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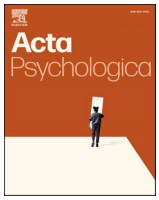

Differential development and trainability of self-regulatory abilities among preschoolers

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ABSTRACT

Self-regulation (SR) as well as self-regulated learning (SRL) show large interindividual variance in preschoolers. This variance may result in differential developmental trajectories. The present study aims to investigate whether a reduction in interindividual differences over time, which could previously be found for preschoolers' SR, is also present for SRL. Furthermore, the present study aims to explore whether preschool SRL training transfers to SR and whether training effects visible in SRL depend on initial performance. A sample of 94 preschoolers participated in this intervention study. Children were assigned to either a training group or to an active control group. Additionally, the sample was divided into high- and low-SRL preschoolers based on pretest SRL performance. Repeated measures ANCOVAs revealed that in the active control group, differences between high- and low-SRL preschoolers decreased over time. The training group showed a greater increase in SRL than the active control group. Training-induced increases did not vary between high- and low-SRL preschoolers. Additionally, increases in SR were identical for training and active control group. Further research on the transferability of preschool SRL training to SR is needed.

1. Introduction

Self-regulatory abilities refer to person's capabilities to behave in a goal-directed manner (Vohs & Baumeister, 2004). Self-regulation (SR) and self-regulated learning (SRL), a subconstruct of SR relevant for learning behavior (Kaplan, 2008), are meaningful predictors of a person's learning performance in school and in higher education (e.g. Bail et al., 2008; Zuffianò et al., 2013). Even at preschool age – in many countries, such as Germany and Italy, this is the last year of kindergarten, when children are between five and six years old – self-regulatory abilities can predict preschool academic competences, such as quantity comprehension and early literacy skills (McWayne et al., 2004; Skibbe et al., 2019). Preschool self-regulatory abilities are also able to predict later school success (e.g., Robson et al., 2020; Sasser et al., 2015; Woodward et al., 2017). In addition to academic competencies, children's self-regulatory abilities can also predict their physical and mental health into adulthood (e.g., Causadias et al., 2012; Hentges et al., 2018; Moffitt et al., 2011). Accordingly, it is desirable that preschoolers have high levels of self-regulatory abilities (especially SRL) so as to successfully master the demands on learning behavior that they will confront in primary school and to continue to develop healthily and resiliently in subsequent stages of life. Unfortunately, there is great interindividual variability in preschoolers' SR and SRL, which means that some children have deficits in these highly school-relevant abilities (e.g. Calkins & Howse, 2004; Jahromi & Stifter, 2008). Two questions therefore arise: 1. Do interindividual differences in self-regulatory abilities decline over time? 2. Is it possible to increase preschoolers' self-regulatory abilities through targeted intervention to help them start school? The present study is aimed at contributing to answering these questions by analyzing the effects of preschoolers' interindividual differences in SRL on their developmental trajectories in regard to SRL and by evaluating a preschool SRL intervention for training effects and for transfer effects to SR.

1.1. Self-regulation and self-regulated learning

In a frequently cited book chapter, Vohs and Baumeister (2004) define context-independent SR as "the exercise of control over oneself, especially with regard to bringing the self into line with preferred (thus, regular) standards" (p. 2). SR is accordingly needed to align one's own behavior with goals (Carver & Scheier, 2017). As a context-independent construct, the exercise of SR enables goal-directed behavioral adaptation

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in any situation. When, on the other hand, self-regulatory processes are specifically needed in the educational context, particularly for the achievement of learning goals, the term SRL is used (Boekaerts & Cascallar, 2006). SRL is therefore defined as "processes whereby learners personally activate and sustain cognitions, affects, and behaviors that are systematically oriented towards the attainment of personal goals" (Zimmerman & Schunk, 2011, p. 1). Zimmerman (2000) presents a model of SR that can be applied to the learning context and therefore serves as a theoretical basis for the SRL training implemented in the present study. For this reason, the application of the model to the learning context will be described in more detail below.

Zimmerman (2000) regards SR(L) as a cyclical process that can be divided into three phases: during the pre-action phase of forethought, the learner sets goals one wants to achieve and activates prior knowledge that helps with task planning and processing. Additionally, the learner establishes self-efficacy beliefs that influence task initiation and, subsequently, persistence while performing a task (Wolters & Benzon, 2013). During the performance and volitional control phase, the learner uses strategies for self-control and self-monitoring in order to stay motivated and work on the task according to one's goals. After task completion, the learner evaluates the results of the task in accordance with one's individual goals in the self-reflection phase. These processes result in affective self-reactions, such as self-satisfaction or self-frustration. The cycle leads to the subsequent forethought phase and is thus closed by deducing changes in plans for future behavior from the results of the self-reflection process (Zimmerman, 2000).

From the model presented, it is clear that cognitive and metacognitive as well as motivational processes are crucial components of SR and SRL (Perels et al., 2020). Since these processes are not yet fully mature at preschool age (Jacob et al., 2019), the following section provides a detailed explanation of child development of self-regulatory abilities and the link between this development and the maturation of precursor skills.

1.2. Development of self-regulation and self-regulated learning at preschool age

To investigate the developmental course of self-regulatory abilities, various measurement instruments have been developed that can be applied in preschool age. Preschoolers' SR is often measured via external rating scales, such as the Child Behavior Rating Scale (Bronson, 1994), delay of gratification tasks, such as the wrapped gift task (Kochanska et al., 2000), or behavioral regulation tasks, such as the Head-Toes-Knees-Shoulders task (HTKS; Ponitz et al., 2009), which was used in the present study (see Methods section). External ratings, such as the Preschool Learning Behaviors Scale (McDermott et al., 2002), are also commonly used to assess preschool SRL. Because external ratings do not allow inferences about internal SRL processes, such as knowledge about SRL strategies, Jacob et al. (2019) developed a child-friendly strategy knowledge test for preschoolers. This test was used in the present study (see Methods section.).

