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Assessing Metacognition in 5- to 6-Year-Old Children: Methodological Considerations

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Abstract

Introduction. Metacognition is a process of awareness and regulation of one's own cognitive processes, in which two components are distinguished: metaknowledge (of the strategies and factors of cognition) and metaregulation (planning, monitoring and evaluation). Metacognition was thought to emerge only at the age of 7-8 years, but recent research suggests that some components of metacognition can be detected from an earlier age. **Methods.** The aim of the study was to identify those components of metacognition that can be assessed in 5–6-year-old children and to develop a methodology for their assessment. The study involved 62 children from 4 years 11 months to 6 years 10 months (mean age 66.8 months, 50% boys) - pupils of senior and preparatory groups of kindergartens in Moscow and Kazan. Two types of tasks were used: mnemic and thinking, the assessment of metacognition components was based on a conversation with children in the process of problem solving. Correlation analysis and analysis of differences by the Mann-Whitney criterion were used for data processing. Qualitative analysis was used to analyse children's answers. **Results.** Components that can be assessed at this age were identified: two components of metaknowledge (of the strategy and success factors), and two components of metaregulation (evaluation of one's success and evaluation of difficulties). Metacognitive evaluation of one's success and difficulties are positively related to success on thinking tasks, but not on memorisation tasks. Also, greater success on thinking tasks is found in children who can identify their strategy and the factors that influenced their outcome. No such relationship was found for mnemic tasks. **Discussion.** The analysis of solving thinking tasks provides greater opportunities for assessing the components of metacognition in children than the analysis of solving memory tasks, this technique is considered as the most promising for future research.

Keywords

metacognition, metaknowledge, metaregulation, problem solving, memorisation, senior preschool age

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Introduction

Metacognition is broadly defined as children's awareness and regulation of their cognitive processes (thinking, memory, imagination, etc.) (Veraksa & Veraksa, 2023). The term 'metacognition' was proposed by J. Flavell (Flavell, 1976) in his model of cognitive monitoring of memory. According to this model, four types of metacognitive phenomena can be distinguished: 1) the subject's awareness of the task, 2) awareness of the strategy, 3) awareness of factors affecting the outcome of the task (task features, strategy, and one's own personality), and 4) metacognitive experience or reflection (affective or cognitive) on the progress of the task (Flavell, 1976; 1979). More recent studies of metacognition have summarised these phenomena into two main components of metacognition, metaknowledge and metaregulation (Paris, Cross & Lipson, 1984; Flavell, 2000; Veenman, Van Hout-Wolters, Afflerbach, 2006; Whitebread et al., 1999). The knowledge component included awareness of the factors influencing the problem-solving process, one's personal characteristics, the features of the task itself, and the features of the chosen strategy. The regulatory component was described as the subject's ability to manage his/her own cognition (Schraw, Moshman, 1995, p. 354), including three types of strategies, planning strategies (selecting the right methods and allocating resources), monitoring (tracking one's own understanding or success in solving the task), and evaluation (comparing what was planned with what was actually achieved).

Is it possible to speak about metacognition in relation to senior preschool children?

The author of the idea of metacognition J. Flavell correlated the emergence of metacognition with Piaget's stage of formal operations, because at this stage children are able to think in a hypothetico-deductive way, which, according to J. Flavell, requires

metacognitive control (Flavell, 1992, p. 118). From Flavell's point of view, the development of metacognition at earlier stages is impossible due to the fact that cognitive egocentrism does not allow the child to refer to his or her own thinking processes and reflect on them. J. Flavell further suggested the idea of the presence of the so-called proto-metacognition level at earlier stages, when children in general know that there are different points of view, but are not yet able to deal with them freely. For example, metacognitive knowledge can appear at the age of 4-6 years as an understanding that in the process of solving a problem 'something goes wrong'. But this, from J. Flavell's point of view, does not apply to metacognitive regulation, which emerges closer to adolescence (Veenman & Spaans, 2005). Accordingly, it was long believed that metacognitive abilities do not appear before the age of 7-8 years (Flavell, 1979; Kreutzer et al., 1975; Veenman et al. 2006). More recently, however, researchers have increasingly begun to suggest that the issue may not be one of age, but of research methods, and techniques have been created that demonstrate the presence of elements of metacognitive abilities as early as 3-4 years of age (Bartsch & Estes, 1996; Lockl & Schneider, 2006; Gascoine, Higgins, & Wall, 2017).

