Metacognitive components as predictors of preschool children’s performance in problem-solving tasks

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The aim of the study was to examine the relation between metacognitive components, declarative and procedural metacognitive knowledge and cognitive regulation, and preschool children’s performance in different problem solving tasks – hidden pictures, classifying and sorting, the same and the different, estimation, patterns, dot-to-dot, mazes and memory tasks. The sample consisted of 347 preschool children aged 3–6. The results showed that children with highly developed metacognitive abilities, declarative and procedural metacognitive knowledge, cognitive monitoring and self-regulation of cognitive strategies, were more successful and efficient in resolving problem tasks. This relation was stronger in older children and in more complex tasks.

Keywords: metacognition, cognitive monitoring, problem solving, preschoolers.

Highlights:

- Metacognition is a significant predictor of children’s performance in problem tasks
- Preschoolers with higher metacognition were more successful and efficient
- Relation of metacognition and performance increases with age and task complexity

Metacognition is defined as knowledge about cognition and regulation of cognition (Flavell & Wellman, 1977; Kankaraš, 2004). Metacognitive knowledge includes understanding of mental verbs and knowledge about person, task, and strategies (declarative and procedural). Metacognitive regulation consists of monitoring, controlling and self-regulating components, related to emotional and motivational states, effortful and inhibitory control (Schneider, 1998). Monitoring cognitive processes includes interactions among the following four...
categories: metacognitive knowledge, metacognitive experiences, goals or tasks, and actions or strategies (Flavell, 1979). Flavell found significant relations between general metacognitive phenomena, such as the use of metacognitive knowledge, self-regulation metacognitive strategies, and problem solving performance (Flavell, 2000).

On a general level, metacognitive abilities are important for children’s cognitive functioning and problem-solving, as is contextual metacognition, related to the problem the child is faced with (Gourgey, 2010; Mayer, 1998; Pintrich, 2002; Schraw, 1998). Studies have shown that older preschoolers significantly develop metacognitive potentials, such as awareness and cognition about own cognitive processes and self-control of cognitive performance (Fisher, 1998; Karnes, Johnson, Cohen, & Beauchamp, 1986; Whitebread et al., 2005). The period from 4 to 9 years of age is especially important for developing metacognitive abilities (Melo, 2015; Young & Fry, 2008). During this period children become aware of themselves as thinking individuals (Geurten, Willems, & Meulemans, 2015; Isquith, Gioia, & Espy, 2004).

Swanson (1990) tested the influence of metacognitive knowledge and aptitude on problem solving in children. He used the method of “think aloud” protocols. Children with higher metacognitive abilities had better performance and were more likely to use hypothetic-deductive and evaluation strategies (Swanson, 1992). The improvement in metacognitive abilities helps children become successful in problem solving (Leseman, 2012; Pawlina & Standford, 2011). The knowledge about cognition leads to proper detection of problems and to selection of appropriate cognitive strategies (Kuhn, 2000; Wang, 2015; Winsler & Naglieri, 2003).

Children exhibit individual differences in choosing metacognitive strategies in problem solving. A higher developmental stadium and more experience lead children to use more adaptive strategies (Shrager & Siegler, 1998; Siegler, 1999). These findings indicate a positive relation between metacognitive abilities and performance in problem-solving situations in preschoolers (Lai, 2011; Mayer, 1998; Whitebread, 1999), but other researchers found that this relation may be negative or insignificant (Larkin, 2010; Robson, 2015; Steiner & Carr, 2003). These differences in results are usually understood in light of various aspects of the respect studies: children’s age, type of task, task complexity, orientation to the correctness or time needed for resolving the task, type of activity – children’s or adult-initiated activities, the assessment of general or specific metacognitive abilities, study design – whether the study is conducted in the child’s natural environment or in a laboratory, the instruments used – observing protocols, interviews (non-structured, semi-structured, post-hoc), think-aloud protocols, sample size (Azevedo, 2009; Chatzipanteli, Grammatikopoulos, & Gregoriadis, 2014; Destan & Roebers, 2015).
Aiming to contribute to a better understanding of the complex relation between metacognitive abilities and problem-solving performance in preschool children, this study strived to overcome some of the limitations evidenced in previous research. Most of the previous studies used just one type of tasks (Jacobs, 2004; Jacobs & Paris, 1987), oriented to one aspect of problem solving – correctness or efficiency (Hasim, Yasin, & Rosli, 2015; Mytkowicz, Goss, & Steinberg, 2014; Sperling, Walls, & Hill, 2000). Also, most of the studies assessed exclusively general metacognitive abilities or contextual metacognition only, without comparing the two measures (Desoete, 2008; Lysaker & Hopper, 2015; Nelson & Narens, 1994). Studies conducted in laboratory are problematic because of ecological validity (Larkin, 2010; Metcalfe & Finn, 2009). Using only interviews and think-aloud protocols is problematic regarding children’s verbal and linguistic abilities (Lai, 2011; Robson, 2016). Most studies included relatively small samples of young participants (N = 20 – 60).

