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Behavioural predictors of the meta-cognitive aspects of thinking in the process of solving super-complex tasks: a case study of middle and senior preschool children

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Abstract

This article offers an explanation and study of the meta-cognitive aspects of thinking which are examined as predictors of the meta-cognitive results of pre-school child education and development. The article also describes the analysis of the goals of the Federal Education Standards for pre-school education. The goals are achieved through creating conditions for forming an object-oriented learning environment for children of the pre-school age. Such meta-cognitive aspects of thinking as meta-cognitive control and meta-cognitive learning are viewed as prerequisites of meta-subject results. By studying the process of solving the Tower of Hanoi puzzle it concludes that the process of solving super-complex tasks triggers the regulatory and self-learning aspects of thinking. It proves that behavioural factors that predetermine the results of manifested meta-cognitive factors of thinking are verbalization of the knowledge about successful task solving, a flexible strategy of task solving; a sustainable positive emotional background during the process of solving a task.

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Keywords: metathinking, meta-cognitive aspects of thinking, behavioral predictors, children of the middle and senior pre-school age

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1. Introduction

The pre-school age is highly important for the proper development of a person in the context of emotions, learning and thinking. In terms of psychology the application of the Federal Educational Standards (FES) in pre-school institutions can be regarded as determination of psychological and pedagogic conditions for individual and optimal child development.

As pre-school childhood and many aspects of pre-school educational institutions are aimed to prepare children for school life the psychological value of pre-school experience itself and the significance of unique experience of both a cognitive and emotional character remain largely underestimated. Little value was placed on how pre-school children progress in games which develop particular and individual features and abilities that cannot be directly connected with perspectives of successful education in school. As a result, the level of preschool children's proficiency in game decreased [1]. A game as a key activity that developmental psychology defines as an activity that encourages personal enhancement has had insufficient practice and advancement in pre-school education. And the importance of a pre-school pedagogue as a competent organizer of games and other various creative activities for preschoolers has also been poorly realized. The situation in the pre-school education is now presumably changing. One of the key goals set by the Ministry of Education for general education in 2016 is to create conditions for forming an object-oriented learning environment for pre-school children.

What the Federal Educational Standards describe as meta-subject results are especially important abilities to be developed in a child. The meta-subject content of the Federal Educational Standards is a new field for preschool psychologists [2].

Y.V. Gromyko [3] determines the meta-subject content as an activity that does not belong to a certain school subject but the one that builds up the educational process in terms of any school subject. In this context a wide range of child activities has meta-subject characteristics in preschool childhood.

Determination of psychological prerequisites of meta-subject activities has several variants. One of them involves meta-cognitive aspects of thinking.

The first ideas on the meta-cognitive mechanisms were introduced by J. Flavell [4] who concluded that meta-cognitive mechanisms, unlike cognitive ones, include the knowledge of one's own knowledge and the ability to control it: regulating and learning aspects.

A.V. Karpov [5] believes that the methodological tools for diagnosis of meta-cognitive formations have obviously been underdeveloped and since the development of meta-cognitive formations evolves during a quite long time period he provided substantiation for "adult versions" of diagnostic methods of meta-cognitive formations which indeed substantially facilitates new researches.

T.N. Tikhomirova [6] showed the high significance of family relations for developing meta-cognitive competencies. Unlike educational systems, emotional relations and ways of communication between family members have a powerful effect on children's abilities and meta-cognitive aspects of their development.

A.A. Karpov [7] proved the principal invariance of determinative impact on the meta-cognitive mechanisms from the common abilities which rely on the dominance of the structural type of this determination.

The question of how meta-cognitive mechanisms (which are the basis of meta-subject results at the pre-school stage of child development) evolve is of topical interest and has been scantily studied. However considering the relationship between meta-cognitive aspects of thinking and common abilities, it is possible to a certain degree to simplify the task of diagnosing the above aspects of thinking in pre-school children.