Methods for assessing metacognition in younger and senior preschool children

The problem of assessing metacognition in preschool children is connected, first of all, with the specificity of the construct 'metacognition' itself, which can be characterised as 'action over action'. This means that metacognition in one way or another reflects the child's reflexive level, which manifests itself not only in cognitive activity, but also, for example, in speech - in understanding irony, humour, mixed (contradictory) emotions, and so on. (Shatskaya et al., 2024). The evaluation of the presence or absence of reflexion is difficult due to the underdevelopment of children's speech skills - it is difficult for children to verbalise rather abstract constructions related to the sphere of cognition. That is why metacognition questionnaires practically do not work on 5-7-year-old children, although such attempts are made (see, for example, Chernokova, 2013).

The most common method of diagnosing metacognition in senior preschoolers is observation according to predetermined criteria. For example, Whitebread et al. (2007) analysed and categorised short video recordings of metacognitive activity, which were collected by teachers over the course of two years. They assessed the degree of metacognitive knowledge (of their personal characteristics, task features and strategy) and the degree of metacognitive regulation (planning, monitoring and evaluation). The results of this study showed the presence of all the described components in children as early as 3 years of age, and more often in situations of co-operation with peers, without the involvement of teachers. Similarly, metacognition was assessed by A. Shamir et al. Shamir et al. (2009), but the authors of this study chose only one type of task (memorising pictures) and observed and assessed the extent to which the components of metacognition were manifested over 10 days. In the study by F. Buehle and N. Oeri

(2024), children were given a task in the middle of which they encountered an inability to finish, with the experimenter leaving the room and recording what the child did and said in terms of the representation of the two components of metacognition, monitoring and control. In a study by D. Bryce & D. Whitebread (Bryce & Whitebread, 2012) children were given the task of assembling a railway from a model, the process was videotaped and the videos were then analysed according to certain criteria.

The second option for assessing metacognition is to talk to the child during and immediately after problem solving. Numerous studies have shown that the younger a child is, the more his or her metacognitive features are tied to the context of solving specific tasks, which means that it is necessary to use diagnostics that are as 'embedded' in the task as possible (Brown, 1987; Schneider & Pressley, 1997; Bernard et al., 2015; Bryce et al., 2012; Whitebread & Pino-Pasternak, 2010; Marulis, 2016). Thus, in the work of Marulis et al. (2016), children 3-5 years old were asked to assemble different kinds of pyramids from different shaped parts, the process was recorded on camera and the results were used to conduct a so-called metacognitive interview. The interview included 4 blocks of questions: 1) did you do well/average or poorly? what did you do to do well? what could have been done to make you do even better? 2) was anything difficult for you? if no, why, if yes, why and what could have made the task easier, 3) would these tasks have been more difficult for another child your age? why yes/why not? 4) how did you know that you did all the tasks correctly? Based on the answers to these questions, only metacognitive knowledge, knowledge of yourself, task and strategy knowledge, was assessed, and it was not so much the answer that was important, but the fact that there was a metacognitive rationale for it. It is believed that metacognitive knowledge in 3-5 year old children is better formed than metaregulation. However, from our point of view, questions about how the child evaluates his/her success ('How did you do - good, average or poorly?') and the presence of difficulties ('Was it difficult for you?') are questions more likely to ask about the regulatory component of metacognition, metacognitive evaluation, while what helped or hindered, exactly about awareness (metacognitive knowledge). In another paper, Bernard et al. (Bernard et al., 2015), metaregulation (procedural metacognition) was assessed through the so-called 'opt-out task', where children had to recognise images of different quality presented on the screen (some were clearly visible, others were worse) and if they could recognise, they pressed a button of one colour, and if they could not, another. Thus, here we were talking about metacognitive evaluation (can or cannot solve) as a component of metaregulation.

Based on the analysis of the methods presented in the literature, we have identified those components of metacognition that seem to be detectable in children aged 5-7:

1. metaknowledge: of the strategy (how I acted) and of the factors (what helped and hindered me), among the factors we can distinguish three groups: personal characteristics, features of the task and features of the strategy,
2. metaregulation: subjective evaluation of success and difficulty, involving comparison with real success and difficulty.

