Network Modeling of the Structure of Conceptual Experience in the Context of Intellectual Competence in Older Adolescence

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Abstract. Adolescence is characterized by dramatic qualitative changes in the physical, intellectual, personal and spiritual aspect. In the field of intellectual development, there comes a period characterized by maximum resolving possibilities due to the ripening of conceptual and metacognitive abilities, as well as a number of personality traits, which, in turn, is necessary for productive actions in a particular subject area - intellectual competence. Thus, the features of older adolescence are the basis for studying the manifestations of intellectual competence in its potential components, in particular, metacognitive abilities, which provide for the management of human cognitive activity. Study participants: 90 schoolchildren from secondary schools of Moscow at the age of 15 years. Techniques: "Conceptual Synthesis", "Methods for Diagnosing the Degree of Development of Reflexivity", "Comparison of Similar Figures", "Intentions" and "Interpretation". According to the results of the research, the indicators of conceptual abilities selectively correlate with the components of intellectual competence, metacognitive and intentional abilities. The core of the conceptual abilities construct is represented by abilities, characterized by the function of generating a new context, speed and accuracy of this process, while cognitively simpler abilities (factual and interrogative narratives) and arbitrary metacognitive abilities are located on the periphery. Thus, there is reason to conclude about the heterogeneity of the construct of conceptual abilities. The specified differentiation of the structure of conceptual abilities is determined by the functional load and cognitive complexity of the components that make up the concept of conceptual abilities system.

Keywords: Concept · Intellectual competence · Abilities · Adolescence

1 Introduction

It seems promising to study the manifestations of intellectual competence among schoolchildren of older adolescence (14–16 years old). This period is a critical, crucial period in a person's life in which the end of one stage of mental development occurs

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and the next one begins. It is at this age that conceptual thinking is finally formed, providing a qualitative increase in the intellectual resources of a teenager. So, L. M. Vekker [18] suggested that the formation of concepts acts as a prerequisite for higher forms of intellectual activity, characterized by the maximum resolving possibilities of the intellect.

Speaking about metacognitive abilities, one should single out voluntary and involuntary metacognitive abilities, which, in turn, perform the functions of voluntary and involuntary regulation of human behavior and activity. In view of the fact that in our previous works [14, 15], among the investigated qualities of thinking, it was the regulatory ones that were used as manifestations of metacognitive abilities, we chose reflexivity as a person's ability to go beyond the self, to comprehend, study and analyze something by comparing your "I" with other personalities and events. This is a conscious and arbitrary component of metacognitive abilities. To balance it with an involuntary component of metacognitive abilities, we chose reflexivity. As is known, reflexivity is the antonym of impulsiveness and is one of the poles of the cognitive style "reflexivity/impulsivity". Considering the cognitive style as an individually-peculiar way of processing information about our environment and the "determinant" of the cognitive attitude to reality, we determined its regulatory nature - what exactly will be considered. So, we have an involuntary intellectual control in the form of a cognitive style and, more broadly, manifestations of metacognitive experience.

In a number of studies, the components of intellectual competence were identified, among which cognitive, metacognitive, personal, motivational indicators were distinguished:

(1) subject knowledge [8, 10];
(2) conceptual, categorical, semantic abilities [8, 9, 12, 13];
(3) intellectual self-regulation [3, 7, 8, 16];
(4) intentional knowledge [9, 16];
(5) specific motivation [4, 5, 9, 11, 14, 17];
(6) the quality of thinking, namely: cognitive need, flexibility, criticality, creativity [13–16].

In this work, we investigated: (1) the manifestations of intellectual competence as an ability to interpret (actively transforming individual experience); (2) arbitrary metacognitive abilities; (3) involuntary metacognitive abilities and intentional abilities.

1.1 Research Questions

Theoretical hypothesis of this study: indicators of conceptual experience are associated with manifestations of intellectual competence in terms of the ability to interpret, including moral dilemmas, as well as - associated with voluntary and involuntary metacognitive abilities as regulatory mechanisms of intellectual activity and intentional abilities.

