A Test "Elementary Logical Operations": Psychometric Characteristics on The Russian Sample

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Abstract. This paper reports on the validation of an Elementary Logical Operations test (ELO) using a Russian sample of 556 participants, aged from 13 to 69 (M/F = 247/304) including adolescents, youths, adults, and alcohol addicted people. The study examined a factor structure and psychometric properties of the ELO test in terms of reliability, construct and concurrent validity. Factor analysis revealed two-component model, the nature of which requires further psychological analysis. Mean scores of the ability to perform elementary logical operations increased from adolescence to adulthood. Differences in indicators of the ELO was not identified in the samples of men and women. Significant differences were found between the sample of the norm (adolescents, youths, adults) and alcohol addicted people. Significant correlations were confirmed between the ability to perform Elementary Logic Operations and all the conceptual abilities under study (Generative abilities, Categorical abilities, and Abilities to classify). Correlations were not found between character traits and the ELO scale which testified to the discriminative validity of the test. General Liner Modeling (Multivariate Tests and Tests of Between-Subjects Effects) showed a significant effect of the ELO on the indicators of Intelligence and Verbal Creativity. Thus, the study demonstrated that the Elementary Logical Operations Test (ELO) provided a brief screening of individual's intellectual and creativity traits.

Keywords: Elementary Logical Operations, Validity, Reliability, Conceptual thinking, Intelligence, Creativity

Development of methods for the evaluation of ability to perform elementary logical operations (ELO) is linked closely with the fundamental problem of reasonable human behavior, key role of which plays conceptual thinking. Thinking, as R. L. Solso, O. H. MacLin, and M. K. MacLin noted, can be thought of as the crown jewel of cognition, it is spectacularly brilliant, one of the great wonders of Homo sapiens [21]. Thinking, concept formation, logic, and decision making are the last links in the information processing chain, ensuring intelligence and adaptation [20]. Human intelligence emerges as a result of conceptual thinking and conceptual learning [11] that reorganizes all mental processes [27]. Conceptual thinking provides a combination of "control and freedom" that determines the productive capabilities of human intelligence [12]. Conceptual thinking ensures the formation of an integral structure of human intelligence [24].

M.A. Kholodnaya noted that conceptual thinking (conceptual abilities in Kholodnaya's terms) is a new generative type of intellectual abilities that determines the productivity of the processes of conceptualization and provides the possibility of generating new mental contents that are not presented in actual external circumstances and are absent in the acquired individual knowledge; ability to create new semantic contexts based on words from far-off semantic fields. The researcher identified three types of conceptual abilities, such as (a) semantic ability, i.e., the ability to form semantic networks and the operation of the content of verbal signs; (b) categorical ability, i.e., the ability to use

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categories of varying degrees of generalization and the discovery of relevant features of the thought object; and (c) generative ability, i.e., the ability to generate new mental contents [6,7].

We consider conceptual thinking as the person's ability to operate with concepts, to establish connections and relationships between the essential features of objects, to understand the logical sequence of events. Based on this understanding of conceptual thinking, the set of conceptual abilities, proposed by M.A. Kholodnaya, should be expanded by including, at least, the ability to perform elementary logical operations, which provides reasonable behavior through identifying true or false propositions, truth or falsity of the picture of the world. The more complete the essential properties of reality are reflected in the picture of the world, the better is a person oriented in oneself, as well as in the world and society.

Some psychologists believe that logic has no connection with actual human behavior. However, M. Wertheimer stressed that this is a mistake. He wrote: "*For application to behavior merely presupposes a connecting axiom, approximately as follows: behavior will be unreasonable, will fail of achievement, will run into trouble, if it is determined by factors parallel to mistakes in the sense of traditional logic*" [29]. No matter how we treat the logic envisaged in the Organon of Aristotle yet, it has great merits:

"In the decisiveness of its will to truth;

in the concentration on the basic difference between a mere assertion, a belief and exact judgement;

in its emphasis on the difference between hazy concepts, hazy generalizations, and exact formulations;

in the development of a host of formal criterion which are suited to testing for, and discovering mistakes, haziness in thinking such as unjustified generalization, jumping at conclusions;

in its emphasis on proof;

in the seriousness of the rules of discussion;

in the insistence on stringency and rigor in each individual step in thinking" [1].