Purpose of the study

The main purpose of the study was to develop a methodology for assessing metacognition in senior preschool children. It was necessary to select a type of cognitive tasks that, firstly, presuppose a conversation with a child 'embedded' in the context of problem solving that does not require a high level of reflection, and, secondly, actually allow us to successfully assess the formation of the selected components of metacognition. As an addition, we planned to test the hypotheses about the growth of the selected components of metacognition with age and about the relationship between the quality of metacognition and the success of problem solving.

The following **preliminary hypotheses** of the study were put forward:

1. The elder the child is, the better developed are all the components of metacognition under study (evaluation of success, evaluation of difficulty, metaknowledge of the strategy and conditions);

2. Those children who have better metaknowledge (of the strategy and conditions) have higher success rate in solving cognitive tasks;

3. Those children who have better metaregulation (success and difficulty evaluation) have higher success in solving cognitive tasks.

Methods

Participants

The metacognition assessment method was tested on 62 children from 4 years 11 months to 6 years 10 months (average age 66.8 months, 50% of the sample were boys), the pupils of the senior and preparatory groups of kindergartens in Moscow and Kazan. No differences between boys and girls were found in any of the parameters.

Methodology

When selecting a specific methodology, we relied on the work of M. Marulis et al. (2016) described above. However, based on the available research, we decided to give a task not only for thinking (pattern construction), but also for memory, assuming to compare the results and choose the most appropriate type of task. Accordingly, in the first series of the study children solved a task for visual memory (memorising pictures), and in the second series - a task for construction based on a pattern (the first 3 tasks from Nikitin blocks). In each series, children were offered to solve three tasks in sequence, and the formation of metacognition components was assessed on the basis of answers to questions after solving each task.

Stage 1. Metacognition in the process of memorisation

The instruction to the tested was as follows:

'I am going to show you pictures now, try to remember as much of them as possible'.

Course of the study: 22 cards with pictures of animals or plants are shown for 40-45 seconds. After that, the cards are removed and the child is asked to name what was depicted on them. The number of cards named is recorded. The same cards with the same instructions are shown two more times. In the intervals between presentations and reproductions, the following questions are asked:

After the first presentation and reproduction:

1. Now you have memorised ___ cards (say how many). I will show you these cards again. How many cards do you think you can remember?

After the second presentation and reproduction:

2. Do you think you did better now than you did the first time? (evaluation of success);
3. What helped you do better? (metaknowledge of the conditions).

After the third presentation and reproduction

4. Do you think you did better now than the last time? (evaluation of success);
5. What helped you do better? (metaknowledge of the conditions);
6. What prevented you from memorising all the cards? (metaknowledge of the conditions);
7. Tell me how you memorised them? (metaknowledge of the strategy).

Based on the results of the interview, the following variables were identified:

1. **Adequacy of success evaluation**: maximum 2 points, 1 point for each question 'Do you think you did better now than you did the first time?' in case the child's answer (better/worse/the same) coincides with the real change in the number of memorised words.

2. **Metaknowledge of the strategy** (awareness of the way of solving the problem): maximum 1 point in case the answers reflect any possible way, maximum for two questions 2 points. Examples of 1-point answers: 'kept silent in order to remember in my head'; 'put them one by one and memorise them that way'; 'a way of concentration'.

3. **Metaknowledge of the conditions**: a total score from 0 to 4 was calculated when the child identified conditions and the presence of one of 4 types of conditions, task, strategy, personal characteristics, external causes, was recorded separately:

- Examples of children highlighting **features of the task** as a condition: 'there are too many pictures'; 'too many similar cards'; 'the cards are beautiful'; 'this is the third time I see them';

- Examples of children highlighting the **features of the strategy** as a condition: 'while I was looking at the second one, I forgot the first one'; 'talking to myself helped'; 'memorising things I didn't name before';
- Examples of children highlighting **personal characteristics** as a condition: 'my brain helps me'; 'my mind', 'my memory', 'my mouth helps me'; 'my eyes help me'; 'my head helps me'; 'I don't memorise well what I don't know';
- Examples of children highlighting **external causes** as conditions: 'my favourite car helped'; 'flowers helped'; 'shouting distracted me'

The adequacy of the difficulty evaluation in Episode 1 was not calculated because the task was set the same all three times.

