oscillation	0.909				
CQV	0.847				
Preference for ambiguous situations		0.895			
Acceptance/avoidance of ambiguous situations		0.804			
BAS — Drive			0.851		
Analogy (Amthauer)			0.759		
BAS — Reward Responsiveness				0.874	
BIS				0.770	
Excluding the word (Amthauer)					0.836
LRTC					–0.690

Note. Coefficients less than 0.4 are not shown

Table 4

Correlations between factors and learning outcomes

	Free Recall	**Recognition**	**Lexical Decision**	**Semantic Definition (Accuracy)**	**Semantic Definition (Quality)**	**Semantic Matching**	**General Success**
Physiological Indicators of Low Attention Concentration	r = –0.188, p = 0.319	r = –0.504**, p = 0.004	r = –0.177, p = 0.351	r = 0.230, p = 0.221	r = 0.136, p = 0.472	r = –0.036, p = 0.851	r = –0.127, p = 0.502
Tolerance of Ambiguity	r = –0.205, p = 0.276	r = –0.093, p = 0.626	r = –0.105, p = 0.580	r = –0.401*, p = 0.028	r = –0.113, p = 0.551	r = –0.160, p = 0.399	r = –0.383*, p = 0.037
Persistence in Conceptual Thinking	r = 0.496**, p = 0.005	r = 0.006, p = 0.974	r = 0.072, p = 0.706	**r = 0.558**, p = 0.001**	r = 0.303, p = 0.103	r = 0.470**, p = 0.009	**r = 0.543**, p = 0.002**
Reward / Punishment Sensitivity	r = 0.107, p = 0.574	r = 0.183, p = 0.334	r = –0.210, p = 0.265	r = –0.113, p = 0.553	r = –0.075, p = 0.695	r = –0.081, p = 0.670	r = –0.149, p = 0.431
Cognitive Processing Neurodynamics	r = 0.053, p = 0.78	r = 0.488**, p = 0.006	r = –0.15, p = 0.428	r = 0.186, p = 0.326	r = 0.095, p = 0.619	r = 0.144, p = 0.446	r = 0.272, p = 0.146

Note. * $p < .05$. ** $p < .01$

Factor Analysis

The Kaiser-Meyer-Olkin coefficient was 0.510, which indicated that the factor analysis was appropriate for these data. The Bartlett's test of sphericity showed that the variables had correlations with each other ($p = 0.004$, chi-square = 74.179, $df = 45$); thus, they were suitable for structure detection. The principal components method with varimax rotation extracted five factors with a cumulative contribution rate of 80.436% (*Table 3*).

Correlation between Factors and Success

The interrelationships between word learning success (both as an integrative variable and for each task separately) and the five factors were analyzed using a non-parametric Spearman's rank correlation test (*Table 4*: p-values reported without correction for multiple comparisons; the correlations which survived FDR corrections for multiple comparisons are **underlined**).

The Reward/Punishment Sensitivity factor did not interact significantly with any of the task results. The factors Physiological Indicators of Low Attention Concentration and Cognitive Processing Neurodynamics significantly correlated with Recognition scores. Tolerance of Ambiguity negatively correlated with General Success and the accuracy of Semantic Definition. The Persistence in Conceptual Thinking factor had positive interrelationships with accuracy scores on three tasks (Free Recall, Semantic Definition, and Semantic Matching) and the composite General Success measure.

Thus, we found a relationship between psychological and neurophysiological characteristics at the basic level of word acquisition related to surface word-form memory (as measured by the recognition task). Moreover, significant correlations were demonstrated for factors with high factor loadings of alpha oscillation parameters. The connection between psychological variables and word-learning success, in turn, concerned the acquisition of novel semantics. The Persistence in Conceptual Thinking factor was revealed as the most influential variable in word-learning success. Moreover, correlations between this factor and behavioral task results (Semantic Definition accuracy and General Success) stayed fully or marginally significant even after FDR corrections (adjusted $p = 0.035$ and 0.068, respectively). This factor depicts persistence as a personal trait and sign of conceptual thinking capacity.