Logic, according to Aristotle, is an instrument of cognition of the truth, an organon of thought. Truth is understood by the philosopher as the correspondence of thoughts to being. "*True*," – believed Aristotle, – "*is to say that the existing is and the non-existent no*". Just as the hands are the instrument of the body, so the mind is the instrument of the soul. The laws of logic govern our thinking only insofar as it is directed at already existing, and not only at possible or emerging objects.

S. L. Rubinstein emphasized that conceptual thinking is formed in the process of historical development based on social practice. Real thinking is a movement of thought that reveals connections and relationships. Thinking takes place in generalizations, it always goes from particular to general and vice versa. The specific content of thinking is a concept. A concept is a generalized knowledge about an object based on the discovery of its essential correlations and relations. Thinking is the result of the interaction of the external and inner world of a person. Since the mind, the inner world is determined indirectly through the relationship to the objective, external world, so the logic of things (objects of thought) enters into the mind of the individual. Thus, the logical is not opposed to the psychological, but is a determining principle in the consciousness of a person. The psychology of thinking cannot be reduced to logic, but it cannot be divorced from the definition of an objective essence in logic [14].

R. L. Solso, O. H. MacLin, and M. K. MacLin viewed thinking as a general process of considering of an issue in one's mind, which results in the formation of a new mental representation. Mental representation is a hypothetical pattern of mental or brain activity that reflects some feature of the world, of the person, or of the interaction between the person and the world. The scholars defined concepts as ideas or groups of ideas (tangible or intangible) that share specific common features or characteristics. Logic is the science of thinking based on laws that determine the validity of a conclusion. An appealing feature of using syllogistic logic in cognitive research is that it makes it possible to evaluate, or validate, the correctness of the thought process on the basis of its form rather than its content. It is possible in syllogistic logic to reduce statements of fact to symbols and manipulate them, as in mathematical equations, without regard to the physical reality they may represent [21].

L. Wittgenstein defined thought as a logical picture of interrelated facts, a proposition endowed with meaning. He wrote: "The totality of true thoughts is a picture of the world. ... The

proposition constructs a world with the help of a logical scaffolding, and therefore one can actually see in the proposition all the logical features possessed by reality…" [28]. Thus, logic is viewed not as a science, but as a way of constructing the world in which one signified always and everywhere corresponds to only one signifier that allows us to think and say clearly. In logic nothing is accidental: if a something can occur the possibility of this must already be prejudged earlier [28]. The picture of the world can agree with reality or not, it can be true or false.

According to Plato, propositions are the smallest logical unit of conceptual thinking. L. Wittgenstein considered proposition as a picture of reality, which can be true or false, depending on the correspondence or discrepancy with the picture of reality. He pointed out that propositions show the logical form of reality. Propositions describe reality by its internal properties, that is, the structure of relations, combinations between the attributes of objects. The essence of propositions is to communicate a new sense to us. The proposition expresses what is contained in a definite and clearly specifiable way: the proposition is articulatable. L. Wittgenstein clarified that in order to understand a proposition, it is necessary to know the situation that it represents, therefore we understand the proposition without its sense having been explained to us. In a proposition, a situation is created by individual experience and there should be as many distinguishable parts in it as in the situation it represents.

L. Wittgenstein emphasized that the elementary propositions are fundamental for the comprehension of the other kinds of propositions. The philosophe noted: "*If all true elementary propositions are given, the result is a complete description of the world. The world is completely described by giving all elementary propositions, and adding which of them are true and which false*" [28]. The main feature of an elementary proposition is that no elementary proposition can contradict other propositions. The elementary proposition is the simplest kind of proposition which consist of names in immediate combination. Name is a set of symbols used to perform certain functions. The elementary proposition asserts the existence of an atomic fact. The atomic fact is determined by the connections among objects (entities, things).

In the present work, we have focused on the psychometric aspects of our newly developed test. First, we examined whether the ELO test demonstrates sufficient internal consistency and tested the following hypotheses:

H1: The internal consistency of the ELO test is sufficient.

Next, we examined ELO's factor structure and its psychometric properties in terms of reliability and contribution of the items to the scale.

H2: The Item-total correlations of the ELO items is sufficient.

H3: The test structure is represented by one factor.

