

Improving Metacognitive Abilities As An Important Prerequisite for Self-Regulated Learning in Preschool Children

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Abstract

Metacognition is a crucial prerequisite for self-regulated learning and refers to the knowledge and the regulation of cognitive processes. Several authors argue that children at preschool age can use initial metacognitive control strategies and monitor their learning activities. This fact will create the conditions for promoting metacognitive activities at an early stage. The development of these activities at this age is influenced by several contextual factors, such as home or school environments. Essential caregivers exert a strong influence in terms of the development of metacognitive abilities. In view of this above 137 children participated in an intervention study aiming to improve metacognitive skills, along with their important caregivers such as parents and kindergarten teachers. Training concepts were designed that combined different kinds of interventions: a direct age-appropriate training of the preschoolers and two indirect interventions catered to parents and kindergarten teachers. The aim of this study was to analyze which training condition is more effective in improving metacognitive skills. We assumed that preschoolers who are consistently supported in their self-regulated learning in kindergarten and at home would benefit the most. Based on our data, we could partly confirm this hypothesis.

Keywords: Self-Regulated Learning, Metacognition, Monitoring, Control, Preschool Age

Introduction

The importance of self-regulated learning in early childhood was emphasized by several studies such as the longitudinal national cohort study Pre-COOL (Mulder, Hoofs, Verhagen, & Lesemann, 2014) or the Effective Provision of Pre-School Education (EPPE) project (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggard, 2004). The ever-growing amount of knowledge available to humans makes it necessary to learn strategies to acquire new information and to adapt existing knowledge to new requirements in life. In this context, self-regulated learning, described as the ability to initiate, regulate, and reflect on activities independently (see Zimmerman, 1989; 2000), is one of the most important learning competencies (Zimmerman, 2013). It has also become apparent that self-regulated learning is predictive for future academic performance in several subjects (e.g. Blair & Razza, 2007; Hidi & Ainly, 2008; Perels, Dignath, & Schmitz, 2009). In addition, the importance of early childhood education is highlighted by further studies (e.g., Starting Strong, see Moss, Krenn-Wache, Na, & Bennett, 2004). Consequently, fostering self-regulated learning as early as possible is especially important because during their first years, children develop learning abilities (De Corte, Verschaffel, & Op 't Eynde, 2000; Hendy & Whitebread, 2000). These learning abilities, once established, are very difficult to change. Given the increasing importance of autonomous acquisition and adaptation of knowledge, children should become competent and independent actors actively regulating their own development and learning behavior. In that regard, some authors claimed that metacognition is a key aspect of self-regulated learning and they underline the importance of the monitoring and control processes, which are necessary for self-regulated learning (Winne, 2001; Winne & Hadwin, 2008). In general, metacognition is defined as higher-order thinking – as well as understanding, analyzing, and control – of cognitive processes (Flavell, Miller, & Miller 2002). Due to the relevance of self-regulated learning and especially metacognitive compe-

tences, the aim of this study is to improve young children's metacognitive abilities, namely their monitoring- and control activities (Winne & Hadwin, 2008).

Self-regulation and Self-regulated Learning

In general, self-regulation is defined as the ability to initiate, regulate, and reflect activities independently (see Zimmerman, 2000). Transferring the construct of self-regulation to the academic context, it is called self-regulated learning. Self-regulated learning can be defined as an 'active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their own cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment' (Pintrich, 2000, p. 453). Therefore, self-regulated learning is characterized by the continuous adaptation of one's own learning behavior, indicating in the independent planning, monitoring and regulating of one's own learning activities (Veenman & Spaans, 2005).

Self-regulated learning is based on a mutual interaction between three components: motivation, cognition, and metacognition (see for instance Adagideli, Saraç, & Ader, 2017; Dinsmore, Alexander, & Loughlin, 2008). These components affect the success of learning and are considered context-related (see Zimmerman, 2000). In the context of the three components, motivation refers to task selection and the initiation of the task performance as well as the effort and persistence during the task performance. This includes activities that serve as initiations of learning (e.g., self-motivation) and maintenance of learning processes (e.g. volitional control) as well as the attribution of success and failure and self-efficacy beliefs (see Corno, 2013; Dörrenbächer & Perels, 2015; Dweck, 2006; Pintrich, Wolters, & Baxter, 2000; Winne, 2001). The cognitive component is to be understood as conceptual and strategic knowledge as well as the ability to apply corresponding strategies (Butler, Perry, & Schnellert,

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2017; Winne, 2018). Another important prerequisite for self-regulated learning is the metacognitive component. This term refers to the knowledge and the regulation of one's own cognitions and thus includes the observation and assessment of one's own acting and thinking (see Flavell, 1979). In accordance with the definition of self-regulation processes and the current process models (e.g. Zimmerman, 2000), self-regulated learning is characterized by the processes of planning, monitoring, regulating and evaluating one's own learning activities (Winne & Hadwin, 1998; Zimmerman, 2001). In other words, metacognition is necessary for the whole self-regulated learning process. Therefore, the focus of this study will primarily be on metacognitive activities.