Research hypotheses: there is a relationship between the level of formation of conceptual abilities and indicators of the formation of intellectual competence, intentional and metacognitive abilities of 9th grade pupils in secondary schools.

1.2 Purpose of the Study

Purpose: to reveal the structure of conceptual experience in the context of intellectual competence and its components in older adolescence.

The objective of this study is to determine the structure of the construct of conceptual experience in the context of manifestations of intellectual competence, voluntary and involuntary metacognitive abilities, and intentional abilities.

Thus, the subject of this study is the network structure of conceptual experience, the object of study is students of secondary schools aged 14–16 who have intellectual competence formed in the process of schooling.

2 Study Participants

The sample consisted of 90 schoolchildren (54 girls and 36 boys) of 9th grade of secondary schools in Moscow aged 15–16 years (median - 15 years).

3 Research Methods

I Block: Methods of Diagnosing Conceptual Abilities. "Conceptual Synthesis" [9]
The material of the methodology "Conceptual Synthesis" consists of three triads that are not related in the meaning of words, namely:

- a shell - a paper clip - a thermometer;
- computer - tornado - pin;
- planet - electrical outlet - hourglass.

According to the instructions, it is necessary to make as many meaningful sentences as possible with the obligatory use of all three words. On forms of A4 format printed on one triad of words. The study participants were verbally read out instructions, in accordance with which students were asked to establish different versions of semantic links between these three words, to write down each version in the form of one or two sentences. The time of work with each of the triads is 3 min.

Each answer was assessed according to the following criteria: 0 points - the absence of written sentences; the absence of established semantic relationships or the use of only two words; 1 point - a simple listing of words in a sentence; 2 points - creating a context within the description of a specific situation; 3 points - making a sentence using comparisons and analogies, combining all three words on the basis of a generalizing category or detailed cause-effect relationships. The scores for all triads are summarized and the total score is set.

Indicator: level of formation of conceptual abilities (ability to generate mental spaces within individual experience).

II Block: Methods for Identifying Metacognitive Abilities

1. "Methods of diagnosing the degree of development of reflexivity" [7].

This technique diagnoses the level of expression of such a generalized metacognitive personal quality as reflexivity. The text of the questionnaire consists of 27 statements, each of which on each form in the form of answers opposite the question number is put a figure corresponding to the variant of his answer: 1 - absolutely wrong; 2 - wrong; 3 - rather wrong; 4 - I do not know; 5 - rather true; 6 - right; 7 - quite right. Of these 27 statements, 15 are direct (No. 1, 3–5, 9–11, 15, 18–20, 22, 24, 25) and 12 are inverse (No. 2, 6–8, 12–14, 16, 17, 21, 23, 26, 27).

The points are added together and the total score is set. The conversion to the walls was not carried out due to the lack of norms for older adolescence and the use of the average value as the norm.

Indicators: arbitrary metacognitive abilities.

2. "Comparison of similar drawings" [6]. The Matching Familiar Figures Test, MFFT test, developed by J. Kagan, is used to diagnose the cognitive style of impulsiveness - reflexivity.

This cognitive style, in accordance with the initial assumption of J. Kagan, characterizes individual differences in the propensity to make decisions quickly or slowly. This style property manifests itself most vividly in conditions of uncertainty, when it is necessary to make the right choice from a certain set of alternatives. Impulsive subjects tend to react quickly in a multiple-choice situation, with hypotheses being put forward without analyzing all possible alternatives. For reflexive subjects, a slow response rate is typical in such a situation, hypotheses are tested and refined many times, the decision is made on the basis of a thorough preliminary analysis of the signs of alternative objects.

The subject is presented with 2 training, then 12 basic sheets, on each of which there is an image of a familiar object on top (the standard figure), and below there are two rows of 8 almost identical images of the same object, among which only one is completely identical to the standard figure. The subject must find and indicate an image that is completely identical to the figure-standard. The instruction is given in writing on a separate sheet (the first sheet of the methodology): "Now you will see one picture and several similar ones. You need to find in this picture exactly the same picture as the one above, and show it. For the initial training, you will be shown two demo cards. Further tasks will not be so simple. Find as quickly as possible a picture as close as possible at the top, and show it right away".