Using such measurement tools, previous studies have shown that preschool age is associated with significant increases in self-regulatory abilities: in terms of SR, rapid growth occurs up to the age of six (McClelland et al., 2014; Montroy et al., 2016; Wanless et al., 2016), after which there is only a slow increase (Montroy et al., 2016). Research on the subconstruct SRL has shown that preschoolers start using basic SRL strategies but are not yet able to use more complex strategies: they perform planning behaviors prior to actions and integrate knowledge about their learning into behavior planning (Jeong & Frye, 2020; Marulis & Nelson, 2021). During actions they monitor their behavior and from the age of six they increasingly succeed in translating the results of monitoring into control behavior (Destan et al., 2014; Marulis & Nelson, 2021). When they are uncertain about performing an action, they exhibit help-seeking behavior (Coughlin et al., 2015). After an action they check the results of their behavior (Bryce et al., 2015). However, certain abilities (e.g. the ability to incorporate task-difficulty information into behavior planning prior to action) are not yet fully developed at preschool age (Schneider, 2008). In addition, preschoolers' (post-)action error detection and correction is still immature (Hanley et al., 2016).

Within the preschool age group, there is large interindividual variation in self-regulatory (learning) competencies (Bryce et al., 2015; Montroy et al., 2016). Since the brain and its corresponding cognitive abilities show only little differentiation at this age (Lee et al., 2013; Shing et al., 2010), this large variability can be explained by interindividual differences in closely linked precursor skills of self-regulatory abilities that are still maturing during childhood. Such skills include executive functions and language skills (e.g. Becker et al., 2014; Bohlmann et al., 2015; Davis et al., 2021). If these precursor skills are at a high level, they facilitate the acquisition of self-regulatory abilities. Accordingly, it is easier for children with strong executive functions and language skills to acquire self-regulatory abilities.

Considering that there is large interindividual variation in SR and SRL among preschoolers and that these abilities are in the process of developing at this age, the question arises whether these differences are stable or associated with differential developmental trajectories of self-regulatory abilities. Differential developmental trajectories could occur as a compensation effect or a Matthew effect. A compensation effect becomes certain in that a high performance level is associated with lower performance growth over time, while higher performance growth can be recorded at an initially low performance level. Thus, the performance of higher and lower achievers converges (e.g., Ready, 2010; Venitz & Perels, 2019). On the other hand, a Matthew effect is evident in that individuals with a low performance level show lower performance growth than individuals with a higher performance level. Thus, the performance of higher and lower achievers diverges (e.g., Huang et al., 2014; Pfost et al., 2014). With regard to the current study, a compensation effect would manifest itself in a convergence over time of the self-regulatory abilities of initially low and initially high level children, whereas a Matthew effect would result in a divergence of said abilities.

While differential developmental trajectories for other preschool skills, such as precursor reading and writing skills, are well studied and support a Matthew effect (e.g. Hooper et al., 2010), empirical findings on differential developmental trajectories of self-regulatory abilities have so far only been available with regard to SR. However, based on Kaplan's (2008) view, which assumes SRL to be a subconstruct of SR, we presume that the findings can be transferred to SRL. Wanless et al. (2016) studied SR developmental trajectories of children from three and a half to six years old. They found that two groups of children can be identified based on their self-regulatory abilities: increasing regulators and steady-then-increasing regulators. Increasing regulators show a steady growth in SR abilities from three and a half to five years. Afterwards, there is only a weak increase up to the age of six. In the group of steady-then-increasing regulators, there is hardly any increase in SR until the age of five, but there is a steady increase in self-regulatory abilities thereafter until the age of six. These results suggest that there is initially a Matthew effect, but that there is a compensatory effect at the age of five to six. Similar results were found by Montroy et al. (2016) for children between three and seven years. In this study, a third group was found to show an increase in SR from about four years of age on. From the age of five on, however, this group only differed slightly from the increasing regulators. The authors additionally investigated whether developmental trajectories can be predicted by demographic variables or language abilities. They found that female children with higher socioeconomic status (SES) are more likely to show an early onset of SR development. In addition, higher language skills favor the early onset of SR development. Because we are not aware of any studies that examine differential SR developmental trajectories and also include executive functions, we cannot make any empirically based conclusions about the influence of executive functions on SR onset.

The presented findings show that a compensatory effect manifests itself in self-regulatory abilities at the preschool age. This effect can be

explained by interindividual differences concerning demographic variables as well as by self-regulatory precursor skills (language skills) that affect the onset and tempo of self-regulatory development. Since children with later developmental onset do not reach the performance level of children with early developmental onset, it is desirable to find methods to promote self-regulatory abilities. To assess the effectiveness of such an intervention, valid-measurement tools are needed. Therefore, the following section presents measurement methods for SR and SRL.