Stage 2. Metacognition in the process of problem solving

The child is shown Nikitin blocks with successively more complicated patterns that need to be assembled. The experimenter demonstrates a sample of solving the simplest problem. The instruction to the tested was as follows:

'Let's play a game. We need to assemble this figure from these blocks (shows the simplest figure). Try it.'

When the child says that he/she has already solved, the experimenter records the fact of solving or its absence and asks questions:

1. Did you do a good job? (evaluation of success);
2. Was it difficult? (evaluation of difficulty).

After the answers are recorded, a more difficult figure is given; after the child says he/she has done everything, again success is recorded and questions are asked:

3. Did you do better or worse than the last time? (evaluation of success);
4. Was it easier or harder for you? Why? (evaluation of difficulty).

After the answers are recorded, an even more difficult figure is given, and questions are asked after the assembly is complete:

5. Did you do better or worse than the last time? (evaluation of success);
6. Was it easier or harder for you? Why? (evaluation of difficulty);
7. What prevented you from assembling the last figure correctly (in case of failure)? What helped you to assemble such a difficult figure (in case of success) (metaknowledge of the conditions);
8. How did you act when you assembled the pieces? (metaknowledge of the strategy);

Based on the results of the interview, the following variables were highlighted:

1. **Adequacy of success evaluation**: maximum 3 points, 1 for each question, 1, 3, 5 if the child's answer (better/worse/the same) coincides with the real success (assembled/not assembled);

2. **Adequacy of difficulty evaluation**: maximum 3 points, 1 for each question, 2, 4, 6 if the child's answer (harder/easier/the same) coincides with the real difficulty of the process, which was recorded by the experimenter;

3. **Metaknowledge of the strategy** (awareness of the way of solving the problem): maximum 2 points in case the answers to questions 7 and 8 reflect any possible way. Examples of answers scored 1 point: 'thought about how to assemble'; 'looked at the pattern'; 'matched by colour';

4. **Metaknowledge of the conditions**: assessed by the answer to question 7, a total score from 0 to 4 was calculated for the fact that the child identified conditions and separately recorded the presence of one of 4 types of conditions, task, strategy, personal characteristics, external causes):

- Examples of children highlighting features of a task as a condition: 'the pattern is too difficult';
- Examples of children highlighting features of the strategy as a condition: 'I was twirling them, spinning them'; 'pick up the right blocks';
- Examples of children highlighting personal characteristics as a condition: 'brain'; 'mind';
- Examples of children highlighting external causes as conditions: 'my favourite doggy helped'; 'you helped'.

Results

Descriptive statistics for each of the parameters in each episode are presented in Table 1.

As for memorising pictures, predictably, the number of words reproduced by children increases with each presentation, with only 8.1% of children inadequately evaluating their actual success compared to the previous one (considering that they did better when they did worse, and vice versa). 53.2% of preschoolers evaluate their memorisation success compared to the previous one as adequately as possible.

Table 1
Descriptive statistics for the parameters of success and metacognition assessment

	N	M	SD	Frequencies by level (if available) (%)
Stage 1 (memorisation)				
Number of words reproduced after 1 presentation (out of 22)	62	5,84	2,34	
Number of words reproduced after 2 presentation (out of 22)	62	7	2,33	

	N	M	SD	Frequencies by level (if available) (%)
Number of words reproduced after 3 presentation (out of 22)	62	8,4	3,08	
Adequacy of success evaluation (0-2)	62	1,45	0,64	2 – 53,2 1 – 38,7 0 – 8,1
Metaknowledge of the strategy (0-2)	62	1,03	0,81	2 – 33,9 1 – 35,5 0 – 30,6
Metaknowledge of the conditions (0-4)	62	1,02	0,64	4 – 0 3 – 0 2 – 20,9 1 – 59,68 0 – 45,16
Task (0–1)	62	0,16	0,37	1 – 16,12 0 – 83,88
Strategy (0–1)	62	0,34	0,48	1 – 33,9 0 – 66,1
Personal characteristics (0–1)	62	0,42	0,5	1 – 41,9 0 – 58,1
External causes (0–1)	62	0,1	0,1	1 – 9,7 0 – 90,3