Metacognition

As mentioned above, metacognition is subdivided into knowledge and regulation (Larkin, 2010; Özsoy, Memiş, & Temur, 2017). In this sense, metacognitive knowledge refers to general knowledge about how people learn and process information, while metacognitive regulation involves the regulation of cognition and learning experiences and helps people control their own learning processes (see Livingston, 2003). Knowledge and regulation are not to be regarded as independent subcomponents. Rather, they are two interacting components of a super-ordinated regulation unit. To define metacognition there are many different approaches (Larkin, 2010; Livingston, 2003).

One well-known approach that has been used frequently as a basis for research on metacognition is the model of procedural meta-memory laid out by Nelson and Narens (see Mazzoni & Nelson, 2014; Nelson & Narens, 1990; 1994). Nelson (1996) simplified the metacognitive concept by defining metacognition as an exchange between two levels, an object-level and a meta-level (see also Mazzoni & Nelson, 2014). Whereas the object-level represents the information storage, the meta-level shows a superordinate authority. These levels are interlinked by two processes: First, the object-level provides the meta-level with information allowing for an assessment of the conditions (at the object-level) (monitoring). Monitoring also allows observation and reflection of one's own cognitive processes and gives some information on the current state of the cognition in relation to the actual goal (see Mazzoni & Nelson, 2014; Nelson & Narens, 1994). Second, the object-level is controlled by the meta-level, i. e. the management of information intake into the object-level (control). Control subsumes all the processes that describe the influence of the meta-level on the object-level. It refers to both conscious and unconscious decisions based on the results of monitoring activities. Control processes may be reflected through observable learning behavior. Bryce and Whitebread (2012) as well as Bryce, Whitebread and Szűcs (2015) assume that monitoring and control activities are some of the few metacognitive abilities that are already developed at preschool age. Both processes, monitoring and control, are necessary for self-regulated learning (Winne & Hadwin, 2008) and play an important role in recording self-regulated learning competencies, too (Dinsmore et al., 2008). Studies revealed that metacognitive abilities in general develop with increasing age and this development takes place continuously (van der Stel & Veenman, 2014). Therefore, it seems feasible to foster young children's metacognitive abilities as a key aspect of self-regulated learning at an early stage (Winne & Hadwin, 2008). The present study picks up on this line of thought by conducting specific interventions and evaluations.

Metacognition and Self-Regulated Learning in the Early Years

Studies on metacognitive competencies and self-regulated learning are more likely to be found in primary and

secondary school education sector (see i.e. Dignath & Büttner, 2008; Leidinger & Perels, 2012), despite evidence suggesting that self-regulated learning develops already in early childhood (Bronson, 2000). The age at which children first acquire metacognitive skills has been discussed matter of some discussion (Veenman & Spaans, 2005): some authors have pointed out that at least some components of control, monitoring and regulation processes of one's own cognitions are available at kindergarten age (see Bronson, 2000; Whitebread, 2012). Children at preschool age are able to adjust inexpedient behavior using initial metacognitive control strategies and can monitor their learning activities (e.g. Winne, 2018; Winne & Perry, 2000). Bronson (2000) also added that these children are capable of choosing tasks and goals corresponding to their cognitive abilities. At the age of five, they allocate attention to the actual task, which represent an important control strategy. Consequently, children at this age possess rudimentary metacognitive abilities such as control and monitoring activities (Bandura, 1997, Bronson, 2000). The existence of these basic competencies offers the opportunity to promote metacognitive activities at an early stage. In addition, such a promotion proves beneficial for academic performances (Blair & Razza, 2007; Diamond, 2016; Rimm-Kaufman, Gurby, Grimm, Nathason, & Brock, 2009). Moffitt and colleagues (2011) consider that an early improvement in these metacognitive skills and abilities leads to a better development and educational outcomes (see also Butler, 2004; Butler & Schnellert, 2012; Dunn, Rakes, & Rakes, 2014; Hidi & Ainly, 2008; Kitsantas, Steen, & Huie, 2017).