The focus on measuring only the time required for task completion showed insignificant or negative correlations between metacognition and problem-solving competences (Lai, 2011; Sperling, Howard, Miller, & Murphy, 2002). Using interviews instead of protocols usually underestimated metacognitive abilities, because of the results depending on children’s linguistic competences (Whitebread et al., 2010; Winne & Perry, 2000). The relation was, therefore, low, negative or insignificant, but if the interview was specific and questions precisely defined, they detected positive relation between metacognitive abilities and problem task performance in preschoolers aged 3–5, while this relation was stronger in older children (Marulis, Sullivan-Palincsar, Berhenke, & Whitebread, 2016; Robson, 2015). The complexity of a task contributes specifically to the direction of the relation between metacognitive abilities and problem-solving performance. If a task was too easy, children had no need to use metacognitive abilities, therefore the relation was non-significant or extremely low, but the complexity of the task raised the level of relation between metacognitive abilities and problem-solving performance (Lai, 2011; Robson, 2016; Sperling et al., 2000).

The relationship between metacognitive and problem-solving ability in 3–6 year old children is a complex one, especially in terms of their developmental relationship. Flavell (2000) has demonstrated that metacognitive ability might depend on a child’s ability to solve a problem; e.g. if a child reaches a certain level of understanding a task then he/she can use a metacognitive strategy with the experimenter support. Once the child’s ability has improved, the child is able to use metacognitive strategies independently. In other words, problem-solving ability could enable metacognitive processes that will improve problem solving. By resolving interesting problems and acting in different tasks, preschool children develop highly-ordered thinking and enhance their metacognitive potentials (Lambert, 2001; Whitebread & O’Sullivan, 2012).
Children’s age is also an important factor that contributes to the inconsistency in previous results. Most results showed that older children have more developed metacognitive abilities and higher possibilities for problem solving, and the relation between them was higher and positive (Schneider, 2008; Whitebread, 1999). Other results showed that this relation was higher in younger children, because they needed stronger efforts for task realization and their metacognitive abilities showed more important role in this process, but task complexity was not controlled in these studies (Lai, 2011; Schneider & Lockl, 2002).

Children were significantly more likely to display self-regulation and metacognition in post-hoc interviews rather than during the activity, but they were more likely to show regulatory aspects such as planning and monitoring during an activity, whilst evaluation was more evident in later discussion (Robson, 2016; Sperling et al., 2000). The used instruments and study design is, therefore, one of the potential reasons why the relation between metacognitive aspects and problem-solving performance was inconsistent.

Our main research question was how metacognitive components and preschool children’s performance in different problem-solving tasks are related? With regard to the inconsistencies of previous findings, resolving this issue had to include an examination of the influence of age differences and task complexity in the relationship between metacognitive and problem-solving abilities. Thus, this study included eight types of problem-solving tasks, with different complexity, orientation toward both important aspects of solving task – correctness and efficiency, assessment of general metacognitive abilities measured by the observation protocol in their natural environment, but also by the semi-structured interview for measuring contextual metacognitive abilities. The main aim was to examine the relation between declarative and procedural metacognitive knowledge, and cognitive regulation (monitoring and self-regulation of cognitive strategies), and preschool children’s performance in different problem-solving tasks. The moderating role of children’s current age and task complexity in relation between metacognitive and problem-solving abilities was also tested.