	N	M	SD	Frequencies by level (if available) (%)
Stage 2 (problem solving)				
Actual success rate of the solution (0-3)	62	1,74	1,02	3 – 11,7 2 – 29,4 1 – 11,8 0 – 41,2
Adequacy of success evaluation (0-3)	62	2,05	0,89	3 – 23,5 2 – 35,3 1 – 41,2 0 – 0
Adequacy of difficulty evaluation (0-3)	62	2,44	0,8	3 – 29,4 2 – 35,3 1 – 29,4 0 – 5,9
Metaknowledge of the strategy (0-2)	55	0,58	0,76	2 – 16,4 1 – 25,5 0 – 58,1
Metaknowledge of the conditions (0-4)	53	0,75	0,59	4 – 0 3 – 0 2 – 7,5 1 – 60,4 0 – 32,1
Task (0–1)	53	0,27	0,42	1 – 22,6 0 – 77,4
Strategy (0–1)	53	0,13	0,34	1 – 13,2 0 – 86,8
Personal characteristics (0–1)	53	0,3	0,46	1 – 30,2 0 – 69,8
External causes (0–1)	53	0,09	0,29	1 – 9,4 0 – 90,6

At the same time, children's actual success in memorising is not related to their evaluation of their success (Spearman's R). However, those who more adequately evaluate the success of their memorisation are much less likely to 'complain' about the features of the task that prevented them from doing better ('there are too many pictures') or about the ease of these tasks ('it's the third time I've looked at it') (Spearman's $R = -0.54$, $p < 0.01$). Children most often identify their personal characteristics (41.9% 'the fact that I am clever helped', 'memory helped') as conditions (what hinders and what helps), followed by strategy features (33.9% 'talking to myself helped', 'remembering things I didn't name before'), task features (16.12% 'too many similar cards'), and external factors (9.7% 'music distracted me'). As for solving thinking tasks, only 11.7 per cent of children coped with all three patterns, and 41.2 per cent did not cope with any of them. At the same time, a correlation between real success and adequacy of evaluation of their success was found in this task. The better children coped, the more accurately they evaluated their success (Spearman's $R = 0.62$, $p < 0.001$). In general, those children who evaluate success more adequately, significantly more accurately evaluate the presence/absence of difficulties in the solution process (Spearman's $R = 0.52$, $p < 0.001$), and identify hindering and helping factors (Spearman's $R = 0.27$, $p < 0.05$). It is also interesting that the children who are more successful in problem solving are those who can identify a solution strategy (Spearman's $R = 0.52$, $p < 0.01$). Children most often identify their personal characteristics as conditions (what hinders and what helps) when assembling figures (30.2% 'I am clever', 'I am diligent', 'I am attentive', etc.), followed by the features of the task (22.6% 'difficult figures', 'we went from simple to complex', etc.), then by the features of the chosen strategy, followed by features of the chosen strategy (13.2% 'I looked at the picture too much, but I should have looked at the blocks', 'I learnt at first, and then it helped'), some children (9.4%) named only external factors ('the noise behind the door disturbed', 'you didn't help me').

Interestingly, no relationships were found between the variables of adequacy of evaluation of success, difficulty and the fact of strategy allocation for two different tasks (memory and thinking). Awareness of the conditions of remembering was not related to awareness of the conditions of assembling the figures. However, those children who more often named external factors (what hindered and what helped) in the memory task, more often named the same external factors in the thinking task (Spearman's $R = 0.34$, $p < 0.05$).

Thus, we obtained the most interesting results when analysing metacognition in solving thinking tasks, which is probably due to the fact that here, unlike in memory tasks, there are clear performance criteria, whether the child assembled the figure as in the sample or not, which allows children to more accurately evaluate the adequacy and difficulty of the tasks.

Hypothesis testing

1. The elder the child is, the better developed are all the components of metacognition under study (success evaluation, difficulty evaluation, metaknowledge of the strategy and conditions).

The hypothesis was not confirmed: age does not make a significant contribution to any of the components of metacognition in either the memory or thinking tasks. This may be due to the lack of a sufficient age spread in our sample, and it is necessary to test the methods on elder children.

2. Those children who have better metaknowledge (of the strategy and the conditions) have higher success in solving cognitive tasks.