1.3. Training self-regulation and self-regulated learning

Meta-analytical findings show that both children's SR and SRL can be effectively promoted through intervention (e.g., Dignath et al., 2008; Pandey et al., 2018). In this context, preschool age in particular can be regarded as an appropriate time for promotion because, as shown above, it represents an early point in the development of self-regulatory competencies, which also manifests itself in increasing maturation of the brain regions associated with self-regulation (e.g., Berger et al., 2007; Kelley et al., 2015). Substantial plasticity is thus evident in the structures assigned to self-regulatory competencies, which could be enhanced by targeted interventions. Accordingly, previous studies have also shown that preschool SR and SRL can be fostered through targeted interventions (e.g. Perels et al., 2009; Schmitt et al., 2015). Because the present study evaluates the effectiveness and transferability of a training program for preschoolers' SRL, the findings regarding SRL trainings are discussed below.

Previous research on the trainability of SRL has focused primarily on older cohorts, such as school or college students (Perels et al., 2020). It has shown that SRL can be promoted at two levels: direct interventions involve the target group of learners themselves by encouraging them to use SRL strategies (e.g., using learning diaries; Dignath-van Ewijk et al., 2015). Indirect interventions, in contrast, target learners' caregivers (e.g., teachers; Carriedo & Alonso-Tapia, 1996) and encourage them to serve as models from whom SRL can be adopted through observational learning, as well as to use support strategies that encourage students to apply SRL strategies in everyday school life. Strategy learning can be accomplished either by teaching the strategies independent of content (Dörrenbächer & Perels, 2016) or by combining strategy teaching with subject-specific content (e.g., in mathematics; Wang & Sperling, 2020).

The following is a description of the studies to date on the trainability of SRL in preschoolers. A study by Perels et al. (2009) found evidence for the trainability of preschool SRL skills through an indirect intervention: preschool teachers who received information about the strategies that can be used in each phase of the Zimmerman (2000) model and who were trained in teaching said strategies to preschoolers made significantly higher gains in SRL competencies than preschool teachers in the control group. The training effect was also evident at the level of preschoolers who did not receive any training themselves. A study by Dörr and Perels (2019) was also able to illustrate the importance of involving caregivers by showing that a combined intervention that trains both caregivers in modeling and supporting the use of SRL strategies and the children themselves through playful practice of these strategies has stronger training effects in preschoolers' observed SRL-related behavior than a training that involves only one target group. This effect was not found when external ratings by caregivers were used as the evaluation measure (Dörr & Perels, 2020), which could be due to the fact that individuals' assessments of others' abilities are formed over a long period of time (Vazire, 2010) and, consequently, possible new behaviors that preschoolers adopt through training may show up in an observation tool but may not yet be integrated into the caregivers' views of children.

Regarding the integration of SRL training into subject instruction, initial studies from countries where basic writing skills instruction occurs in preschool (e.g., Malaysia; Kim & Nor, 2019; or Israel; Schiff et al., 2016) have shown that preschoolers can improve their SRL competencies as well as their basic writing skills through SRL training incorporated into their writing instruction. Both studies used direct approaches to promote strategy use. In the study by Kim and Nor (2019), the strategies to be taught (e.g., goal setting) were first explained to the children and then practiced by the children. In the study by Schiff et al. (2016), signal signs designed to remind children of the instructed strategies (e.g., monitoring) were posted and the strategy presented was explained to the children.

Because preschoolers' self-regulative abilities are strongly linked to verbal skills (Montroy et al., 2016) and their SRL is often accompanied by verbalizations of their SRL behaviors (Harris, 1990), Jacob et al. (2020) examined whether interactive SRL training, in which children learn the strategies together with others by asking and answering guiding questions to each other, is superior to autonomous training, in which children perform the tasks to practice SRL strategies through play alone. In this study the authors found no evidence that preschoolers benefit more from interactive than autonomous SRL training.

In addition to changes in the trained skills, so-called transfer effects (i.e. training-induced changes in non-trained abilities) are also of interest in training research. A precondition for the occurrence of transfer effects is that the training strengthens processes that underlie the trained as well as the transferred skill. To date, we do not know of any study investigating transfer effects of SRL training on SR. However, meta-analytical findings support the basic assumption of the transferability of SRL training, e.g. to academic performance (Dignath et al., 2008; Dignath & Büttner, 2008). Against this background, a transfer of SRL training to SR is conceivable. The assumption of a transfer effect can also be justified from a theoretical perspective: because SRL can be seen as a subconstruct of SR and the underlying processes show a correspondingly large overlap (Kaplan, 2008), processes that form the basis for SR should be strengthened by SRL training, leading to increases in children's SR. Based on this theoretical perspective, it is also reasonable that SR training will lead to strengthening of SRL competencies. However, this assumption cannot be investigated with the present study due to the exclusive implementation of SRL training.

Due to the high interindividual variance of SRL skills at the preschool age mentioned above, the question arises whether the success of SRL training is influenced by the initial SRL competencies of the children. Matthew and compensation effects are also conceivable for training-induced differential progressions. A training-induced Matthew effect could be explained by the fact that those participants who show higher baseline performance have more resources to acquire the trained skills, so they benefit more from the training. Training-induced compensation effects, on the other hand, can be explained by the fact that individuals with high baseline performance already have sufficient resources in the skill that is being trained, and there is thus little room for plasticity. Since we are currently not aware of any study on differential training-related trajectories of SRL competencies in preschoolers, a study with a sample of preschool teachers is discussed here instead: Venitz and Perels (2019) trained preschool teachers to reflect on their own SRL behavior and to promote preschoolers' SRL. The results of the study suggest a compensation effect; a subgroup of preschool teachers who initially used SRL-promotion strategies less frequently showed a greater training-induced increase in the use of these strategies than a subgroup of preschool teachers who already used the promotion strategies more frequently prior to training. A study with children at the early secondary school age also found a compensatory effect for SRL training (González-Pienda et al., 2014). This study examined students' knowledge of SRL strategies, frequency of strategy use, and weekly study time. It was found that only students with little knowledge about SRL strategies were able to increase their strategy knowledge through training. In addition, only those students who originally used SRL strategies infrequently increased the frequency of strategy use through training. Also, in terms of weekly study time, only those students who had little study time before training showed a training-induced increase.