Method

Participants

The sample consisted of 347 preschool children – 176 girls and 171 boys, in the age range of 3–6 years. According to their current age at the moment when they have been assessed, in the first group were children aged 3–4 (N = 114), the second group consisted of children aged 4–5 (N = 117) and in the third group were children aged 5–6 (N = 116). All the participants were children with typical developmental characteristics. Children were selected from nine preschools. Ethical committee of preschool institutions, preschool teachers and parents of each child signed the agreement for children’s participation in this study.
Procedural

The data was collected in nine preschools, during the period of two years. During the four months children’s behavior in different activities was observed for assessing the metacognitive abilities by Whitebread’s protocol. The children were engaged in the activities of problem-solving tasks in the middle of that period – two months after starting the observation procedure. Children’s parents were informed in detail about the realization of the study. Participants individually resolved problem-solving tasks in a test room in their preschools. Problem-solving situations were created for the purpose of this study. Two main researchers and four qualified assistants were engaged in the procedure of data collection.

Instruments

The instrument for assessing problem-solving performance consisted of eight categories of problem-solving tasks: hidden pictures, classifying and sorting, the same and the different, estimation, patterns, dot-to-dot, mazes and memory tasks. Each category of problem-solving situation consisted of a group of five different tasks, which were set from the easiest level to more difficult ones. It is assumed that participants in the sample were on Piaget’s preoperational stage of cognitive development, but it is possible that some children at the age of 6 are already at stage of concrete operations. Problem-solving tasks were therefore adapted to their cognitive capacities. Children at the pre-operational stage can think beyond “here” and “now” and are able to explore environment by using mental representations. Symbolic thinking, imagination and intuition develop intensively at this cognitive stage (Piaget, 1964).

The first type of tasks was “hidden pictures” – the task was to find the missing part of the presented picture. One part of the picture was cut off and the child should have detected the cut part among the offered parts. The second form of the task was “classifying and sorting” – the task was to categorize the exposed objects made of cardboard, according to the three criteria: size, shape and the color of the object. The third category of the tasks was “the same and the different” – children should have compared objects within the presented group. They should have detected objects that are the same according to one criterion and single out one presented object that was different from the others. The fourth type of the tasks was “estimation” – children should have estimated the number of the exposed objects made of cardboard. The researchers asked children to determine the position of the estimated number of objects among the numbers given. Moreover, the researchers asked children to compare the proximity of the estimated number of objects to the other numbers offered. The maximum number of the exposed objects at one time was nine. The fifth form of the tasks was “patterns”. The materials were small figures of wood. Children were asked to complete the figure patterns that the researcher had already started to create. The sixth type of tasks was “dot-to-dot”. The materials were cardboards with dots that the children were required to connect and create. The seventh category was the “mazes”. The materials were big cardboards with a drawn maze and toys. The task was to find the way from one toy that was placed at the beginning of the maze to the other toy placed at the finish of the path. The eighth type was “memory tasks”. The materials were cardboards of different shapes organized in a specific pattern, and the children were supposed to memorize the presented figure pattern. After that, the researcher presented the reorganized schedule of figures and the children were supposed to detect which figures had changed their places.

The measures of children’s performance in problem-solving tasks were operationalized through the level of successfulness – correctness of the responses and the level of efficiency – the time required for the performance of a task. Both measures were expressed using the scale ranging from 1 – very low /slow performance to 3 – very good/fast performance. The composite scores on the two scales for each type of tasks were formed by using the HOMALS method of optimal scaling (Breiman & Friedman, 1985; Meulman, 1992). It quantifies nominal
or ordinal variables, their new values staying optimal, with the minimum loss of information (Michalidis & De Leeuw, 1996). The total level of children’s general performance in problem-solving situations was operationalized as the general level of successfulness (the average rate of the response correctness in different types of tasks) and the general level of efficiency (the average rate of the response time in different types of tasks). Higher total scores for general successfulness and lower total scores for the general efficiency indicate higher general performance in the different problem-solving situations. In this study the instrument showed adequate metric characteristics (Chronbach’s $\alpha = .82 -.85$ per category).

The data about metacognition and self-regulation were collected by an observational checklist and a semi-structured interview. The complementary use of observational methods and reflective dialogue provides stronger reliability of the collected data on metacognition.