The assessment was carried out using the key: example 1-1, example 2-5, sheet - 4, steamer - 7, flower - 1, lamp - 8, bear cub - 4, cat - 1, cowboy - 8, glasses - 4, chicken 5, aircraft - 1, scissors - 5, dress - 5. Indicators of impulsivity/reflexivity: (1) latent time of the first response (amount); (2) the total number of errors.

III Block: Methods of Diagnosis of Intentional Abilities "Intentions" [15].

For competent people are characterized by a special kind of mindset. For example, Albert Einstein pointed out a certain "sense of direction" of the search, which he experienced as "a feeling of moving forward towards something specific …" (quoted in: [1, p. 153]). This kind of mentality appears in situations of generating new ideas. So, J. Poya pointed out that an idea suitable for solving a specific task arises together with the subjective conviction of the correctness and reachability of this solution (cited in: [1, p. 154]).

The material of the method of "mindset" consists of 9 questions from various school subjects. For the correct answer to these questions is not enough knowledge of 9-graders of the school curriculum - you need an intellectual presentiment, a sense of direction of the decision. For example, question 8: "How do you guess why many birds make a long and dangerous flight for the Arctic Circle for nesting, because their habitat is much warmer and about 1/3 of birds die during migration. Justify your answer", refers to the knowledge of the characteristics of northern latitudes and the time of migration of birds (terns, etc.) - the polar day, which increases the feeding time.

After each question is a scale from 1 to 7 which indicates confidence in the correctness of the answer given by the participant in the study.

The answers themselves are proposed to be recorded on a separate white sheet of A4 format at the end of the methodology.

Instructions for the method of "mindset" were given in writing in the upper part first sheet: "We offer you a number of tasks from various school subjects. Try to solve them based on the knowledge of the school curriculum or your own forebodings, guesses, ideas. After solving each of the tasks, select and write down in the table the degree of your confidence in the correctness of the answer given by you: 1 - absolutely not sure (a); 2 - not sure (a); 3 - rather not sure (a) than sure (a); 4 - I do not know; 5 - more confident (a) than not sure (a); 6 - sure (a); 7 - absolutely sure (a). Do not miss a single task. Remember that this is not a test of your abilities, but only the identification of individual characteristics mindset of yours".

Criteria for evaluating the answers: 1 point - the answer without argument (any answer, regardless of correctness); 2 points - the answer (any answer) with arguments (it does not matter whether the statements are correct as a confirmation of their point of view) +1 point for different options of argumentation, if any; 3 points - giving an example or analogy from different subject areas (+0.5 points for each example in case there are several). The scores on the answers to the questions are summed up and the total score is determined by the intensity of the mindset (premonitions). Also, the points are summed up according to the confidence in the correctness of the answer and the overall score is determined on the stability of the mindset (subjective confidence in the correctness of the decision made).

Indicators: (1) mindset, (2) stability of mindset.

IV Block: Methodology for Assessing Intellectual Competence "Interpretation" [13]

Interpretation (essay) on one of the moral dilemmas of A. I. Podolsky and O. A. Karabanova (cited by: [1, pp. 57–61]) reveals the peculiarities of structuring individual experience in its ability and readiness for high-quality information processing based on cognitive and motivational-personal attitude to the latter [2, 19]. This approach allows you to identify features of the transformation of this information in the formation of a personal attitude to it and the argumentation of its position. The qualitative characteristics of the essay were considered as a manifestation of the pupils' intellectual competence, since writing an essay along with the essay is one of the aspects of the success of a real school learning activity. For writing an essay, the students were provided with a white A4 sheet, which was supposed to write an essay on the moral dilemma: "Kohl and Petya worked in the garden in the summer - they picked

strawberries. Kohl wanted to buy a sports watch, which he had already looked after himself for a long time. Kolya is from a low-income family, so parents cannot buy him such watches. Peter wants to improve his computer with the money he earned. Kohl is much inferior to Petya in strength and dexterity, and he rests more often, so Petya collected much more strawberries. In the evening the brigadier came to pay the guys for the work done. Recounted boxes of strawberries, collected by both guys. I counted the amount they earned and asked, turning to Petya: "Well, guys, do you pay equally, or did someone collect more, do they need more?"