1.4. Present study

This study aims at investigating the (six week) short-term development of SR and SRL and the training-induced trajectory of SRL as well as the transferability of SRL training to SR. We adopt the following hypotheses regarding SRL: since self-regulatory abilities develop rapidly during preschool age (e.g., Jeong & Frye, 2020; Marulis & Nelson, 2021; Montroy et al., 2016), we hypothesize that *SRL competencies increase from pretest to posttest* (*H1*). Since previous studies on developmental trajectories of SR found compensatory effects (Montroy et al., 2016; Wanless et al., 2016, we expect that *SRL differences between high-SRL preschoolers and low-SRL preschoolers decrease from pretest to posttest* (*H2*). Based on previous findings that SRL is trainable at the preschool age (e.g., Dörr & Perels, 2019; Kim & Nor, 2019), we hypothesize that *SRL competencies improve more from pretest to posttest in a preschool group receiving an SRL training than in an active control group* (*H3*). Since previous studies on differential SRL training effects have found compensatory effects (González-Pienda et al., 2014; Venitz & Perels, 2019), we assume that *low-SRL preschoolers show stronger training-induced increases in SRL from pretest to posttest than do high-SRL preschoolers* (*H4*).

We additionally adopt the following hypotheses regarding SR: Due to the rapid development of self-regulatory abilities during preschool age (e.g., Jeong & Frye, 2020; Marulis & Nelson, 2021; Montroy et al., 2016), we assume that *SR competencies increase from pretest to posttest* (*H5*). Based on previous findings that SRL trainings transfer to related abilities (Dignath et al., 2008; Dignath & Büttner, 2008), we expect that *SR competencies improve more from pretest to posttest in a preschool group receiving SRL training than in an active control group* (*H6*).

2. Methods

2.1. Participants

From 12 German kindergartens (9 in urban, 3 in rural locations; 6 under public, 6 under independent sponsorship; all with morning and afternoon care hours), we recruited $N = 152$ preschoolers whose parents had given their written consent for the children to participate in this study. According to their parents, the children had normal or corrected to-normal vision, no hearing impairment, no known learning disability or developmental delay. 108 children agreed to complete the tests used for data analysis (the rest dropped out because of comprehension, attention or motivation problems). We excluded an additional 14 children who attended less than three of the eight training sessions to ensure that the included children received sufficient training. Thus, the final sample consisted of $n = 94$ preschoolers (54.3 % female, 44.7 % male, 1.1 % missing data on sex; $M_{age} = 6;2$ years, age range: 5;0–7;0 years; 75.5 % raised monolingual, 17.0 % raised bilingual, 6.4 % raised trilingual, 1.1 % missing data on mono−/multilingualism; $M_{SES\ (scale\ ranging\ from\ 1\ to\ 3)} = 2.52$, $SD = 0.70$). For data analysis on preschoolers' SR, another eight children had to be excluded because they refused to complete the task that was used to determine children's SR performance. From the final sample ($n = 94$), an average of about eight children per kindergarten participated in the study, with a range of six to 12 children. The final sample did not differ significantly in age, SES, sex ratio or SRL from the preschoolers who were not included in the data analysis. However, children in the final sample had significantly higher active and passive vocabulary and SR levels than the excluded children.

Since it cannot be assumed that the preschoolers would not share the training content with their peers, the assignment to the training conditions was made at the kindergarten level; the kindergartens were randomly assigned to a training group or to an active control group. Five kindergartens were assigned to the training group and seven kindergartens to the active control group. Since a workshop for preschool teachers was also planned for the intervention in the training group (see below), we assessed the own SRL behavior of the preschool teachers of both groups by means of a self-report questionnaire (Venitz & Perels, 2019) before the intervention. Preschool teachers' own SRL did not differ between the two groups, $t(26) = -1.38$, $p = .178$.

For data analysis, the sample was additionally divided into a group of high-SRL preschoolers and low-SRL preschoolers based on their pretest performance on the SRL test. Children who scored higher than average were assigned to the high-SRL group, and children who scored lower than average were assigned to the low-SRL group – this is an approach to performance-based sampling that has also been used by authors outside the SRL context (e.g. Lee & Ewert, 2013; McNamara & Kintsch, 1996). In reference to the intervention, four groups resulted: a high-SRL training group (HT), a high-SRL active control group (HC), a low-SRL training group (LT) and a low-SRL active control group (LC). An overview of the group sizes and the age and gender distributions of the four resulting groups as well as for the two higher-order groups of high-SRL and low-SRL preschoolers is given in Table 1. By using a $\chi 2$ test, we found that girls were significantly more likely than boys to be classified in the two high-SRL groups at the $p < .050$ level. With regard to age, there were no significant differences between the high-SRL and low-SRL groups as determined by a *t*-test.