2. Method

2.1. Description of the empirical study

Based on the above, the method of observation was selected for this study as it is the most informative for the study of children.

The object of the study is meta-cognitive aspects of thinking.

The subject of the study is behavioral manifestations (predictors) of the meta-cognitive aspects of thinking (regulating and learning) in children of the middle and the senior pre-school ages in the process of solving super-complex tasks.

The goal of the study is to show behavioral characteristics that mediate activation of the regulating (meta-cognitive control) and self-knowledge (meta-cognitive learning) aspects of thinking in children of the middle and senior pre-school age in the process of solving super-complex tasks.

The tasks of the study are:

1. To determine the behavioral patterns which children of the middle and senior pre-school age manifest when solving super-complex tasks;
2. To find out the behavioral factors which mediate the activation of the optimal level of the regulating (meta-cognitive control) and self-knowledge (meta-cognitive learning) aspects of thinking in children of the middle and senior pre-school age when they solve super-complex tasks.

The hypothesis of the study is as follows: the activation of the optimal level of the regulating (meta-cognitive control) and self-knowledge (meta-cognitive learning) aspects of thinking by middle and senior pre-school children in the process of solving super-complex tasks is related to such behavioral factors as 1. Verbalization of knowledge about successful task solving (mega-cognitive learning); 2. Manifestation of flexibility (facility) in the task solving strategy (meta-cognitive control); 3. Maintaining a positive emotional background while solving tasks.

2.2. The Procedure of the study

Children of the middle and senior pre-school age (4-7 years) were observed for this study. All the examinees attend the # 11 child development center in Vladivostok (N=39). For the purpose of the study, visual active thinking was predominantly triggered. This type of thinking is comprehendible for this age. Three age groups – a middle group (4-5 years), a senior group (5-6 years) and a school preparatory group - participated in this study. The children were offered to solve the tower of Hanoi puzzle with three rods and with gradually increasing complexity (from 2 to 4 disks). The choice of this puzzle problem was determined by several conditions: 1. The rules of the puzzle are comprehensible to middle and senior preschool children; 2. According to several authors [4],[5],[7], the activation of the meta-cognitive aspects of thinking can be triggered only when solving super-complex tasks. The minimal number of moves for solving puzzle problems with 3 disks is equal to 7. If the puzzle has 4 disks the number of moves goes up to 15, which exceeds a child's memory capacity and appears to be super-complex for this age and thus proves to foster the meta-cognitive aspects of thinking. The procedure of the study was executed in accordance with the K. Duncker protocol. The rules of the puzzle were explained to the children by using 2 disks as an illustration. The method of permanent participant (involved) observation was used to observe the puzzle solving process. Following that the phenomena observed were translated into criteria which were ranged on the 7 point scale.

3. Results and discussion

The following criteria were formed: 1) a child shows his/her interest in solving the puzzle; 2) a child plans his/her actions and moves; 3) a child successfully fulfills the planned actions and moves; 4) a child verbalizes his/her knowledge about a successful solution of the puzzle; 5) a child initiates collective (cooperative) actions to solve the puzzle; 6) a child shows his/her flexibility in the task solving strategy of; 7) a child maintains a positive

emotional background when solving the puzzle. The coherence of the criteria is quite high. The correlations between the criteria are presented in Table 1.

Table 1. Correlations between the manifestation levels of the behavioral predictors diagnosed, according to Spearman

Criteria	1	2	3	4	5	6	7
1	1	0.607	0.484	0.6	0.507	0.498	0.526
2	0.607	1	0.676	0.589	0.329	0.491	0.566
3	0.484	0.676	1	0.547	0.134	0.56	0.438
4	0.6	0.589	0.547	1	0.578	0.572	0.468
5	0.507	0.329	0.134	0.578	1	0.572	0.652
6	0.498	0.491	0.56	0.572	0.572	1	0.685
7	0.526	0.566	0.438	0.468	0.652	0.685	1

The correlation ratio was measured using the Spearman correlation coefficient. The strongest correlation appeared between criteria 1 and 2, 2 and 3, 1 and 4. The highest correlation ratio was presented between criteria 3 and 5. The results of the study allowed us to perform a factor analysis using the method of major components. The results of the analysis are shown in Table 2.