Improving Metacognition in Young Children

As outlined above, children at preschool age possess some rudimentary metacognitive abilities. They are able to recognize, plan, monitor, and control their cognitive processes (see Bronson, 2000; Özsoy et al., 2017; Whitebread, Anderson, Coltman, Page, Pino-Pasternak, & Mehta, 2005). Therefore, studies that deal with the improvement of metacognitive competences seem conceivable. In fact, Hattie, Biggs, and Purdie (1996) assume that interventions with young children are effective since unfavorable learning habits have not yet been internalized and so it is easier to affect a good learning behavior. Nevertheless, most intervention studies in this area were conducted within the school sector (see Desoete, Roeyers, & de Clercq, 2003; Labuhn, Zimmerman, & Hasselhorn, 2010; Perels et al., 2009). Comparable studies at the elementary level are rare (see Perels, Dignath, & Schmitz, 2009). Larkin (2010) highlights the transition from kindergarten to primary school as a sensitive phase in childhood because at this early stage children already develop their abilities and their attention on challenging tasks. In addition, Pramling (1990) determines that most metacognitive development takes place within this age range. Thus, it is favorable to make use of this crucial phase to promote preschoolers' awareness of their own learning processes. Fthenakis (2009) even mentions that it is beneficial to encourage children at preschool age in learning to cope with challenges or problem situations. That is, the appropriation of learning competencies is viewed as an important cornerstone of lifelong learning (Fthenakis, Gisbert, Griebel, Kunze, Niesel, & Wustmann, 2007; Lüftenecker et al., 2012). Thus, intervention research in the preschool sector has become increasingly important (see Adagideli et al., 2017; Whitebread, 2012).

With regard to possible metacognitive interventions at this age, there is a distinction between indirect and direct interventions (see Schmidt & Otto, 2010). Direct interventions address the learners themselves with the aim of optimizing learning behavior. Regarding direct interventions in general, there are a few successful studies (e.g. Glaser &

Brunstein, 2007; Landmann & Schmitz, 2007; Perels, Gürtler, & Schmitz, 2005), but there are practically no studies designed for the age of preschool children. Indirect interventions on the other hand focus on the environment of the learner (e.g. Pramling, 1990;1996; Souvignier & Mokhlesgerami, 2006; Whitebread et al., 2009). Usually, central caregivers such as parents or kindergarten teachers are involved in indirect interventions. Several studies have shown positive effects of some indirect interventions involving special programs for parents (Lund, Rheinberg, & Gladesch, 2001) or teachers (De Jager, Jansen, & Reezig, 2005; Souvignier & Mokhlesgerami, 2006). This kind of intervention aims at optimizing the learning environment in a way that optimal learning opportunities can be created (see Deci & Ryan, 2000). Within this context, special attention is to be attributed to observational learning/modeling. This term refers to adults' behavior (parents or kindergarten teachers) demonstrating positive examples of, e.g., certain learning behavior, which is subsequently imitated by children observing this behavior (Martinez-Pons, 2002). This kind of social learning is of considerable importance for early childhood development. Therefore, modeling or observational learning is taken into account in the reported study.

The present study combines both direct and indirect intervention to improve metacognition in preschoolers with the aim of paving the way to self-regulated learning: combined training with children, parents, and teachers (CPT), trainings with children and teachers (CT), training with children and parents (CP), training with children only (C), and a group without training (control group (CG)). The important aspect here is that the preschool children are represented in each training condition, merely the contextual factors are changing.

Measuring Metacognition in Young Children

Only a few studies in the realm of metacognition have been concerned with the preschool sector (e.g., Whitebread et al., 2009). To evaluate intervention-induced improvements, it is necessary to establish measuring procedures for children under the age of six. Questionnaires or other well-established self-report methods cannot be used due to lack of literacy at this age (Whitebread et al., 2009). Therefore, preschool children require instruments in relation to their age, in particular nonverbal methods (Turner, 1995). Indeed, one possible alternative to self-reported methods are observations (see Whitebread et al., 2005). The advantage of observation methods is the collection of naturally occurring behavior in concrete learning settings regardless of language skills. For the present study, online measurements (Veenman, Prins, & Verheij, 2003) and standardized observations of preschool children were used while handling a problem-solving task (cf. train track task; Whitebread et al., 2009; Bryce & Whitebread, 2012). Thus, children's problem-solving behavior is examined by means of video recordings and an observation sheet, stemming from the Cambridgeshire Independent Learning project CINDLE (Whitebread et al., 2009).

Present Study

The current study deals with the effects of both direct and indirect trainings of metacognitive skills in the context of self-regulated learning. More precisely, we investigate the metacognitive monitoring and control strategies in young children at preschool age. The core research question is whether it is possible to improve metacognitive activities like monitoring and control activities in young children. Furthermore, the aim is to find out which training condition is more effective. We assume that the combination of the direct and indirect intervention will result in the highest increase of metacognitive competencies. Thus,

the training condition with simultaneous training of children, teachers and parents (CTP) should result in the best outcomes concerning the metacognitive abilities and a childlike performance measure, since preschoolers who are consistently supported in their self-regulated learning in kindergarten and at home produce the best results. Furthermore, we investigated whether an improvement of metacognitive abilities leads to a performance improvement in a problem-solving task. Based on the assumption that, on the one hand, metacognition is a prerequisite for self-regulated learning behaviors (Boekaerts, 1999) and, on the other hand, that there is a positive correlation between self-regulated learning and performance (Butler, Schnellert, & Perry, 2017; De Corte, Mason, Depaepe, & Verschaffel, 2011; Hidi & Ainly, 2008), we assume that the interventions improve the results of a problem-solving train track task (Bryce & Whitebread, 2012), evaluated as a performance measure (see Blair & Razza, 2007).