The observational protocol used in this study was the adopted checklist created by Whitebread and his associates (2009). Whitebread’s checklist consists of 22 items (CHILD – Checklist of Independent Learning Development 3–5). The purpose of this instrument is to assess metacognitive components and self-regulation in preschoolers (aged 3, 4 and 5). The observational protocol is developed for measuring metacognitive components – metacognitive knowledge, metacognitive regulation, emotional and motivational regulation. By identifying different verbal and nonverbal children’s behavior and their responses that represent metacognition, this instrument measures metacognitive capacities in preschool children. Metacognitive manifestations were coded by preschool teachers during the individual or group learning and problem-solving activities, by rating individual child on each behavior on a 4-point Likert’s type scale (the continuum from “always” to “never”). The checklist is highly reliable – nearly 96% agreement between different valulators was reported. The average measure of congruence among the raters that used different coding schedules was 84% (Lai, 2011). In this study the instrument showed adequate metric characteristics (Chronbach’s $\alpha = .81 -.87$ per subscale).

The semi-structured interview consisted of seven questions created for this research, and its main purpose was to provide stronger reliability of the collected data. The questions were asked by the researcher during the process of children’s problem-solving. Children were encouraged by the researchers to think aloud and verbalize their thoughts. The seven auxiliary questions that the children were asked were: 1. What are you doing now?, 2. How have you done that?, 3. What are you planning to do next?, 4. Why have you chosen this action?, 5. What helps you in solving this task?, 6. What disturbs you in solving this task?, and 7. Can you try to do something else? The data were collected by assistant researchers in the process of rating children’s metacognitive manifestations. The answers were rated on the 1–3 scale (1 – not metacognitive, 2 – partially metacognitive, 3 – metacognitive answer). In this study the instrument showed adequate reliability (Chronbach’s $\alpha = .84$).

Results

Descriptive analysis

The descriptive data, means and standard deviations for metacognitive components and self-regulation, rated in the terms of proper scales of the Checklist of Independent Learning (Whitebread et al., 2009), semi-structured interview, and for problem-solving performance are presented in Tables 1, 2 and 3.
Table 1
Descriptive data for metacognitive components and self-regulation

<table>
<thead>
<tr>
<th>Metacognitive component and self-regulation</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is aware of own strengths and weaknesses</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.13</td>
<td>0.38</td>
</tr>
<tr>
<td>Can speak about how they have done something or what they have learnt</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>3.41</td>
<td>0.66</td>
</tr>
<tr>
<td>Can make reasoned choices and decisions</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.07</td>
<td>0.1</td>
</tr>
<tr>
<td>Asks questions and suggests answers</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>3.01</td>
<td>0.32</td>
</tr>
<tr>
<td>Uses previously taught strategies</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>1.42</td>
<td>0.83</td>
</tr>
<tr>
<td>Adopts previously heard language for own purposes</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>1.26</td>
<td>0.89</td>
</tr>
<tr>
<td><strong>Emotional</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can speak about own and other’s behavior and consequences</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.21</td>
<td>0.53</td>
</tr>
<tr>
<td>Tackles new tasks confidently</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>3.11</td>
<td>0.10</td>
</tr>
<tr>
<td>Can control attention and resist distraction</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.35</td>
<td>0.26</td>
</tr>
<tr>
<td>Monitors progress and seeks help appropriately</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>3.09</td>
<td>0.40</td>
</tr>
<tr>
<td>Persists in the face of difficulties</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.86</td>
<td>0.60</td>
</tr>
<tr>
<td><strong>Motivation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiates activities</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>1.75</td>
<td>0.51</td>
</tr>
<tr>
<td>Finds own resources without adult help</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>3.16</td>
<td>1.00</td>
</tr>
<tr>
<td>Develops own ways of carrying out tasks</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.81</td>
<td>0.19</td>
</tr>
<tr>
<td>Plans own tasks, targets and goals</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.67</td>
<td>0.21</td>
</tr>
<tr>
<td>Enjoys solving problems</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>3.03</td>
<td>0.56</td>
</tr>
<tr>
<td><strong>Pro-social</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negotiates when and how to carry out tasks</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>1.17</td>
<td>0.02</td>
</tr>
<tr>
<td>Can resolve social problems with peers</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.14</td>
<td>0.47</td>
</tr>
<tr>
<td>Is aware of feelings and others and helps and comforts</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.97</td>
<td>0.38</td>
</tr>
<tr>
<td>Engages in independent cooperative activities with peers</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>3.12</td>
<td>0.53</td>
</tr>
<tr>
<td>Shares and takes turns independently</td>
<td>347</td>
<td>1</td>
<td>4</td>
<td>2.76</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Table 2
Descriptive data for semi-structured interview