Table 2. Combined dispersion explained

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**4.134**	59.059	59.059	4.134	59.059	59.059
2	**1.089**	15.562	74.621	1.089	15.562	74.621
3	.612	8.743	83.364			
4	.480	6.858	90.222			
5	.331	4.734	94.956			
6	.214	3.064	98.020			
7	.139	1.980	100.000			

Table 2 allows us to see that only two components have the value of more than 1. Therefore, further analysis was performed only for these two factors. The first factor explains 59.059% of the summarized dispersion, and the second factor accounts for 15.562%.

Table 3 presents relations between the criteria and the above components. It is shown that all the variables (the criteria) appear to have the strongest correlation with Factor 1, and Criterion 3 (the child successfully fulfills the planned actions) proves to have a nearly equal impact on Factor 1 and Factor 2.

Table 3. Component Matrix

	Component	
	1	2
Criterion 1	0.767	-0.004
Criterion 2	0.770	0.407
Criterion 3	0.678	0.652

Criterion 4	0.805	-0.225
Criterion 5	0.713	-0.645
Criterion 6	0.826	0.034
Criterion 7	0.809	-0.172

The numerical values of the criteria allow us to say that Criterion 6 has the strongest impact for Factor 1 and Criteria 2 and 4 has some lesser impact for the same factor.

Factor 1 was defined as "successful task solution" when the puzzle had 3 and more disks and Factor 2 – "the task not solved" – for the puzzle with 3 and more disks. The analysis showed that those children who managed to gain the highest point for Criterion 6 (primarily) and for Criteria 4 and 7 (in a lesser degree) proved to solve the puzzle. It means that such behavioral predictors as the verbalization of the knowledge about the successful task solution, the flexibility in the task solving strategy; the maintaining of the positive emotional background in the process of task solving have a direct relation with solution (completion) of super-complex tasks which relies on the activation of the meta-cognitive aspects of thinking. Therefore those children who gained the maximal number of points for all the criteria, in particular for Criteria 4, 6 and 7, and managed to solve the puzzle, also proved to show the optimal level of activation of the meta-cognitive aspects of thinking.

The analysis of Factor 2 – "the task unsolved" – displayed that Criteria 3 and 5 have the strongest – direct and reverse - correlation with this factor. It means that those children who failed to solve the puzzle, appear to have low points for Criterion 5 (the child initiates cooperative activity for solving the puzzle) and high points for Criterion 3 (the child successfully fulfills the planned actions).

4. Conclusion

During the process of solving super-complex tasks the children of the middle and senior pre-school age display the following behavioral factors: 1) the child shows his/her interest in solving the puzzle; 2) the child plans his/her actions and moves; 3) the child successfully fulfills the planned actions and moves; 4) the child verbalizes his/her knowledge about the successful solution of the puzzle; 5) the child initiates collective (cooperative) actions to solve the puzzle; 6) the child shows his/her flexibility in the task solving strategy; 7) the child maintains a positive emotional background when solving the puzzle.

Such behavioral agents as 1. Verbalization of the knowledge about successful task solving (mega-cognitive learning); 2. Manifestation of flexibility (facility) in the task solving strategy (meta-cognitive control); 3. Maintaining a positive emotional background while solving tasks have a direct correlation with the successful solution of super-complex tasks by middle and senior pre-school children which stimulates such meta-cognitive aspects of thinking as the regulating aspect (meta-cognitive control) and self-knowledge (meta-cognitive learning). Those children who were unable to solve the puzzle appeared to rarely initiate cooperative actions for solving a task but they managed to fulfill their planned actions which allow us to conclude that they have either an exceedingly high level or an insufficient level of manifestation of the above meta-cognitive aspects of thinking.

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