2.2. Intervention

The training that Jacob et al. (2020) used to autonomously promote SRL in preschool children was implemented as intervention for the training group. The intervention involved training both the preschoolers and the preschool teachers. The children's training was structured as follows: the children received nine training sessions over a five-week period; one session was an introduction and was used for getting to know one other, and eight sessions were used to learn various SRL strategies. The children were taught seven SRL strategies that preschoolers can already learn based on their (meta-)cognitive abilities (Jacob et al., 2019); one strategy was taught in each of the first seven strategy-related sessions and all the strategies were repeated in the last session (see Appendix A). A representation of a fictitious character before acting, during acting and after acting was used to visualize Zimmerman's phase model (2000) for the children and to teach them when each strategy can be used meaningfully. The character represented in this child-friendly model was the protagonist of the frame story that was used to introduce each SRL strategy. The character was a mole named “Mulle”. In the frame story, the mole is confronted with various situations that require self-regulated action, before, during and after digging a tunnel to a flower meadow that is behind a fence. Mulle's behavior in these situations was used as a model for the preschoolers to apply the SRL strategies.

Following previous studies of preschool SRL promotion (e.g., Dörr & Perels, 2019), the training sessions lasted about 45 min and had a consistent routine. At the beginning, the group came together to greet each other. Afterwards, the group repeated the contents of the previous session. An SRL trainer then read aloud a part of the frame story to the children to introduce the SRL strategy to be learnt in that session. This was followed by a practical section in which the children had to practice

Table 1
Descriptive statistics on group size and age and gender distribution by group membership.

Group	*n*	Age in years: *M* (range)	Gender: % female (% missing)
HT	21	6;0 (5;4–6;5)	61.9 (0.0)
HC	30	6;3 (5;1–7;0)	63.3 (0.0)
LT	26	5;10 (5;0–6;7)	46.2 (3.8)
LC	17	6;3 (5;6–6;9)	41.2 (0.0)
High-SRL	51	6;2 (5;1–7;0)	62.7 (0.0)
Low-SRL	43	6;1 (5;0–6;9)	44.2 (2.3)*

Note. HT = high-SRL training group, HC = high-SRL active control group, LT = low-SRL training group, LC = low-SRL active control group, H = both high-SRL groups, L = both low-SRL groups. Significant differences between the high- and low-SRL preschoolers are marked with an asterisk.

the presented strategy in a playful way. The table in Appendix A gives an overview of the strategies that were learned in each session, as well as the content of the frame story and the exercises that were used to practice the strategies. The practice phase was followed by a reflection task related to the rehearsed SRL strategy and was designed analogously to the items in the SRL test in the pretest and posttest (see below): the children were given a new situation in which the strategy might help Mulle. Children were presented with various ways of dealing with the situation – two in terms of the learned SRL strategy and two that were non-self-regulatory – and they were asked to assess the quality of the various ways of dealing with the situation. Because of the analogous design to the test used to measure child SRL, preschoolers did not receive feedback on their choices to rule out that improvements in the posttest were due solely to practice effects in the reflective tasks. Appendix B provides an overview of the reflection tasks for all training sessions.

At the end of each lesson, the children received a small sticker as a reward for their participation and were allowed to stick it to their own illustration of the phase model with Mulle before, during and after digging.

For the active control group, the sessions proceeded as follows: first, a short sequence of the frame story was read aloud in which the use of the SRL strategies was not mentioned. Then, the children completed the reflection task, which was identical to that of the training group, and finally, they received the reward stickers for the illustration of the phase model. To better understand the different design of the frame story, a short sequence of the planning session story for 1. the active control group and 2. the training group is provided in Appendix C.

Training sessions for the training group as well as for the active control group took place on the premises of the respective kindergarten and were each held by two trainers. The professional trainers were two doctoral and 10 psychology students who had received extensive training in advance on the procedure and process of each session. Furthermore, they received manuals for each session to ensure a standardized training process. The trainers were divided among the training sessions in the kindergartens according to their time availability.

The preschool teachers of the training group received a one-session workshop in the respective institution on the theoretical foundations of SRL as well as on the possibilities of promoting the presented SRL strategies among preschoolers in everyday life. The workshop, which preceded the children's training, lasted about two hours. At the beginning of the workshop, the preschool teachers reflected on their own SRL (model) behavior. They were then introduced to Zimmerman's (2000) phase model. Through interaction with the preschool teachers, exemplary situations were identified in which preschoolers use the strategies included in the model. Preschool teachers were shown ways to promote preschoolers' use of SRL strategies in their daily routines. At the end of the workshop, the preschool teachers received a training manual in which the theoretical basics of SRL were repeated and practical exercises given with which the learned strategies were to be practiced by the preschoolers in everyday kindergarten life after each direct training session. Preschool teachers were asked to rate the frequency of use of each exercise using a three-point scale ranging from 0 = "not used" to 1 = "used once" to 2 = "used more than once". In the active control group, there was no indirect intervention for preschool teachers.

2.3. Measures

2.3.1. SRL

A scenario-based test of preschoolers' knowledge of SRL strategies developed by Jacob et al. (2019) was used in the pretest and posttest to assess training effectiveness. This measurement tool is a direct test instrument that allows for the recording of children's non-observable SRL competencies. The test is constructed analogously to the training using a frame story that is read aloud to the children and visualized with colorful drawings. The protagonist of the story is confronted with situations before, during and after an action in which SRL strategies are useful (e.g. remembering past experiences of successful crafting in order to activate self-efficacy beliefs before crafting). The test items are presented as the protagonist's suggestions to deal with the given situations; some of these suggestions reflect SRL strategies and some reflect non-self-regulatory and impulsive behavior. The children's task is to rate each suggestion as a "great idea" or a "bad idea" and their performance is recorded as follows: if the children's ratings match the item's target usefulness (i.e. an SRL item is rated as a "great idea" or a non-SRL item is rated as a "bad idea"), they receive one point. If the children's ratings are contrary to the item's target usefulness (i.e. an SRL item is rated as a "bad idea" or a non-SRL item is rated as a "great idea"), they receive a negative point. Children do not receive feedback on their judgments to avoid practice effects from pretest to posttest. The test instrument consists of 11 items; therefore, children can score anywhere from −11 to 11 points. The measurement tool has sufficient reliability (internal consistency: Cronbach's $\alpha = 0.68$ in the present sample and $\alpha = 0.72$ in the validation study by Jacob et al., 2019) and validity (e.g. significant correlation to an external rating of SRL competencies: $r = 0.20, p < .050$; Jacob et al., 2019). An overview of the test items is provided in Appendix D.