<table>
<thead>
<tr>
<th>Semi-structured interview</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total score</td>
<td>347</td>
<td>7</td>
<td>21</td>
<td>13.4</td>
<td>4.57</td>
</tr>
</tbody>
</table>

*Note. N – number of participants, Min – minimum result, Max – maximum result, M – mean, SD – standard deviation*

Table 3
Descriptive data for children’s performance in problem-solving tasks

<table>
<thead>
<tr>
<th>Performance in problem-solving tasks</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successfulness</td>
<td>347</td>
<td>40</td>
<td>120</td>
<td>84.5</td>
<td>12.8</td>
</tr>
<tr>
<td>Efficiency</td>
<td>347</td>
<td>40</td>
<td>120</td>
<td>82.9</td>
<td>11.3</td>
</tr>
<tr>
<td>Total score</td>
<td>347</td>
<td>80</td>
<td>160</td>
<td>83.7</td>
<td>12.1</td>
</tr>
</tbody>
</table>

*Note. N – number of participants, Min – minimum result, Max – maximum result, M – mean, SD – standard deviation*
The results of inter-correlation between subscales of the metacognitive instrument showed a moderate level of correlations. The scores on these subscales are centered, therefore the variables could enter a unique model, which put under control a potential problem of multicolinearity of variables (Belsley, Kuh, & Walsch, 2004).

Table 4
Pearson’s correlations between subscales of the Checklist of Independent Learning

<table>
<thead>
<tr>
<th>Pearson’s coefficients of correlation</th>
<th>Cognitive</th>
<th>Emotional</th>
<th>Motivational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional</td>
<td>.61*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivational</td>
<td>.60*</td>
<td>.55*</td>
<td></td>
</tr>
<tr>
<td>Pro-social</td>
<td>.54*</td>
<td>.52*</td>
<td>.55*</td>
</tr>
</tbody>
</table>

*Note. * significance level $p < .05$

The overall semi-interview scores correlated significantly with the overall Whitebread’s CHILD score ($r = .78$, $p < .01$). Pearson’s coefficients of correlations between scores on subscales of CHILD and the overall semi-interview scores are also significant (cognitive: $r = .86$, $p < .01$; emotional: $r = .74$, $p < .03$; motivational: $r = .71$, $p < .01$; pro-social: $r = .62$, $p < .05$).

Testing the main hypotheses

Before testing the structural model, measurement models for the latent dimensions included in the study were tested first. The metacognitive and self-regulation factor are specified by the proper scales of the Checklist of Independent Learning: cognitive, emotional, motivational and pro-social. Problem-solving performance is specified through two dimensions: successfulness and efficiency. Before implementing the final SEM model, the levels of children’s achievement in problem-solving tasks had undergone statistical method of scaling data (HOMALS). Both models have satisfactory fit indices and show themselves as proper for using in structure analyses:

- Checklist of Independent Learning: $\chi^2(df = 213) = 251$, $p < .001$, RMSEA = .037 (90% CI (.03, .045)), CFI/TLI = .89/.90, WRMR = .86;
- performance in problem-solving tasks: $\chi^2(df = 206) = 238$, $p < .001$, RMSEA = .039 (90% CI (.03, .05)), CFI/TLI = .94/.95, WRMR = .88). All $\chi^2$s are significant at $p < .001$. 

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The main hypotheses were tested using the SEM model. The final model of the relation between metacognitive components and self-regulation and the performance in problem-solving tasks, including age and task complexity as a moderator variable are shown in Figure 1. The model was a good fit, $\chi^2(df = 817) = 962, p < .001, \text{RMSEA} = .034 \ (90\% \ CI \ (.02, .04)), \ CFI/TLI = .93/.92, \ WRMR = .89$. The pattern of significant direct paths was replicated and there were significant direct effects of metacognitive components and self-regulation on the performance in problem-solving tasks – successfulness (cognitive: $\beta = 0.841, p < .001$; emotional: $\beta = 0.672, p < .003$, motivational: $\beta = 0.754, p < .001$, pro-social: $\beta = 0.613, p < .004$) and efficiency (cognitive: $\beta = -0.781, p < .001$, emotional: $\beta = -0.615, p < .002$, motivational: $\beta = -0.728, p < .001$, pro-social: $\beta = -0.439, p < .006$). The metacognitive and self-regulation factors were significantly related to the level of children’s achievement of correct responses and efficiency in the different problem-solving tasks. Higher scores in metacognitive components and self-regulation indicate higher scores in achieving the correct responses in different problem-solving tasks and lower scores for the time required for resolving problem-solving tasks.