The moral dilemma itself was verbally read to study participants. The essay size standards were not mentioned to students, it was only reported that they should write as much text as they themselves would consider necessary for the disclosure of the topic.

Indicators of the "Interpretation" method: the score received by each research participant. In particular, the measure of the complexity of the generated text (mental narrative) was evaluated by the following criteria: 0 points - no written essay; 1 point is a formally written essay where descriptive judgments appear and no point of view is expressed; 2 points - an essay with an establishment of relationships of cause and effect; 3 points - the statement of their own attitude to the problem and/or the use of analogy from another context in the presence of causal relationships

Also analyzed the texts of essays (narratives), in which the unit of analysis were the proposals (narratives of various kinds). When classifying proposals, the following were singled out: (1) sentences of a factual type (statement of facts, for example: "Kohl from a low-income family") – X1; (2) sentences of a reasoning type (arguing any statement, for example: "Since Peter knows perfectly well that he (Kohl. - Ed.) Is from a low-income family, the money must be divided equally)" – X4; (3) sentences of a systematizing type (highlighting a category, building a hierarchical sentence, for example: "This question may have several answers: if they (boys. - Ed.) Are friends, then they must be paid equally, and if they are unfamiliar, then more money must be paid to who worked more" – X3; (4) interrogative sentences (sentences-questions, for example: "How could Petya have done otherwise?") – X2; (5) sentences of an interpretive type (care in an alternative or more general context, for example: "And if there were not enough money, you can move to another job and then buy everything") – X5; (6) sentences of emotional and evaluative, informative type (impersonal evaluation in a broad category, for example: "So everyone would be satisfied, and Peter and Kohl!") – X7; (7) proposals of emotional-evaluative personal type (expressing a personal attitude to the events described, for example: "I would be in Petit's place, as a good friend, told the brigadier to divide the money equally") – X6.

The points for each type of sentences selected are calculated separately for the entire essay written by the student for each of these types. Indicators: intellectual competence (total score), factual type narratives, argumentative type narratives, interrogative type narratives, interpretative type narratives, emotional-evaluative meaningful narratives, and emotional-evaluative personality type narratives.

4 Results

Due to the fact that the distribution of a number of variables is not normal, despite the large number of study participants - 90 students, non-parametric statistics were used for statistical data analysis - the Spearman method of correlation analysis. This method of analysis is consistent with the goals and objectives of this study, although, of course, in the future, the sample size will be increased to obtain more reliable results and use more rigorous methods of analysis. The next step was to conduct a correlation analysis (Spearman) of the indicators of conceptual, intentional, metacognitive abilities and indicators of intellectual competence. The results of this analysis are presented in Table 1.

Table 1. Correlation of conceptual ability indicators and indicators of intellectual competence, metacognitive and intentional abilities