Method

Participants

The study involved $N = 137$ children (45% female, $M_{age} = 5.54$ years, $SD = 0.50$) assigned to five groups: combined training with children, parents, and teachers (CPT, $n = 20$, 38% female, $M_{age} = 5.12$ years, $SD = 0.33$), trainings with children and teachers (CT, $n = 21$, 33% female, $M_{age} = 5.60$ years, $SD = 0.50$) or training with children and parents (CP, $n = 9$, 0% female, $M_{age} = 5.67$ years, $SD = 0.58$), training with children only (C, $n = 51$, 48% female, $M_{age} = 5.60$ years, $SD = 0.50$), and finally a group without training (control group (CG), $n = 36$, 67% female, $M_{age} = 5.80$ years, $SD = 0.50$). The aim was to random all participants into the five training conditions. The participants were recruited from 20 different kindergartens and daycare centers in Germany. All of them are in the last year of preschool, which is the preparatory year for primary school. Participation in the study was voluntary and required the parents' agreement. Testing and filming are only allowed when written consent is obtained. There are video data for each of the 137 children at two different points: before and after the intervention. The data was collected anonymously.

Intervention

The intervention consists of different training conditions: one direct training for the children, one training for the kindergarten teachers and one training for the parents. These three training conditions were combined systematically, resulting in the already mentioned five condition groups: combined training with children, parents, and teachers (CPT), trainings with children and teachers or parents (CP/CT), training with children only (C), and finally a group without training [control group (CG)].

The indirect intervention for the caregivers (teachers and parents) is characterized by a multi-level approach. On the first level, caregivers learned more about the metacognitive processes including strategies of metacognition in order to act as role model (see Martinez-Pons, 2002; Venitz & Perels, 2017), as described in the previous section. Caregivers serve as social models and they provide information on how to execute a task and how to engage in learning processes (Usher & Schunk, 2018). In addition, they had the opportunity to reflect on their own learning behavior concerning the three phases mentioned above, and if necessary to modify them. On the second level, kindergarten teachers and parents were introduced to strategies to support children's metacognitive competencies (Martinez-Pons, 2002). Whereas the training for parents focused on strategies in the home environment, the training for the kindergarten teachers pointed out some useful strategies for working in kindergarten. The training

took place in three sessions (one session per week), which were conducted separately for both groups. Each session lasted about one and a half hours and followed a common structure.

The direct intervention for the preschoolers was made up out of ten sessions, at two sessions per week, each lasting about 45 minutes. The training sessions included playful elements (for example stories, present plays, simple design tasks or problem-solving tasks) to make the content accessible to the children. The intervention did not focus on conveying the use of potential strategies in an abstract way, but rather on the application of the strategies in many multifaceted situations. This intensive training serves as education of the children according to the application of self-regulated learning processes including metacognitive strategies. The overarching concept of the training sessions was to reduce the number of trainer's instructions successively, so that ideally an autonomous use of strategies by preschoolers can be observed in the end. Children's training sessions had a common structure, too, with a short greeting, a brief introduction of the new subject and strategy and the application of the strategy in a playful manner. So the preschoolers could practice or hone the respective strategy by means of short age-appropriate exercises with the guidance of the trainers.

Design

The study follows a repeated measures factorial design taking into account the described four experimental groups and a control group. First, the focus is on the report of the metacognitive activities monitoring and control, which are the dependent variables. For this, the observation data were acquired via a standardized observation sheet (see Whitebread et al., 2009). Data were collected before and after the interventions.

Measures

Metacognition. We use an observation method to assess metacognition that can be applied completely independently of language abilities. Preschoolers were filmed while solving a standardized problem-solving task, the train track task, drawn from the CINDLE project (see Whitebread et al., 2009).