In addition, there was a significant, but not high, moderator effect of age on the relation between metacognitive components and self-regulation and problem-solving performance (moderator effect: $\beta = 0.318, p < .001$). With the increase in a child’s age, the relation between metacognitive components and self-regulation and problem-solving performance, successfulness and efficiency, tends to be slightly higher. Moreover, moderator effect of task complexity on the relation between metacognitive components and self-regulation and problem-solving performance (moderator effect: $\beta = 0.523, p < .005$) was confirmed. Therefore, with the increase in task complexity, the relation between metacognitive components and self-regulation and problem-solving performance, successfulness and efficiency, tend to be moderately higher.
Metacognitive ability decreases time needed for problem-solving when problem solving ability is kept under control (cognitive: $\beta = -0.642, p < .002$, emotional: $\beta = -0.529, p < .003$, motivational: $\beta = -0.636, p < .003$, pro-social: $\beta = -0.327, p < .005$).

Efficiency and correctness in problem-solving tasks were positively correlated ($\beta = 0.489, p < .005$). Feedback relation between problem solving performance and metacognitive abilities was not confirmed ($\beta = 0.339, p < .281$).

**Discussion**

Metacognitive abilities intensively develop in preschool period (Gourgey, 2010; Mayer, 1998), along with problem-solving cognitive skills (Schneider, 1998; Wang, 2015). The results of the previous research showed positive relation between metacognitive abilities and achievement in problem-solving tasks in preschool children (Karnes et al., 1986; Mayer, 1998; Swanson, 1990). However, studies also found that this relation was negatively directed or not significant (Larkin, 2010; Robson, 2016). Inconsistencies with the previous results are caused by the different aspects of the studies: children’s age, type of task, task complexity, orientation to correctness or time in task resolving, assessment of the type of metacognitive abilities, environment and used instruments (Azevedo, 2009; Chatzipanteli et al., 2014; Destan & Roebers, 2015).

The main question of this study is to determine the kind of the relation between metacognitive components and preschool children’s performance in different problem-solving tasks. With the aim of overcoming some dilemmas and sidedness in understanding complex relation between metacognitive abilities and problem-solving performance in preschool children, this study included the control of age differences and task complexity in terms of the relationship between metacognitive and problem-solving abilities, different types of tasks, orientation to correctness and time in task resolving, assessment of metacognitive abilities by observational protocol and semi-structured interview.

The findings of the study showed that children with highly developed metacognitive potentials – declarative and procedural metacognitive knowledge, cognitive monitoring and self-regulation of cognitive strategies – were more successful and efficient in solving different problem tasks, and this result is consistent with the findings that showed positive relation between metacognitive and problem-solving abilities in preschoolers (Melo, 2015; Pintrich, 2002; Wang, 2015).

Metacognitive components and self-regulation indicators: cognitive, emotional, motivational and pro-social, significantly contributed to the levels of successfulness and efficiency, which leads to the conclusion that more developed metacognitive components and self-regulation predispose preschoolers for success in giving correct answers in different problem solving tasks and in shorter performance time in resolving different problem tasks. Such findings are congruent to the relevant theories (Flavell, 1979) and to the results of previous studies (Jacobs, 2004; Mayer, 1998; Robson, 2016; Schneider, 1998),
which emphasize the importance of metacognitive factors in resolving problem situations. Therefore, the Flavell’s model of cognitive monitoring includes (1979) monitoring cognitive process into interactions among metacognitive knowledge, metacognitive experiences, goals or tasks, and actions or strategies. The studies which showed negative correlation between metacognition and problem-solving in preschoolers were mostly oriented towards measuring only one type of adult-initiated tasks, or they measured one dimension of achievement in completing task or used one type of measuring instruments, usually observational protocols (Lysaker & Hopper, 2015; Mytkowicz et al., 2014; Sperling et al., 2002).