2.3.2. SR

We used the HTKS (e.g. McClelland et al., 2014; Ponitz et al., 2009) in the pretest and posttest to assess the transferability of the SRL training to SR. At the beginning of this task, the children are instructed to touch their head or toes (and later also their shoulders or knees) and to name the touched part of their body when the experimenter says the name of that part of the body. When children have learnt this stimulus-reaction scheme, they are instructed to touch and name the opposite to the announced part of the body (e.g. to say "toes" and touch toes when the experimenter has said "head"). The task consists of 20 trials; for the first 10 trials, only the head and toes are used, for the second half of the task, shoulders and knees are added. Children can receive up to two points each for motor and verbal reaction, two points when they show the right reaction immediately and one point when the right reaction is shown after correction. In total, children can score up to 80 points. The task shows high reliability (internal consistency: Cronbach's $\alpha = 0.96$ in the present sample and $\alpha = 0.96$ in a study by McClelland et al., 2014) and satisfactory validity (e.g. significant correlation to an external rating of SR competencies: $r = 0.20$, $p < .010$; Ponitz et al., 2009).

2.3.3. Control measures

Because children's language skills and SES have a significant impact on the development of self-regulatory abilities (Montroy et al., 2016), these variables were assessed in the pretest as control variables. Preschoolers' active and passive vocabularies were measured using the German Begriffe Erkennen (recognizing terms) test and the German Passiver Wortschatztest (passive vocabulary test) from the intelligence test battery Hannover-Wechsler-Intelligenztest III (HAWIVA-III; Ricken et al., 2007). In the recognizing terms test, children are given definitions for terms by the experimenter and afterwards identify the word that has just been described (e.g. the experimenter says, "This person brings letters to people", and the correct answer is "postman"). The test consists of 12 items and children receive one point for each correct answer. The test is cancelled if five answers are wrong. In the passive vocabulary test, the experimenter says a word (e.g. "windmill") and the children choose the picture that shows that word from a selection of four pictures. The test consists of 18 items, and children receive one point for each picture correctly selected. In case of five wrong answers, the test is cancelled. In the present sample, the tests for verbal abilities have satisfactory to good reliabilities (Cronbach's $\alpha = 0.70$ for the passive vocabulary test and Cronbach's $\alpha = 0.82$ for the recognizing terms test) and correlate significantly with each other ($r = 0.59$, $p < .001$), indicating good validity.

As an indicator of preschoolers' family SES, we used parental education, which we measured using the book question (Bos et al., 2007):

children were asked how many books their family has at home. Children chose between "none or just a few", "enough to fill a shelf" and "more than 200 books". These answers are illustrated by pictures of a narrow bookshelf that is barely full, a narrow bookshelf that is much fuller and a wide bookshelf that is almost full. The book question correlated with parental education at $r = 0.45$ in the 2012 PISA study, indicating good validity (Kipman, 2018).

Table 2 shows comparative descriptive statistics for the control variables for the four groups as well as for the two higher-order groups of high-SRL and low-SRL preschoolers. *t*-tests showed that the children in the two high-SRL groups had significantly ($p < .050$) higher parental educational backgrounds as determined by the book question and scored significantly higher on the recognizing terms test and the passive vocabulary test than the children in the two low-SRL groups.

2.4. Testing procedure

The pretest and posttest were conducted as individual tests in quiet rooms of the kindergartens. The time between tests was approximately six weeks for both the training group as well as for the active control group. Since we collected the control measures (book question, recognizing terms test and passive vocabulary test) in the pretest in addition to the training and transfer measures, the pretest was divided into two sessions so as not to exceed the attention capacities of the preschoolers. The posttest, in which only the training and transfer measures were collected, was conducted in one session. The order of testing was the same for all subjects: the first pretest session began with the book question, followed by the SRL test and the passive vocabulary test. In the second pretest session, the HTKS was administered first, followed by the recognizing terms test. In the posttest session, the SRL test was administered first, followed by the HTKS. Each test session lasted about 15 to 20 min. The tests were each conducted by two test administrators. The test administrators received training in administrating and recording the tests. Instruction and protocol manuals were also used for purposes of standardization.

2.5. Data analysis

We conducted our data analysis using IBM SPSS, version 25 for Windows. Although the present data are of nested structure due to the assignment of training conditions at the kindergarten level, we refrained from calculating multilevel models because a sample size of 12 at the kindergarten level and of about eight children per kindergarten is not sufficient for accurate parameter estimation (e.g., Bickel, 2007; Maas & Hox, 2005). For this reason, the data were analyzed by variance analysis. We calculated intraclass correlations (ICCs) to test the influence of kindergarten affiliation on performance in the SRL test and in the HTKS (Castro, 2002). We found small ICCs for the SRL test, ICC = 0.08, as well as for the HTKS, ICC = 0.01. Accordingly, kindergarten membership explains only a relatively small proportion (8 %) of SRL test performance and 1 % of HTKS performance and the ICCs were below or just above the cut-off of ICC = 0.05 above which multilevel analyses are recommended (Heck et al., 2013).