The problem-solving task per se consists of the reconstruction of two geometric shapes (a closed circle (oval) and a form similar to the Greek Letter Omega (goggles)) by means of wooden railway tracks, adapted from Karmiloff-Smith's closed-circuit railway task (1979). The demonstrated problem-solving behavior while processing the train track task is coded by means of an observation sheet, which is dedicated to the recording of observable metacognitive behavior. This involves the categories monitoring (e.g., self-questioning, child highlights a problem to be solved, poses themselves a question: 'How will it curve around'; see Table 1), control (e.g., planning and explicitly stating a plan, which can be before or during the task: 'I'm going to do these straight bits first!'; see Table 1) and a third scale lack of monitoring and control (e.g., no strategy, when something will not work: 'uses same strategy over and over or gives up'; see Table 1). It follows the procedural metacognitive model by Nelson and Narens (1990).

The observation data were analyzed by two independent observers. Before the actual analysis took place, the observers completed an extensive training for the correct use of the observation categories. For this purpose, two observers coded 20 videos independently. Of special importance is a sufficient accordance between the two observers in terms of the above-mentioned categories (Gwet, 2014). High agreement indicates an accurate and reliable

encoding of the observation data (reliability) and the dependability of the emitted judgments. For this reason, several meetings took place during which the application of the categories was practiced based on example videos. This process was repeated until a sufficient rater agreement was achieved and the observers found convergent solutions. Cohen's kappa served as a measure of rater agreement (Fleiss & Cohen, 1973). A sufficient agreement occurs if the values range is between .60 and .75; values greater than .75 are considered very good (Fleiss & Cohen, 1973). Ten sessions of rater conferences were necessary before a satisfying rater agreement could be found. In our study, we found an adequate agreement with $\kappa_{\text{monitor}} = 0.83$, $\kappa_{\text{control}} = 0.66$, and $\kappa_{\text{lackof}} = 0.71$.

Table 1. Categories monitoring, control, and lack of monitoring and control of the encoding scheme

Item	Example
<i>Monitoring</i>	
Checking own	Child pauses and looks at whole train track they have made so far.
Checking plan	Child glances back to the plan of train track they are working on.
Prospective monitoring	"This is going to be a challenge!"
Clarification	"Do I use all the pieces?"
Reviewing	Child glances around all the pieces of train track
Self-questioning	"How will I curve around?" (to self)
Commentary	"Right, this bit is done..."
Evaluation	"But that bit isn't right!"
Justified termination	"Finished!"
<i>Control</i>	
Clearing space	Child clears the space on the table with hands before placing first piece down.
Planning	"I'm going to do these straight bits first!"
Sorting	Child compares the lengths of two straights.
Seeking	Child searches for all large curves.
Change strategy	Child reserves piece of track so that it curves in the correct way.
<i>Lack of Monitoring and Control</i>	
No strategy	Child tries to force two pieces of train track over and over and then gives up.
Not following plan	Child says they will start with straight edge, but then places a curved track piece.
Narrow view	Child looks for a straight piece but only looks in one area of the table.
Focus on join	Child is making a circle, but is so focused on making it join that he/she adds straight pieces.
Two positives	Child needs to add one more "junction-piece."
Large/small curves	In making a curved edge, child uses all small curves and has not realized, that he/she switched to large curves.
Finishing error	Child says that he/she has finished, when he/she has made a circle, not the goggle shape.
Goal neglect	"It's because these ones don't turn as well as those ones."

Train track task

The correctness of childrens' solutions of the train track task is considered as a performance measure (Bryce & Whitebread, 2012; Whitebread et al., 2009). For both shapes, there were a total of nine items, which decipher important features of the track (e.g. for the oval shape: 'the track is jointed up', 'the track has one curved end', 'the track has another curved end', for the goggle shape: 'the track has one down/side bulge', 'the track has an inverted curve in center', 'the inverted curve is deep'), captured through a standardized category scheme (see Bryce & Whitebread, 2012; Whitebread et al., 2009). For each identified feature, one point can be received, so in total, 18 points are the maximum one can reach. The quality of the solutions of the train track task (Bryce & Whitebread, 2012; Whitebread et al., 2009) was determined by two independent raters. Similar to the evaluation of the observable problem-solving behavior, a sufficient accordance between the two raters was necessary, which required several rater meetings and exercises. The rater agreement was again calculated using Cohen's kappa. Due to an unequal marginal distribution of the ratings an adjusted Cohen's kappa κ_n is calculated (see Brennan & Prediger, 1981). The adjusted kappa value in this study was $\kappa_n = 0.93$; thus, the accordance accounts for 93%, which is a value that is regarded as good (Fleiss & Cohen, 1973).

Statistical Analyses

The effects of the interventions are tested via a 2 (time pretest/posttest) \times 5 (intervention group) analysis of covariance (ANCOVA) with pretest values as covariates was conducted. An examination of the hypotheses was conducted using a univariate ANOVA with planned contrasts for the a priori comparison of the five training conditions. In particular, we assumed that (1) children under the training conditions (CPT; CT/CP, C) show better results than children in the control group (CG), that (2) these children show better results than the children under the single direct condition (C) and finally (3) that children under the combined condition CPT show better results than the children under the condition CT/CP. The effect sizes for the variance analyses were reported with partial eta squared (η_p^2), and for the contrasts, Cohen's d was used (Cohen, 1969).