The relationship between metacognitive and problem-solving ability in preschool children in terms of their developmental relationship showed that with the increase in children’s age and with the increase of task complexity, the relation between metacognitive components and self-regulation and problem-solving performance – successfulness and efficiency, tends to be slightly to moderately higher. One of the important factors that contribute to the inconsistency in previous findings is children’s age. Older preschoolers have more developed metacognition and higher abilities for problem solving, and the relation between them was usually higher and more positive (Chatzipanteli et al., 2014; Gourgey, 2010; Whitebread, 1999). Some results showed that this relation was higher in very young children, because their problem-solving abilities were lower, therefore they needed stronger efforts for task realization and metacognitive abilities and showed a more important role in this process, but these studies did not include the control of task complexity and problem-solving ability (Larkin, 2010; Metcalfe & Finn, 2009; Schneider, 2008). This study showed that metacognitive ability decreases the time needed for problem-solving when problem-solving ability is kept under control. Additionally, the findings indicate the importance of metacognition in efficiency of problem resolving.

The complexity of task and the compatibility of the tasks with children’s age contribute specifically to the direction of the relation between metacognitive abilities and problem-solving performance. In the case of easy tasks, children have no need to invest extra efforts and use their metacognitive potentials, therefore the relation in those cases was non-significant or extremely low (Desoete, 2008; Robson, 2016; Schneider & Lockl, 2002; Sperling et al., 2000). This study showed that the complexity of a task raised the level of relation between metacognitive abilities and problem-solving ability, and the reason for that is the need for additional resources in complex problem situations.

Efficiency and correctness in problem-solving tasks are positively correlated, and it can be concluded that they measured joint capacity for problem-solving task (Melo, 2015). Feedback relation between problem-solving performance and metacognitive abilities was not confirmed. The finding does not comply with Flavell’s previous results, which show that a child’s metacognitive ability might depend on the child’s ability to solve a problem. Moreover, problem-solving ability could enable metacognitive processes that will then improve problem-solving ability (Flavell, 2000). The feedback relation between problem-solving performance and metacognitive abilities was not confirmed in
this study probably because the main assessment of metacognition was general metacognitive abilities, but not specific and contextual, as was in some studies that showed feedback relation (Jacobs & Paris, 1987; Lambert, 2001; Sperling et al., 2002; Whitebread & O’ Sullivan, 2012).

A high correlation in metacognitive abilities measured by observational protocol and semi-structured interview was obtained. The finding additionally confirms reliability of the measures of metacognition in this research. Using only interviews instead of observation protocols in early childhood usually underestimated metacognitive indicators, because of linguistic abilities, therefore the relation between metacognition and problem-solving achievement was low, negative or insignificant (Marulis et al., 2016; Robson, 2015; Winne & Perry, 2000).

Conclusion

This research showed that preschool children with highly developed metacognitive abilities were more successful and efficient in different problem-solving tasks. Their age and the complexity of a task increase this relation. These results have implications within the context of possible limitations of the previous studies. A larger sample of observations, including the different types of problem tasks, a study conducted in a child’s natural environment, and the use of more than one method for data collection tend to provide stronger reliability of the collected data and to resolve a part of the previous dilemmas. Evaluating and improving the proper models for further comprehension of the feedback relation of the specific metacognitive abilities and problem solving in preschoolers present the recommendations for future research.

Educational implications are reflected in the field of preschool children’s meta-learning and problem solving. By improving the knowledge of cognition and regulation of cognitive behaviors, teachers can contribute to problem-solving successfulness of preschoolers. In particular, teachers should encourage the use of metacognitive strategies in older preschoolers and in complex tasks resolving.

References


METACOGNITIVE COMPONENTS AS THE PREDICTORS OF PRESCHOOL CHILDREN’S PERFORMANCE IN PROBLEM SOLVING TASKS

Метакогнитивне компоненте као предиктори постигнућа предшколске деце у задацима решавања problema

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Циљ овог истраживања било је испитивање односа између метакогнитивних компоненти, декларативног и процедуралног метакогнитивног знања и когнитивне регулације и постигнућа предшколске деце у различitim задацима решавања проблема – скривених слика, класификације и сортирања, исто и различито, процене, шема, тачка-до-тачке, лавиринта и задатака памћења. Узорак се састојао од 347 деце предшколског узраста старости 3 до 6 година. Резултати су показали да су деца са високом развитим метакогнитивним способностима, декларативним и процедуралним метакогнитивним знањем, когнитивним праћењем и саморегулацијом когнитивних стратегија била успешнија и ефикаснија у решавању проблемских задатака. Овај однос је био јачи код старије деце и у комплекснијим задацима.

Кључне речи: метакогнитивна, когнитивно праћење, решавање проблема, предшколци.

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