Between-group Comparison of ERPs to Novel Words

To assess overall differences in brain activity between the LSL and MSL groups, amplitudes of ERPs over the frontal sensor ROI were compared across 800 ms after stimulus onset, using the two-tailed independent-sample Wilcoxon test step in bins of 8 ms. Significant differences were found at 153–161 ms ($Z = -1.98$, $p = 0.047$ uncorrected), 161–169 ms ($Z = -2.54$, $p = 0.011$ uncorrected), and 169-177 ms ($Z = -2.08$, $p = 0.037$ uncorrected) from the stimulus onset: more successful learners had lower frontal ERP amplitude (*Figure 3*). None of these results, however, survived after FDR corrections.

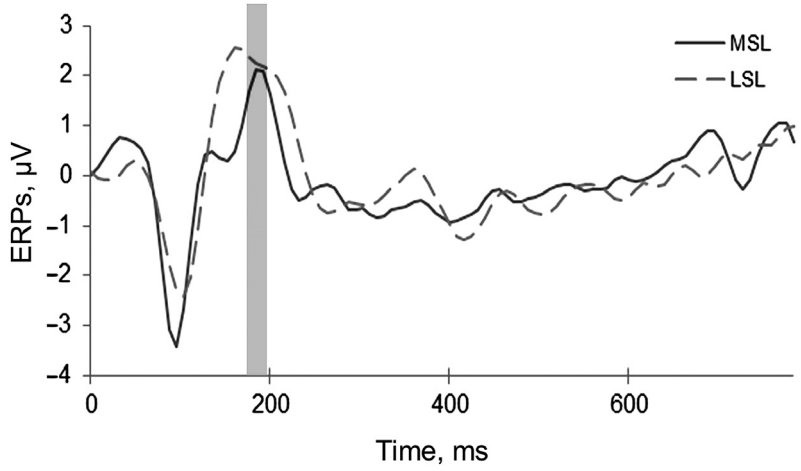

Figure 3. Average frontal ERPs on novel words for groups of more (MSL) and less (LSL) successful learners. P2 time window, where the differences were most expressed, is highlighted

Discussion

Our study aimed to investigate success in novel word acquisition in connection with learners' attention level (measured as amplitude of P200 component and alpha oscillation parameters), verbal cognitive abilities, motivation, and tolerance of ambiguity. The results showed that both psychological and physiological variables interacted with word learning success. Socio-demographic characteristics, on the other hand, did not correlate with this parameter. However, groups of more and less successful learners differed significantly in the number of years of education; more successful participants had more studying experience. This may suggest that the experience of learning novel material during formal education (and possibly of being tested on it) could positively influence the ability to learn novel words. This may be due to an increase in the number of vocabulary learning strategies that accelerate vocabulary growth (Nie, 2017), and more general cognitive learning strategies which help in acquiring information efficiently (Kostromina & Dvornikova, 2016).

The two groups differed in frontal ERP only in the time window around 150-180 ms. This wave likely corresponds to the P200 component, whose amplitude is known to negatively correlate with the level of attention (Crowley & Colrain, 2004) and to reflect inhibition of irrelevant information (Meghdadi et al., 2021; Zhao, Zhou, & Fu, 2013). Thus, more successful word learners were more attentive than others and were better at suppressing irrelevant inputs. Interestingly, this result was found during the reading task *after* the training session; we may hypothesize that the same trait was also expressed during the learning per se.

As for P200 as a marker of orthographic encoding, in a recent study it was shown that novel (firstly seen) words elicited lower P200 than previously known ones; however, this effect had disappeared after a short phonological training session (Bermú-

dez-Margaretto et al., 2020). The fact that the EEGs were recorded after the training session that provided an equal number of encounters with novel words for both groups of participants, suggests that the presence differences in P200 amplitude more likely reflected the level of attention than the depth of orthographic processing during visual recognition.

We also expected to find differences in the N400 amplitude, since this component is known to reflect lexico-semantic properties of verbal (and other meaningful) stimuli and their integration into a person's lexicon. However, no N400 effects were found, and no marked deflection was recorded in the N400 range, as can be seen in *Figure 3*. The absence of significant differences in the amplitude of the N400 component probably stems from the absence of context in the passive word reading task applied in the EEGs (Abel, Schneider, & Maguire, 2018; Bermúdez-Margaretto, Beltrán, Cuetos, & Domínguez, 2018).