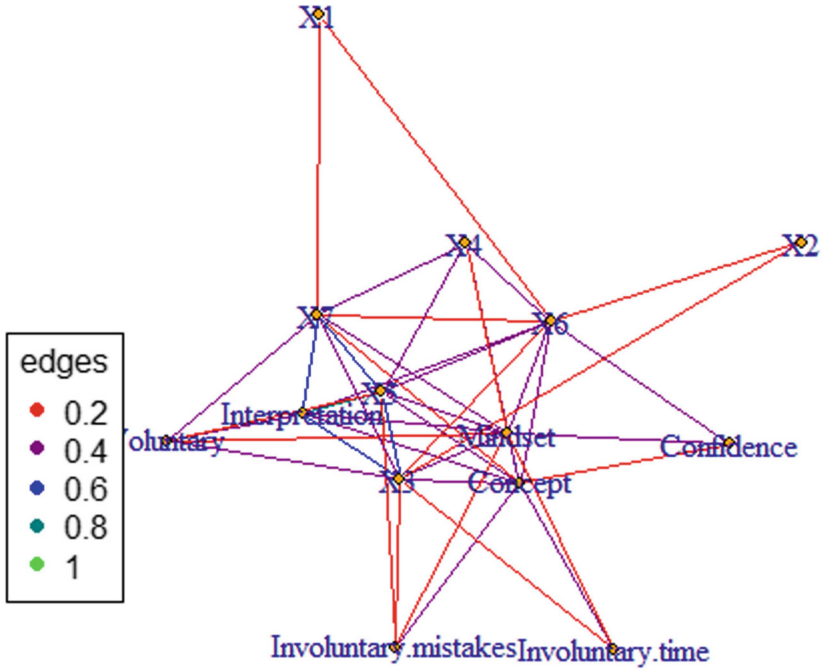
Indicators	Conceptual abilities
Interpretation	0,32
Voluntary metacognitive abilities	0,09
Involuntary metacognitive abilities - time	−0,31
Involuntary metacognitive abilities - errors	−0,34
Mindset	0,60
Confidence	0,30
Emotional-evaluative personal type narratives	0,40
Emotional-evaluative informative type narratives	0,25
Interpretive type narratives	0,40
Factual type narratives	0,09
Systematic type narratives	0,33
Question type narratives	0,17
Argument type narratives	0,32

According to the Table 1, the indicators of conceptual abilities are significantly correlated both with the general indicator of intellectual competence in older adolescence (Rs = 0.32; ρ = 0.001; df = 90), and with its particular manifestations - narratives of various types, namely, with reasoning narratives (Rs = 0.32; ρ = 0.01; df = 90), interpretive (Rs = 0.40; ρ = 0.001; df = 90), emotional-evaluative, meaningful and personal types (Rs = 0.25; ρ = 0.05; df = 90 and Rs = 0.40; ρ = 0.001; df = 90, respectively), as well as the systematizing type (Rs = 0.33; ρ = 0.001; df = 90). The conducted empirical research also established significant correlation links between conceptual abilities and manifestations of intentional abilities, attitudes and intellectual confidence in the correctness of the proposed solution to a difficult situation (Rs = 0.60; ρ = 0.001; df = 90 and Rs = 0.30; ρ = 0.001; df = 90, respectively). Indicators of involuntary intellectual control - temporal and accuracy characteristics - are correlated with the indicator of conceptual abilities. It is noteworthy that correlations with conceptual abilities were not revealed with indices of voluntary

intellectual control, whereas in the case of involuntary intellectual control, they were exclusively negative. Thus, there is reason to assume the significance of the contribution to the construct of conceptual abilities in this age period of involuntary metacognitive abilities. Using a detailed analysis of particular manifestations of conceptual experience, it was possible to identify correlations of intellectual competence and involuntary metacognitive abilities. The results indicate a different functional load of these manifestations of metacognitive experience, despite the unity of the cognitive style "reflexivity/impulsivity" and involuntary intellectual control, which is argued not only theoretically but also empirically (Sipovskaya, St. Petersburg). Despite this, it should be noted that both constructs, both conceptual and metacognitive abilities, regulate intellectual activity. However, there is a fundamental difference between these types of abilities: in the case of conceptual abilities, it is about building a new mental space, based on the available mental resources. Speaking of arbitrary metacognitive abilities, one should bear in mind the operation of retrospective, situational and perspective reflection, that is, management of past, current events and forecasting, which does not imply the unfolding of a new context. It is probably these arguments that can be used to interpret the results.