Due to the importance of the children's SESs as well as their language skills for the development of self-regulatory skills (Montroy et al., 2016) and to the fact that language skills as well as SES, in contrast to gender, are changeable (language skills can be directly changed through language support interventions and SES indirectly changed through educational opportunities for parents), children's scores in the book question, the recognizing terms test and the passive vocabulary test were used as covariates in the analyses if they did not interact significantly with the independent variables. Because ANCOVA assumes homogeneous regression slopes (e.g., Hamilton, 1977), control variables were included in the analyses as independent variables instead of covariates if they interacted significantly with the independent variables, as recommended by Sweet and Grace-Martin (2010). Since SPSS does not automatically center covariates in repeated measures ANCOVAs, the covariates were z-standardized before being included in the calculations. This procedure ensures that the probability of Type I errors remains low and that the test power is sufficiently high in relation to the within-subject factor (Schneider et al., 2015).

Table 2
Descriptive statistics for relevant variables collected in the pretest, differentiated by group membership.

Group	PE: *M* (*SD*)	AV score: *M* (*SD*)	PV score: *M* (*SD*)
HT	2.86 (0.36)	7.38 (3.12)	11.52 (2.60)
HC	2.50 (0.73)	8.27 (3.11)	12.13 (1.81)
LT	2.31 (0.84)	5.92 (3.60)	8.54 (4.06)
LC	2.47 (0.62)	7.76 (2.63)	11.47 (2.55)
High-SRL	2.65 (0.63)	7.90 (3.11)	11.88 (2.17)
Low-SRL	2.37 (0.76)*	6.65 (3.34) *	9.70 (3.80) *

Note. HT = high-SRL training group, HC = high-SRL active control group, LT = low-SRL training group, LC = low-SRL active control group, High-SRL = both high-SRL groups, Low-SRL = both low-SRL groups, PE = parental education, AV = active Vocabulary, PV = passive vocabulary. Significant differences between the high- and low-SRL preschoolers are marked with an asterisk.

3. Results

We calculated Kolmogorov-Smirnov tests as pre-analyses to examine the distribution of SRL and SR data. Both data deviated significantly from a normal distribution. A descriptive analysis suggests a left-skewed distribution of both the SRL and SR data. Since variance-analytic procedures have been shown to be robust to violations of the normal distribution assumption (Schmider et al., 2010), a variance-analytic approach is used for the analyses on SRL and SR despite the absence of normal distributions.

3.1. Manipulation check

We used the ratings of the preschool teachers in the training group on the frequency of use of the everyday exercises to examine whether practice of the SRL strategies taught occurred outside of the preschoolers' training. We calculated a one-sample *t*-test with the frequency rating of exercise use averaged across all exercises as the dependent variable. We found that the averaged frequency rating was significantly different from 0, $t(8) = 2.67$, $p = .028$ ($M = 0.56$, $SD = 0.63$). Therefore, it can be assumed that the children in the training group also had the opportunity to practice the learned SRL strategies after the training sessions.

To check whether the division of the sample into a high-SRL group and a low-SRL group was meaningful, we tested for significant differences between the two groups in their SRL performance. We conducted a two-sample *t*-test with the level of initial SRL performance (high-SRL group vs. low-SRL group) as the independent variable and SRL test score in pretest as the dependent variable. We found that the high-SRL group scored significantly higher in the SRL test in the pretest than did the low-SRL group, $t(92) = 14.82$, $p < .001$, $d = 1.68$ ($M_{high\text{-}SRL} = 3.90$, $SD_{high\text{-}SRL} = 2.13$; $M_{low\text{-}SRL} = -4.07$, $SD_{low\text{-}SRL} = 3.07$). Therefore, it can be assumed that our sample split was reasonable in terms of SRL pretest performance.

3.2. Analyses of the training measure: SRL test

Performance on the SRL test in pretest and posttest served as dependent variable in the analyses of SRL. Table 3 shows the means and standard deviations of the SRL test scores in pretest and posttest plus their differences for the two training conditions (training group vs. active control group) as well as for the high- and low-SRL groups within the two training conditions.

For hypotheses 1 and 2, which concern the training-independent

Table 3
Descriptive statistics of the pretest scores, posttest scores and the differences between posttest score and pretest score in the SRL test by condition.

Group	SRL test pretest: *M* (*SD*)	SRL test posttest: *M* (*SD*)	SRL test diff: *M* (*SD*)
Training group	−1.04 (5.38)	2.28 (5.40)	3.32 (4.83)
HT	3.95 (2.16)	5.29 (4.95)	1.33 (4.75)
LT	−5.08 (3.42)	−0.15 (4.50)	4.92 (4.35)
Active control group	1.55 (3.65)	2.19 (4.48)	0.64 (4.63)
HC	3.87 (2.15)	3.07 (4.38)	−0.80 (4.16)
LC	−2.53 (1.51)	0.65 (4.37)	3.18 (4.42)

Note. SRL test diff = difference between posttest score and pretest score in the SRL test, HT = high-SRL training group, LT = low-SRL training group, HC = high-SRL active control group, LC = low-SRL active control group. Since −11 to 11 points are possible in the SRL test, the mean values for this test may be negative.

short- term development of SRL, our analyses were based solely on the data from the active control group ($n = 47$). We calculated a repeated measures ANCOVA with the within-subject factor time (pretest SRL vs. posttest SRL) and the between-subject factor initial SRL performance (high-SRL group vs. low-SRL group). For hypothesis 1, which assumes a general increase in SRL competencies over time, we considered the main effect of the factor time. We did not find a significant main effect of the factor time, $F(1, 42) = 1.84$, $p = .182$, $\eta_p^2 = 0.04$.