Results

Pre-analyses showed that the variables do not have a normal distribution. It is argued, that a violation of this condition becomes less important to the application of variance analytical methods in view of increasing sample size (Bortz, 2005; p. 286). It can be assumed that a variance analysis is robust when faced with this violation, in case with a rising number of participants, even in the face of unequal group sizes (ibid., p. 287). Therefore, we used a variance analytical method. No significant pretest differences were found regarding the scales monitoring ($F(3, 130) = .87, p = .46$) and lack of monitoring and control ($F(3, 130) = 1.15, p = .33$). However, there was a difference between the training groups, referring to the scale control, ($F(3, 130) = 6.10, p = .00$).

To further investigate the question of whether the implemented interventions lead to an improvement a one-way ANCOVA was conducted to determine a statistically significant difference between the five groups on monitoring, control, lack of monitoring and control and the performance measure, controlling for the respective pretest values. The results as well as the z-standardized means and standard deviations are displayed in Tables 2 and 3.

The (omnibus) evaluation of the data shows a significant interaction effect time \times group for the scale control, $F(4, 131) = 2.55, p = .04, \eta_p^2 = .07$. The interaction results from an increase in the means of the conditions CPT and CT with a simultaneous decrease in the means of the conditions CP, C and CG. Concerning the scale monitoring, no interaction effect could be found, $F(4, 131) = 1.96, p = .10$. Regarding the scale lack of monitoring and control, similar results were obtained, $F(4, 131) = .58, p = .67$. Table 3 illustrates the results of the evaluation referring to the performance data. No significant effect could be obtained.

Taking a closer look at the planned contrasts (see Table 4) corresponding to the hypothesis, the contrasts are formulated as follows. Contrast (1) expresses the superiority of all training conditions (CPT, CT/CP and C) over the condition without training (control group, CG). The combination of the direct and the two indirect interventions (CPT) is superior to the condition with the direct intervention and one indirect intervention (training with children and parents or with children and teachers CT and CP) (Contrast (2)). Contrast (3) evaluates whether condition with the direct intervention and one indirect intervention (CT/CP) is superior to the single direct condition (C).

For the scale control we found some significant contrasts. The planned contrast showed that all training conditions (CPT, CT/CP and C) are superior to the control group ($t_{(133)} = 3.20, p < .001, d = .67$). Furthermore, we found a superiority of the combined training condition (CPT) over the condition CT/CP ($t_{(133)} = 2.82, p < .001, d = .59$). Regarding the scales monitoring, lack of monitoring and control and performance, it is clear that no effect can be found. Based on these findings, it can be confirmed that - referring to the scale control - a combined intervention leads to better improvements than a single intervention condition.

Discussion

It is reasonable to ask why the intervention would not affect the monitoring activities or lead to a compensation in lack of monitoring and control. It could be a sign that young children are still limited in their metacognition, especially in monitoring their own cognition and learning behavior (Bryce, Whitebread, & Szűcs, 2015; Freeman, Karayanidis, & Chalmers, 2017; Flavell, 1979). The procedural meta-memory is responsible for goal-oriented planning, monitoring, and control of one's own memory and learning activities (Mazzoni & Nelson, 2014). This ability increases with age. Further, Mazzoni and Nelson (2014) argued that if any problems are registered during the learning process, the learner must refer to adequate control processes. This could be demonstrated in our study: Children showed more control behavior while solving the problem-solving task after the intervention, but only in the combined condition CPT. In the opinion of Larkin (2010), control can only work if it receives information from the object-level, what, as we specified in a previous section, we know as the process of monitoring (see Nelson & Narens, 1990). That is, if any control activities were registered in this age group, monitoring activities must also theoretically exist. Pressley, Johnson, Symons, McGoldrick and Kurita (1989) stressed that the monitoring of memory processes takes place at a young age quite well (see also Mazzoni & Nelson, 2014). Thus, we only found an effect on the scale control, which is not an indication that no monitoring activities have transpired. Schneider and Lockl (2006) points out that a development of the procedural meta-memory is much harder to prove, in comparison to the declarative meta-memory which appears with less distinctive changes (Nelson, 1990). The development or improvement in procedural meta-memory is only due to the adequate use of control activities with increasing age.