With regard to the correlation of particular indicators of intellectual competence and conceptual abilities, their heterogeneity attracts attention. Thus, very high correlations were found between the indicators of conceptual abilities and narratives of argumentative, systematizing, interpretive, and emotional-evaluative content and personality types, while correlations with narratives of factual and interrogative types were not identified. In our opinion, such selectivity of correlations can be explained by the varying complexity of the narratives of these types. Factual type narratives are characterized by a simple enumeration or even a retelling of facts, interrogative type narratives, we assume, perform the functions of planning and regulating attitudes towards the expressed problem, these types of sentences are auxiliary and less independent as semantic units. Much more expressive and gnostically charged are narratives of emotionally evaluative personality type, and this load of them is likely to be the reason for the presence of significant correlations between conceptual abilities and intellectual competence indicators. Other types of narratives imply an active attitude of the research participant to the problem and a more moderate emotional and gnostic regulation of intellectual behavior. The second, i.e. "Active and moderately affective", a way of mental activity is more correlated with both intellectual competence and metacognitive abilities. Activity implies a whole arsenal of ways to regulate activities, including intellectual ones, whereas, with a passive attitude towards the world, more scarce regulatory tools are enough. The regulatory and planning functions of speech are more characteristic of the preparation and preliminary reflection of the material, when the achievement of the result is only expected. Such "mental pre-training" does not correlate with conceptual abilities.

The opposite situation with respect to significant correlations reveals itself with respect to involuntary metacognitive abilities, where both the cognitive pace and cognitive accuracy characterize the manifestations of conceptual abilities and, accordingly, the productivity of intellectual activity.



Graph 1. Network model of conceptual abilities.

Based on the results given in Graph 1, one can make an input that the core of the conceptual abilities construct is represented by abilities characterized by the function of generating a new context, speed and accuracy of this process, while cognitively simpler abilities (factual and interrogative narratives) and arbitrary metacognitive abilities are located on the periphery.

Thus, there is reason to conclude about the heterogeneity of the construct of conceptual abilities. The specified differentiation of the structure of conceptual abilities is determined by the functional load and cognitive complexity of the components that make up the concept of conceptual abilities system.

5 Findings

The results obtained in this study indicate the complexity of the conceptual composition of conceptual abilities in older adolescence.

Based on the results carried out in the presented empirical work, we can talk about the multi-level principle of formation of conceptual abilities in older adolescence or the uneven participation in the productivity of intellectual activity of arbitrary and verbalized intellectual control and involuntary. Thus, the involvement of involuntary intellectual control, belonging to the metacognitive level of intellectual activity, in the construct of conceptual abilities was revealed. However, the identified correlations are

different, and this difference depends on the type of functional load. The results obtained are pioneering in view of the fact that earlier data comparable with those obtained in this study were not obtained. As it was supposed, conceptual abilities, as abilities to productive actions in any subject area, with necessity require control over initiation, choice of the mode of activity, the course of activity itself and obtaining a result, as well as comparison of the planned and obtained result of activity. At a conscious, arbitrary level, this control was revealed in our study along with a more implicit, hidden and involuntary intellectual control.

Thus, based on the results of the study, we can conclude that there is a correlation between the high level of formation of conceptual abilities and indicators of the formation of intellectual competence, intentional and metacognitive abilities in students of 9th grade of secondary school. Thus, it was possible to realize the research goal, namely, to reveal the specifics of the conceptual aspects of intellectual competence in older adolescence. In addition, there is reason to talk about the concept as an integrative metastructure, the components of which are private abilities, among which are metacognitive and intentional abilities, as well as manifestations of intellectual competence.

As a direct practical application of the results obtained in this empirical study, it can be said that they can be used in developing such methods for assessing intellectual competence that would characterize the individual characteristics of the intellectual resources of individuals. The obtained results also reveal features, including style features of intelligent strategies for making effective decisions in a situation of uncertainty, and can supplement the data obtained using traditional psychometric techniques. Nevertheless, some questions in the framework of this work were not raised and, accordingly, no answer was received. We are talking about, for example, the expansion of the statistical apparatus, which would allow to reveal a greater number of links due to the fact that they may be non-linear. It should also be noted that other potential components of conceptual abilities were not mentioned in this work, such as, for example, motivation, which can perform initiating and regulatory functions in relation to intellectual activity.

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