Then, with the goal to estimate the concurrent and construct validities of the ELO, we compared it with three scales that measure various aspects of conceptual thinking and that are being developed in the Russian Psychology: the Categorial Ability (Generalization of three words test [7, 9]), Generative Ability (Concept Synthesis Test [7,9]), and the Ability to Classify objects (Free sorting words technique [10]). Based on the experimental research (Kholodnaya &Volkova [8]; Shcherbakova, Makarova, & Nikiforova [18]; Rusalov & Naumova [15]; Sipovskaya [19]; Volkova [26], et al.), we developed a hypothesis regarding the relationship between ELO and other conceptual abilities scales.

H4: The ELO scale has a significant positive correlation with the scales of conceptual abilities (Generative abilities (GA), Categorical abilities (CaA), and Abilities to classify (ACl)).

Since complex intellectual structures such as intelligence and creativity involve different levels of cognitive processes, it can be expected that the basic intellectual function as measured by ELO will be conceptual ability.

It is shown that generalized characteristics of temperament in the intellectual sphere (intellectual scales of temperament) have high correlations with indicators of psychometric intelligence (Wechsler's scales) [15]

H5: The ELO scale has significant positive relations with the scales of Analytical Intelligence, Verbal and Non-verbal Creativity, and with the intellectual scales of temperament.

In order to test the discriminant validity, we assessed the correlations among the ELO scale and character traits. As a tool for psychological assessment, the intelligence approach contrasts to the personality ones. Personality scholars describe individual differences in terms of behavior or character traits, while intelligence

experts refer mainly to the cognitive qualities of mind and problem solving. Assessment of personality traits is most often carried out through the questionnaires, whereas intelligence is measured using a set of universal test problems that are less language dependent and less prone to distortion of findings due to social desirability. Based on the above considerations, we assume that there is no relationship between the indicators of character traits and the ability to perform elementary logical operations

H6: The ELO scale has no significant correlations with the character scales.

Method

Sample

The Elementary Logical Operations was administered to 556 subjects, aged from 13 to 69 (M/F = 247/304; mean age in years = 19.79, SD = 8.66) including adolescents (13.78, SD=0.60), youth (20.03, SD=1.42), adults (39.96, SD=10.10), and alcohol addicted people (41.50, SD=7.13). The study involved respondents from Moscow, Kaluga, and Ufa. They signed a consent form before participating in this study and then filled in the test papers.

Measure

The Elementary Logical Operations (ELO). The ELO had 24 statements, assigned to evaluate ability to perform elementary logical operations. Respondents were offered to compare the ratio among the values of A, B and C and to draw the conclusions from the analysis of these ratios.

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Table 1. Stimulus

	Elementary Logical Operations (ELO)	Truth	False
1.	**A** is equal to **B**, and **B** is equal to **C**, then **C** is equal to **A**		
2.	**A** is equal to **B**, and **B** is greater than **C**, then **C** is greater than **A**		
3.	**A** is equal to **B**, and **B** is equal to **C**, then **C** is not equal to **A**		
4.	**A** is equal to **B**, and B is less than **C**, then **C** is not equal to **A**		
5.	**A** is equal to **B**, and **B** is greater than **C**, then **C** is not equal to **A**		
6.	**A** is equal to **B**, and **B** is less than **C**, then **C** is equal to **A**		
7.	**A** is not equal to **B**, and **B** is equal to **C**, then **C** is not equal to **A**		
8.	**A** is not equal to **B**, and **B** is equal to **C**, then **C** is equal to **A**		
9.	**A** is greater than **B**, and **B** is equal to **C**, then **C** is not equal to **A**		
10.	**A** is greater than **B**, and **B** is equal to **C**, then **C** is equal to **A**		
11.	**A** is greater than **B**, and **B** is greater than **C**, then **C** is not equal to **A**		
12.	**A** is greater than **B** and **B** is greater than **C**, then **C** is equal to **A**		
13.	**A** is more than **B**, and **B** is more than **C**, then **C** is more than **A**		
14.	**A** is more than **B**, and **B** is more than **C**, then **C** is less than **A**		
15.	**A** is less than **B**, and **B** is equal to **C**, then **C** is not equal to **A**		
16.	**A** is less than **B**, and **B** is less than **C**, then **C** is not equal to **A**		
17.	**A** is less than **B**, and **B** is equal to **C**, then **C** is equal to **A**		
18.	**A** is less than **B**, and **B** is less than **C**, then **C** is equal to **A**		
19.	**A** is less than **B**, and **B** is less than **C**, then **C** is less than **A**		
20.	**A** is less than **B**, and **B** is less than **C**, then **C** is more than **A**		
21.	**A** is part **B**, and **B** is part **C**, then **C** is greater than **A**		
22.	And part **B**, and **B** is equal to **C**, then **C** is greater than **A**		
23.	And part **B**, and **B** is equal to **C**, then **C** is less than **A**		
24.	**A** is part **B**, and **B** is part **C**, then **C** is equal to **A**		