Factors with high factor loadings of alpha oscillations parameters had significant correlations with accuracy in the Recognition task only. Thus, better recognition of novel words appeared to relate to higher attention concentration as reflected in the amplitude of alpha oscillations (Bastiaansen et al., 2002; Klimesch, 1999), and to excitation/inhibition balance as reflected in LRTC (Beliaeva et al., 2019). This might indicate that the perception of novel words required high involvement of the executive control systems, upregulating the level of attention.

We also found that the General Success and Accuracy of the Semantic Definition task negatively correlated with the ambiguity tolerance measure. The least ambiguity-tolerant students had better performance in the acquisition of word meanings. These results contradict previous studies that indicated a positive influence of ambiguity tolerance on L2 acquisition. However, there is evidence that the correlation of ambiguity tolerance with academic success could vary (Osin, 2010). Dealing with a large number (here, 20) of unknown words could elicit anxiety in learners with low levels of ambiguity tolerance. That, in turn, could have motivated them to resolve the ambiguities in order to understand the meanings of new words better, fostering better learning. Interestingly, the Quality variable (Semantic Definition task) showed no correlations with psychophysiological factors. It seems that the wording of definitions is a complex cognitive process that connects with other psychological and neurophysiological parameters that were not included in the study; alternatively, the measure applied here to estimate definitions' quality may not have been sufficiently precise or sensitive to demonstrate such connections.

The Persistence in Conceptual Thinking factor positively correlated with the results of three tasks and the integrative variable General Success. This result implies that logical conceptual thinking ability and persistence in reaching goals support the acquisition of both the forms and meanings of novel words. Moreover, only this factor stayed significantly correlated with learning outcomes after FDR corrections. Thus, our study showed that psychological features had stronger interrelationships with word acquisition success than neurophysiological ones. It appears necessary to continue interdisciplinary investigation of the word acquisition process to better elucidate connections between its psychological, behavioral, and neurophysiological aspects, which remain poorly understood (Mkrtychian et al., 2019).

Conclusion

This study investigated psychological and neurophysiological factors involved in successful word acquisition. The results have shown a range of psychological features related to performance in semantic tasks on novel word comprehension, whereas neurophysiological variables seem to be linked to successful recognition of newly acquired word forms. The more successful group of learners also showed lower P200 amplitude than their less successful peers, suggesting differences in the level of attention, which may have contributed to better learning.

Limitations

Whereas the present study has produced novel results on psychological and neurophysiological factors related to successful word acquisition, it still has several confounds and limitations that necessitate caution in interpreting its results. The relatively small sample size restricted the number of variables that could be analyzed. Thus, only 10 parameters were used in the research. Crucially, only some of the alpha-band parameters were explored, while neither brain oscillations in other bands — such as beta and theta, which are closely related to memory and learning (Herweg, Solomon, & Kahana, 2020), including verbally (Bakker, Takashima, van Hell, Janzen, & Mcqueen, 2015) — nor ERPs above other brain areas, were examined.

Moreover, whereas relationships between word learning success and psychophysiological factors could vary depending on age (Kamal, Morrison, Campbell, & Taler, 2021; Morrison & Taler, 2020), the results of the study are restricted to the young sample used in the experiments (18-35 years old). Finally, all participants were monolingual Russian speakers, and the novel words were orthographically and phonologically native-like, and were presented in L1 sentence context. Thus, the results of the study may not be generalizable to other languages or L2 learning without further investigation.

Ethics Statement

The study obtained ethics approval from the Ethics Committee of St. Petersburg State University (protocols № 90 from 20.02.2019 and № 82 from 25.04.2018). Written informed consent was obtained from all subjects involved in the study.

Author Contributions

Y.S. and S.K. conceived of the idea. E.B, N.M., D.T., and D.G. performed the computations. E.B., N.M., and D.T. performed the visualization. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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