Table 2. Means (z-standardized), standard deviations and results of the interaction time x group (ANCOVA with pretest value as covariate) with the scales monitoring, control, and lack of monitoring and control

AV	M(SD)					
	Group	Pre-test	Post-test	df	F	η_p^2
Monitoring	CPT	-0.26 (0.84)	0.19 (1.13)	4/131	1.96	0.06
	CT	-0.26 (1.06)	-0.56 (0.63)			
	CP	0.37 (1.17)	0.31 (0.67)			
	C	0.04 (1.03)	0.01 (1.09)			
	CG	0.15 (0.95)	0.13 (0.97)			
Control	CPT	0.73 (1.26)	0.83 (1.66)	4/131	2.55*	0.07
	CT	-0.05 (1.07)	0.11 (0.86)			
	CP	0.58 (0.92)	-0.04 (0.57)			
	C	0.00 (0.99)	-0.12 (0.80)			
	CG	-0.40 (0.56)	0.34 (0.65)			
Lack of monitoring and control	CPT	0.31 (0.76)	0.20 (1.04)	4/131	0.58	0.04
	CT	-0.34 (0.71)	-0.21 (0.94)			
	CP	0.51 (1.92)	-0.07 (1.15)			
	C	-0.14 (0.65)	-0.12 (0.92)			
	CG	0.09 (1.27)	0.18 (1.08)			

Note: CPT (Children/Parents/Teachers, n= 20), CT (Children/Teachers, n= 21), CP (Children/Parents, n= 9), C (Children, n= 51), CG (Control Group, n= 36), *p< .05

Table 3. Means (z-standardized), standard deviations and results of the interaction time x group (ANCOVA with pretest value as covariate) with performance

AV	M(SD)					
	Group	Pre-test	Post-test	df	F	η_p^2
Performance	CPT	-0.17 (1.08)	-0.00 (0.95)	4/131	0.85	0.04
	CT	0.32 (1.10)	0.19 (0.98)			
	CP	0.06 (0.87)	0.33 (0.71)			
	C	-0.24 (1.05)	-0.13 (1.07)			
	CG	0.23 (.77)	-0.01 (1.02)			

Note: CPT (Children/Parents/Teachers, n= 20), CT (Children/Teachers, n= 21), CP (Children/Parents, n= 9), C (Children, n= 51), CG (Control Group, n= 36), *p< 0.05.

A closer look at the instruments applied in this study and the three scales analyzed suggests that the difficulty to collect actual monitoring and control activities might lie in the scales themselves. The control activities (scale control) are operationalized with real observable behavior like clearing space, sorting, seeking, changing strategies, or gesturing. In contrast, the monitoring scale is operationalized with more verbal abilities like checking plan, prospective monitoring, self-questioning, or less observable behavior like reviewing or error detection. Thus, it is also possible that the children, for example, highlight a problem to

be solved and pose themselves a question, or judge the task before task begins, but this can happen in the form of "inner speech" (see Alarcón-Rubio, Sánchez-Medina, & Prieto-García, 2014; Diaz & Berk, 2014; Vygotsky, 1978). Ultimately, control activities are better or easier to encode by the observer than monitoring activities, for the simple reason that control activities are more easily observed than monitoring activities.

However, the question arises why we did not find any results regarding the performance measures. It could be

Table 4. Results of the a priori defined contrasts

AV	Contrast	Contrast value (SD) Posttest	df	t	d
monitoring	1	-0.42 (0.51)	133	-0.82	-0.17
	2	0.42 (0.23)	133	1.71	0.52
	3	-0.27 (0.20)	133	-1.35	-0.33
control	1	2.50 (0.78)	133	3.20**	0.67
	2	1.07 (0.38)	133	2.82**	0.59
	3	0.26 (0.30)	133	0.87	0.24
lack of monitoring and control	1	-0.16 (0.15)	133	-1.04	-0.22
	2	0.10 (0.08)	133	1.28	0.34
	3	-0.02 (0.06)	133	-0.27	-0.04
performance	1	0.03 (0.12)	133	0.23	0.05
	2	-0.05 (0.06)	133	-0.81	-0.26
	3	0.07 (0.05)	133	1.55	0.39

Note: # $p < .10$, * $p < .05$, ** $p < .01$

that such an effect does not appear in general or if our performance recording procedure is inadequate. The preschool age entails a challenge concerning the application of performance measures. Common instruments, which collect cognitive abilities such as mathematic or literacy abilities, cannot be used because these skills are not yet developed at this age (Blair & Razza, 2007). This age group requires a more generic measure, independent of previous knowledge. It can be questioned whether the handling of the wooden railway tracks is an appropriate measure, but so far no alternative procedures exist for this age group. Moreover, the train track task was successfully used in other studies involving young children (e.g. Whitebread et al., 2005). Bryce and Whitebread (2012) stated that the problem-solving train track task is suitable to represent metacognitive abilities in young children as accurately as possible. They argued it is a 'novel challenge with familiar materials' (Bryce & Whitebread, 2012, p. 214); however, there is no evidence for the familiarity of the wooden railway tracks used in the task. It is therefore conceivable that some participating children may not have had previous experience with railway tracks. In this case it is a 'challenge with familiar materials' by no means. Apart from that, it could be a gender-specific problem and boys have much more practical experiences with wooden railways tracks than most girls. Therefore, it may be appropriate that experiences in dealing with the used materials must be collected in further studies. However, no gender difference could be found in the present study. Further studies might want to focus on the development of a performance measure for preschool age children that can be used in a generic manner.