For example, if **A** is equal to **B** and **B** is equal to **C** then "**C** is equal to **A**". This conclusion is true. And the conclusion "**C** is not equal to **A**" under the given conditions is false. There are four possible answers: (1) C is equal to A; (2) C is not equal to A; (3) C is greater than A; (4) C is less than A. Only those problems were offered that had only one correct answer. The test tasks for the ELO test were presented in Table 1.

The test time was limited to four minutes. The raw score was calculated by the number of correct answers in accordance with the keys (STable 2). Raw scores were converted to S-scores through percentile standardization (STable 3). The ability to perform Elementary Logical Operations is considered as high if S-score ≥ 7 and as low if S-score ≤ 3.

Generalization of three words test [7,9]. The test was developed to assess Categorical Abilities (CaA), namely, the ability to generalize; ability to identify common essential features of three concepts and to select a reference generic category. The respondent was given three words and was asked to find out common feature among these concepts and then to name this feature. For example: **lighthouse – newspaper – bonfire.** The measure of generality of each answer was assessed:

0 score – only two words out of three were generalized, or thematic generalization was based on situational connections (street, town, man, etc.);

1 score – generalization through a specific feature (beautiful, large, built by man, many details, can give light, long, etc.);

2 score – generalization based on an essential characteristic using a strict generic category (signals, sources of information).

Thirty seconds are allotted for each triad of words.

The Concept Synthesis Test [7,9]. It was designed to measure *Generative abilities* (GA). The researcher pronounces three words and offers the respondents to compose one or more sentences that would include all the three words. For instance: **computer – tornado – pin.** The time limit was 3 minutes. The answers were rated 0, 1, 2 and 3 scores:

0 score – the test taker uses only two target words in a sentence, for example, "*A **pin** and a **tornado** could hurt a human*".

1 score – the test taker includes three target words in a sentence, but either two of them are used in the same functional role being opposed to the third one or all three words are used in the same functional role: "*A **tornado** lifted a **pin** and a **computer** into the air*".

2 score – the test taker includes three target words in a sentence for description of a concrete situation: "*Children were watching a movie about a **tornado** on a **computer** and were playing with **pins**".*

3 score – the test taker includes three target words in a sentence, linked together either on the basis of a generalized category or analogy, or by causal relation, or by common complex context: "*A **pin** and a **computer** are artificial objects made by human, and a **tornado** is a natural phenomenon which is beyond human control*" or "*A **pin** got inside a **computer** caused a short circuit, which made a man switch his attention from the computer and he heard the news about an oncoming **tornado***" [18].

The Free sorting words technique [10]. This diagnostic tool was used to measure the Ability to Classify objects (ACl). The respondent was asked to divide 35 words, denoting various aspects of the concept Time, into groups in the most convenient and logical way from the respondent 's point of view. The test taker was to indicate a classification attribute for each group. Task run time was limited to five minutes. One score was awarded for each adequately specifiable classification attribute. The classification index was calculated as a number of specifiable classification attributes divided by the total number of the identified groups. The closer the classification index was to one, the more accurately the objects were classified.

The Standard Progressive Matrixes (SPM) [13]. SPM is a well-validated measure of fluid reasoning ability (gF) [3]. The Raven's Standard Progressive Matrixes contain 60 nonverbal items. Each item consists of 3 × 3 matrix with a missing piece to be completed by selecting an answer from six or eight alternatives. Time for completing the tasks was 20 minutes.