The hypothesis was confirmed only for thinking tasks. Children with metaknowledge of the strategy and the conditions performed better on such tasks (Spearman's R for strategy = 0.52, $p < 0.001$, Spearman's R for conditions = 0.28, $p < 0, 05$).

3. Those children who have better metaregulation (evaluation of success and difficulty) have higher success in cognitive tasks.

The hypothesis was confirmed, again, only for thinking tasks. Children with a higher level of metaregulation performed better on such tasks (Spearman's R for success adequacy = 0.62, $p < 0.001$, Spearman's R for difficulty adequacy = 0.3, $p < 0.05$). The results of hypothesis testing allow us to state that the technique involving thinking tasks gives more interesting results on metaknowledge than the technique where children solve memorisation tasks.

Discussion

The problematics of metacognition in senior preschool and primary school children is embedded in the broader context of the problem of formation and development of the child's subjectivity both in kindergarten and in primary school (Tsukerman & Obukhova, 2024; Nisskaya & Tsyganova, 2024). However, before identifying the conditions for the formation of metacognition components, it is important to find adequate methods for their assessment. In recent years, there has been an active discussion of such methods (Buehle & Oeri, 2024; Lyons & Ghetti, 2010; Lockl & Schneider, 2006; Gascoine, Higgins & Wall, 2017; Chernokova, 2013). However, due to the reflexive 'nature' of the phenomenon of metacognition itself, which by definition implies awareness and regulation of one's cognitive processes, the study of metacognition in childhood is very difficult. Nevertheless, even a simple observation of senior preschoolers and young schoolchildren shows that they differ in the level of formation of metacognitive skills, some children, for example, easily evaluate their success or level of difficulty in performing a task, while others cannot adequately describe their actual results and the amount of effort expended. Some children can identify the method by which the task was solved, while others find it difficult to even realise that a method can be used here. In the present study, an attempt was made to find an approach to assess metacognition in preschool children on the basis of their solving different types of cognitive tasks, memorisation tasks and thinking tasks accessible to this age (for example, such as assembling a figure according to a pattern).

In this paper, based on the analysis of the literature, the components of metacognition, in terms of the formation of which children can really differ. Most often, psychological

works present methods for assessing only one of the components of metacognition, metaknowledge (Marulis et al., 2016; Schneider & Pressley, 1997), mainly knowledge about the tasks, strategies and factors of cognition (Flavell, 1979; Schraw & Moshman, 1995). Metaregulation as mastery of strategies for planning, monitoring, and evaluating problem solving is thought to be a later age-related acquisition. However, as our study showed, individual components of metaregulation may be present in the form of adequacy in evaluating the success and difficulty of a task.

A significant result of our work was the fact that we discovered that thinking tasks apparently more reliably assess those components of metacognition that can be seen in senior preschoolers. These are two components of metaknowledge (metaknowledge of the strategy and metaknowledge of the conditions) and two components of metaregulation (adequacy of evaluation of one's success and adequacy of evaluation of difficulty). The question about conditions (metaknowledge of the conditions) in solving thinking tasks, 'What helped you and what hindered you in performing these tasks?' was very interesting from the point of view of the differences obtained. In answering this question, children clearly divided into four groups: most of them named their personal characteristics as such conditions ('my mind', 'my brain', 'I think well', etc.), the second place is occupied by the features of the task ('the pattern was too difficult'), then by strategies ('I matched the colour', 'I twisted') and, finally, by external causes ('it was noisy'). In the memorisation tasks, the distribution of children into groups was similar, but the second place was 'taken' not by the features of the task, but by the features of the strategy (the third place, by the features of the task, the fourth, by external causes). Apparently, this is due to the specificity of memory tasks compared to patterning tasks: in memory tasks, strategy plays a clearly more important role. This leads us to the idea of finding such thinking tasks in which the strategy would appear to children more explicitly, where it would be possible to actually choose different solution strategies.

Unfortunately, we did not obtain age differences for any of the variants of the methodology, which is probably due to the small sample of the study.

Conclusion

The most reliable type of tasks for assessing the components of metacognition are thinking tasks, in particular, the ability to reproduce the pattern of a figure; however, such tasks should include the possibility of using different ways of solving them. The development of a specific methodology based on the results obtained and its testing, including on elder children, is the task of subsequent research.

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Conflict of interest information

The authors have no conflicts of interest to declare.