We can find some limitation in the methodical implementation. It was not possible to realize a randomized assignment of the preschoolers to the different training conditions. The interest of the kindergarten management in the direct intervention with the preschoolers was high. The participation of the kindergarten teachers or parents themselves depended on time-related and organizational factors. Many institutions were understaffed or had a full schedule, so that the intervention with teachers was often not conceivable. In addition, a lot of institutions have had some bad experiences with parent's willingness to participate in enrichment offers like the one made for this study. In fact, it was difficult to find enough parents for a realization of the interventions. From the very beginning of the study most of the kindergarten institutions already signed up for a certain condition, making randomizing almost impossible. Under these circumstances, it was quite

difficult to gain enough participants for each intervention condition. Precisely since it was difficult to fill the conditions that take parents into account, the intended sample sizes for some conditions weren't fulfilled. This issue lead also to the fact that the sample sizes of the training condition groups differ (Keppel & Wickens, 1991). Therefore, children's pretest values were controlled.

However, the problem may also lie in the field of data acquisition. The used observation sheet pursues the claim of a collection of naturally occurring behavior in standardized learning settings. This also includes the collection of verbal and nonverbal behavior. However, the sheet cannot collect the 'inner speech,' which is often used in this age range (Alarcón-Rubio et al., 2014; Diaz & Berk, 2014; Vygotsky, 1978). As described above, important abilities such as those contained in the scale monitoring cannot be recognized. Consequently, metacognitive activities cannot be measured completely by means of observation methods. It is conceivable to encourage children to speak about their thoughts in terms of 'think-aloud protocols' (Greene, Deekens, Copeland, & Yu, 2018; Veenman, VanHout-Wolters, & Afflersbach, 2006). Observation data may therefore be complemented with these protocols. With such a multi-method approach (see also Desoete, 2008), it may be easier to get a comprehensive picture of the observable and non-observable metacognitive abilities and the actual use of monitoring and control strategies. Furthermore, future studies could try to adapt the observation sheet for the assessment of young children's metacognitive abilities. Therefore, the focus of further studies must be placed on the assessment of monitoring activities, or rather in the adaptation of the assessment instrument in the sense that an acquisition of monitoring activities is easier to carry out. It is therefore conceivable that in further research another 'online observation' could take place (Veenman, 2013). Independent observers could monitor kindergarten teachers while working with the preschoolers; it is also important to ensure whether the support strategies are implemented and whether there are some differences in the use of monitoring and control strategies. Such observations would be quite difficult to implement in the home environment. However, in today's kindergartens, observations are a daily business. Apart from the limitations in measurement, additional limitations in the intervention must be reported. Clear and standardized instructions were given to all participants. Nevertheless, it was not validated whether and in what manner parents and kindergarten teachers implemented the learned strategies. Both samples, parents and teach-

ers, stated in a survey that they were aware of more support strategies after the intervention. However, an actual use of these strategies in dealing with the preschoolers was not checked.

Conclusion

Overall, the results of the study are generally sobering. What we could demonstrate was an early improvement in some of the metacognitive skills assessed, namely control activities as a crucial prerequisite for self-regulated learning. Based on the dataset analyzed here this would imply that preschoolers possess some metacognitive abilities (Larkin, 2010). Thus, an improvement of this ability seems possible already in this age range (Bronson, 2000; Bryce & Whitebread, 2012), laying the foundation for young children to become self-regulated learners one day. Moreover, the involvement of caregivers – parents and kindergarten teachers – proved to be useful. Parents as well as kindergarten teachers learned more about children's ability to apply metacognitive skills in the early years, and they got to know helpful strategies to support the children in their use of these abilities. For the reported age group, a large number of suitable instruments does not yet exist and most of the familiar instruments are used in this study. Thus it becomes apparent that these instruments have some weaknesses and therefore cautious adaptation is recommended when using these instruments. Generally, in forthcoming studies an emphasis should be placed upon the development of age-appropriate instruments to evaluate metacognitive abilities and self-regulated learning in young children. In addition, more analyses must be undertaken to make additional assertions referring to gender differences or age effects (Perry et al., 2018). It may also be of interest to determine whether the metacognitive abilities are correlated with intelligence.

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