The Torrance Test Creativity Thinking (TCT) [2] in Tunick's adaptations for Russians [23]. TCT consists of a verbal (verbal creativity) and a figural (nonverbal creativity) test battery. In this study, the Unusual Use subtest was used to evaluate Verbal Creativity and the Incomplete Figures subtest was implemented to assess Nonverbal Creativity. Originality rate was determined based on E. V. Volkova's data for 18–24-year-old respondents [25].

The Structure Temperament Questionnaire [16]. STQ-S was used for evaluation of Intellectual Activity (IA). Shortened version of the Structure Temperament Questionnaire (STQ) contained 26 items. STQ-S had a high correlation with full version of questionnaire STQ. The given scale is thought to be temperamental scale of intelligence measured by Wechsler test [17].

Character traits are scored with shortened version of the questionnaire developed for measuring human character. This questionnaire contained 20 items. The shortened version of questionnaire had a high correlation with full-version of questionnaire ($r>0.6$; $p < 0.05$) and a high internal consistency. Character scales covered such traits as hyperthymicity, stuckness, emotivity, pedanticity, anxiety, cyclothymicity, demonstrativeness, excitability, dystimicity, and exaltations [17].

Procedures

Statistical treatment empirical data included descriptive statistics of raw data (Means, SD, Skewness, and Kurtosis) and reliability statistics (Cronbach's alphas) for the ELO scale. The test scores corresponded to the normal distribution (Skewness and Kurtosis =±1). The reliability of the tested parts was assessed on the basis of correlations between the sum of scores of even and odd items. The structure of connections among test items was identified on the basis of Factor Analysis (Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization). Absolute loadings of 0.50 or stronger were taken as significant. Differences in indicators of the Ability to perform Elementary Logical Operations were identified (Student's t-test, ANOVA) in comparable samples of men and women, adolescents and youths, adults of norm and alcohol addicted.

A percentile standardization procedure was carried out to convert the raw scores into a single scale of S-scores. Evidence for concurrent validity of the ELO test was demonstrated through significant correlations with all conceptual abilities under study: Generative abilities (GA), Categorical abilities (CaA), and Abilities to classify (ACl). Discriminatory validity of the ELO test, according to theoretical concepts, implies the absence of significant correlations with character indicators.

The use General linear modeling (General Linear Model: Multivariate Tests) makes it possible to statistically analyze the peculiarities of the relationships among ELO indicators and indicators of conceptual abilities (GA, CaA, ACl), temperamental Intellectual Activity (AI), Intelligence, Verbal and Non-verbal Creativity.

Results

Descriptive statistics

Table 1 shows the descriptive statistics. Test scores corresponded to the normal distribution (Means and standard deviations (SD) were reported for the male and female sub-samples and for the full sample). The reliability measured by the Cronbach Alpha coefficients were in the acceptable range (0.87-0.95). These results testified that the Elementary Logical Operations scale had sufficient internal consistency (*H1*).

Table 2. Means, Standard Deviations (SD) and Alphas for the samples

		Male Sample		Female Sample		Total Sample		
		Mean	SD	Mean	SD	Mean	SD	Alpha
Total Sample	13-69	18.61	5.03	18.35	5.18	18.46	5.10	.92
Adolescence (N=201)	13-15	17.81	5.56	17.90	5.80	17.85	5.67	.91
Youth (N=295)	18-24	19.36	4.52	18.74	4.76	18.97	4.68	.87
Adults (N=30)	25-69	20.70	2.71	23.00	1.00	20.00	2.72	.91
Alcohol addicted (N=30)	27-55	14.50	5.20	13.20	2.58	14.19	2.72	.95

Item-total correlations of the ELO and Factor Analysis

Item-total correlations of the ELO items varied from 0.502 to 0.745 p=0.001 (STable 6), except item 2 (r=0.347, p=0.001). Correlation between test parts, the sum of scores obtained on even test items and the sum of scores received on odd test items, was 0.848 p=0.001 (STable 5), which testified to the stability of the results of individual sets of test items or single items of the test.

Descriptive statistics (KMO = 0.901; Bartlett sphericity values =5382.020; Df = 276; p = 0.001) showed that we have sufficient grounds to apply Factor Analysis [22]. Theoretically we assumed that there is one factor. However, we received two-and four-component models (Principal Component Analysis. Varimax with Kaiser Normalization). According to the Cattell's scree test, two-component model was determined (Figure 1), because the optimal number of components (factors) was above the inflection point of the curve where the graph turns into a straight line [4,5]. This model cumulatively explained 47.399 % of the variance of the primary scales. Percentage of the explained variance for each factor was 25.51(1, 3-12 items) and 21.89% (16-24 items), respectively (STable 8).

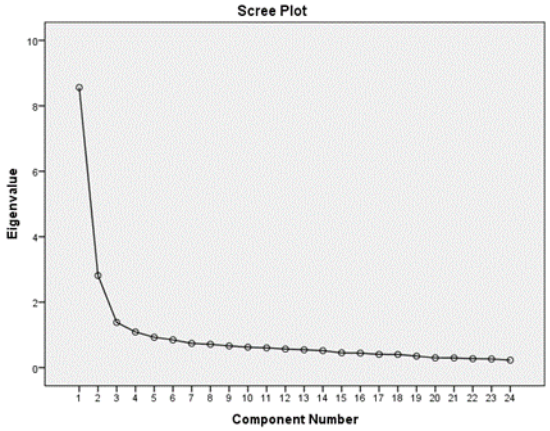

Figure 1. Scree Plot

Based on Eigenvalues greater than 1, we identified four significant factors which described 57.68% of variance of the correlation matrix. Percentage of the explained variance for each factor was 16.68; 16.62; 15.29; and 9.079, respectively. The first factor combined 5-12 items, the second –12-18 items, the third – 19-24 items, and the fourth – 1-4 items (Stable 9). Comparison of the two- and four-component models showed that they do not contradict each other. Moreover, the Four-Component Model makes the Two-Component Model specific. However, the question of the nature of these findings requires further psychological analysis of the thinking operations when solving these kinds of elementary logical problems.

Multiple Comparisons

Mean scores of the ability to perform elementary logical operations increased from adolescence to adulthood (Figure 2). Differences in indicators of the Ability to perform Elementary Logical Operations were not identified (Student's t-test; ANOVA, Multiple Comparisons, Bonferroni correction) in samples of men (18.61±5.03) and women (18.35±5.18), youth (18.97±4.68) and adults (20.00±2.72), but significant differences were found between the sample of the norm (adolescents, youths, adults) and alcohol addicted people (14.19±2.72) as well as between the sample of adolescents (17.85±5.67) and adults (20.00±2.72). More detailed information was presented in Supplementary materials (STable 10).

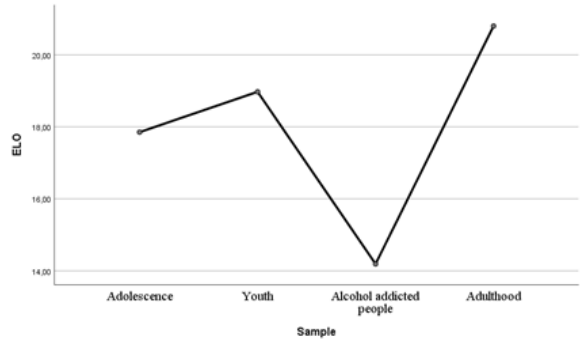

Figure 2. Mean Plots for comparable samples

Concurrent validity

Before assessing the concurrent and discriminatory validities, all raw scores were converted into a single scale of S-scores through a percentile standardization procedure (STable 3). Significant correlations among the ability to perform Elementary Logic Operation with such conceptual abilities as GA, CaA, and ACl were revealed (Table 3). The data obtained confirmed the concurrent validity of ELO. Thus, hypothesis *H2* was supported.

Discriminatory validity

According to the data presented in Table 4, significant correlations were not found between the indicator of the ability to perform Elementary Logical Operations and those of Character traits. This fact supported the hypothesis *H6* of the discriminative validity of the ELO test.

Table 3. Correlations of the ELO with conceptual abilities scales

	Generative abilities (GA)	Categorical abilities (CaA)	Abilities to classify (ACl)
Ability to Perform Elementary Logical Operations ELO	0.176**	0.124*	0.148**

Total sample. N= 556. *p< 0.05. **p< 0.01. ***p< 0.001.

Table 4. Correlations between the ELO and Character scales

ELO	Hyperthymicity	Stuckness	Emotivity	Pedanticity	Anxiety	Cyclothymicity	Demonstrativeness	Excitability	Dystimicity	Exaltation
Pearson Correlation	.110	-.047	-.096	-0.074	-.055	-.040	-.033	-.053	.001	-.014
Sig. (2-tailed)	.057	.425	.106	.212	.352	.495	.582	.369	.988	.816

General Linear Model: Multivariate Tests and Tests of Between-Subjects Effects

The data obtained matched GLM requirements. Box's Test of Equality of Covariance Matrices of the dependent variables (Intelligence, Verbal Creativity, and Nonverbal Creativity) were equal across groups (Box's M=162.522; F= 0.897; Sig.=0.792). Levene's Test of Equality of Error Variances testified that the errors variance of the dependent variables was identical across groups (Table 5). The dependent variables (Intelligence, VC, and NC) were S-Scales. The independent variables (ELO, GA, ACl, and CaA) were categories with low, mean, and high levels of conceptual abilities (ELO, GA, ACl, and CaA).

Table 5. Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Nonverbal Creativity	1.218	55	238	.160
Verbal Creativity	1.278	55	238	.109
Intelligence (SPM)	1.628	55	238	.07

General Linear Model (Multivariate Tests, Pillai's Trace) revealed a statistically significant main effect of the ELO factor on the gradation of Intelligence, Verbal and Non-verbal Creativity indicators (F=2.527; Hypothesis df=6; p=0.020). The interaction of factors CaA * ACl (F=2.012; Hypothesis df=12; p=0.021) and GA * CaA * ELO (F=1.616; Hypothesis df=18; p=0.050) also significantly affected the gradation of Intelligence and Creativity

indicators. The covariate of Intellectual Activity (IA) as a temperamental indicator had a significant effect on the dependent variables of Intelligence, Verbal and Non-verbal Creativity. This covariate also changed the statistical significance of the factors (ELO, GA, ACl, and CaA) and their interactions (F=2.828; Hypothesis df=3; p=0.039). More detailed information is presented in additional materials (STable 12).

General Linear Model (Tests of Between-Subjects Effects) showed:

- The independent factor ELO effected significantly the distribution of the Intelligence indicator (3.663, 4.675, 5.680; F = 6.879, p = 0.001).
- Interaction between independent factors of Categorical abilities (CaA) and of Abilities to classify (ACl) influenced significantly the distribution of Nonverbal Creativity (F = 2.684, p = 0.032).
- Interaction between independent factors of Elementary Logical Operations (ELO) and of Abilities to classify (ACl) effected significantly the distribution of Verbal Creativity Scores (F = 2.417, p = 0.049).
- Interaction among independent factors of Elementary Logical Operations (ELO), of Generative abilities (GA), and of Categorical abilities (CaA) had a significant impact on the distribution of the Verbal Creativity Score (F = 3.089, p = 0.006).

Thus, hypothesis *H5* was partially confirmed. The results obtained showed a significant effect of ELO on the indicators of Intelligence and Verbal Creativity. However, this pattern was not found in relation to Non-verbal Creativity (STable 14, 16).

Conclusion

This study demonstrated that Elementary Logical Operations Test (ELO) provided a brief screening of intellectual traits (*H5*). Significant positive relationships were found among the ability to perform Elementary Logical Operations with Generative, Categorical Abilities and the Ability to Classify objects. The main effect of the ELO scores on Intelligence and Verbal Creativity indicators were confirmed.

The results showed that the Elementary Logical Operations scale had sufficient internal consistency (*H1*), concurrent (*H2*) and discriminatory (*H6*) validities. We believed that the ELO test structure was single-factor. However, we revealed existence of two-and four-component models. The issue of these the ELO test factor structure requires further investigations. The results showed that the Ability to perform Elementary Logical Operations increased with age. It should be emphasized that the differences between men and women were not found. However, a strong significant decrease in the Ability to perform Elementary Logical Operations was revealed in a sample of alcohol addicted people, which makes it possible to use this test as a non-invasive tool for assessing the measure of alcohol intoxication.

We believe that the study of thinking in general and intelligence in particular can make a significant contribution to solving such theoretical problems as understanding of the mechanisms of reasonable human behavior.

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