For hypothesis 2, which assumes a stronger increase in SRL competencies for the low-SRL group than for the high-SRL group, we considered the interaction effect of the factors time and initial SRL performance in the ANCOVA described above. The ANCOVA revealed a significant interaction, $F(1, 42) = 10.20$, $p = .003$, $\eta_p^2 = 0.20$. Therefore, we conducted paired *t*-tests and regarded Cohen's *d* as a measure of effect size to check whether the group-differential trajectories correspond to the formulated hypothesis. We found that for the high-SRL active control group, there was no significant difference between the SRL test scores in pretest and posttest, $t(29) = -1.05$, $p = .150$, $d = -0.19$, whereas for the low-SRL active control group, the SRL test score in posttest was significantly higher than the SRL test score in pretest, $t(16) = 2.96$, $p = .005$, $d = 0.72$. Accordingly, within the active control group, the low-SRL group showed improvement in SRL competencies in comparison to the high-SRL group.

Data analyses testing hypothesis 3, according to which a stronger increase in SRL competencies is expected for the SRL training group than for the active control group, were based on the entire sample ($n = 94$). We conducted a repeated measures ANCOVA with the within-subject factor time (pretest SRL vs. posttest SRL) and the between-subject factor training condition (SRL training group vs. active control group), and we considered the interaction effect of the factors time and training condition. Because the variable active vocabulary interacted significantly with the factor time in this analysis, it was included as an independent variable rather than a covariate. To ensure that the subgroups resulting from the training condition and active vocabulary factors were sufficiently large and still retained variance in the active vocabulary variable, we formed four levels for the latter factor based on quartiles in active vocabulary (very low vs. low vs. high vs. very high active vocabulary; for descriptive analyses on the SRL of the resulting subgroups, see Appendix E).

Since the active control group scored significantly higher on the SRL test in the pretest than the SRL training group, $t(92) = 2.74$, $p = .008$, $d = 0.54$, we included SRL pretest performance as an additional covariate in our calculations. We found a significant interaction effect between the factors time and training condition in the repeated measures ANCOVA, $F(1, 83) = 4.36$, $p = .040$, $\eta_p^2 = 0.05$. (This interaction effect is interpretable, since the three-way interaction of the two factors and the active vocabulary factor did not reach significance, $F(1, 83) = 1.72$, $p = .169$, $\eta_p^2 = 0.06$.)

We additionally calculated two two-factor ANCOVAs with the factors training condition and active vocabulary, one with SRL posttest performance as the dependent variable and SRL pretest performance as additional covariate and one with the difference between posttest performance and pretest performance in the SRL test as the dependent variable and SRL pretest performance as additional covariate, as these procedures are recommended in case of significant pretest differences between experimental groups (Farmus et al., 2019; Hendrix et al., 1978). These alternative procedures resulted in significant main effects for the factor training with the same F, p and η_p^2 values as the three-factor ANCOVA.

Subsequent paired *t*-tests revealed significant differences between the SRL test scores in pretest and posttest for the SRL training group, $t(46) = 4.71$, $p < .001$, $d = 0.69$ but not for the active control group, $t(46) = 0.95$, $p = .175$, $d = 0.14$. Thus, a general increase in SRL competencies occurred for the SRL training group, but not for the active control group.

Regarding the results of the data analysis for hypothesis 3, it should be mentioned that a significant interaction effect from the factors time and training could not be found when the calculations were carried out without taking the control variables (active vocabulary, passive vocabulary and SES) into account, $F(1, 91) = 2.74$, $p = .102$, $\eta_p^2 = 0.03$.

Our calculation for hypothesis 4, according to which a lower SRL pretest performance is associated with a larger training-induced increase in SRL competencies than a higher SRL pretest performance, was based exclusively on the data from the SRL training group ($n = 47$). We calculated a repeated measures ANCOVA with the within-subject factor time (pretest SRL vs. posttest SRL) and the between-subject factor initial SRL performance (high-SRL group vs. low-SRL group). We considered the interaction effect of the factors time and initial SRL performance and did not find a significant interaction, $F(1, 42) = 2.73$, $p = .106$, $\eta_p^2 = 0.06$. Accordingly, within the SRL training group, the high-SRL group increased its SRL competencies to the same degree as the low-SRL group.

Regarding the results of the data analysis for hypothesis 4, it should be mentioned that without taking the control variables (active vocabulary, passive vocabulary and SES) into account, we found a significant interaction effect between the factors time and initial SRL performance, $F(1, 45) = 1.37$, $p = .010$, $\eta_p^2 = 0.14$. The data analyses on the remaining SRL-related hypotheses, without taking into account the control variables, led to changes in effect sizes but not in significances. A comparison of the analyses with and without the inclusion of the covariates can be found in Table 4.

3.3. Analyses of the transfer measure for SR: HTKS

Performance on the HTKS in pretest and posttest served as the dependent variable in the SR analyses. Table 5 shows the means and standard deviations for the HTKS scores in pretest and posttest in addition to their difference for the two training conditions (training group vs. active control group).

Table 4
Analyses on the hypotheses with and without covariates.

Hypothesis (related construct)	Estimates with covariates	Estimates without covariates
H1 (SRL)	$F(1, 42) = 1.84$, $p = .182$, $\eta_p^2 = 0.04$	$F(1, 45) = 3.39$, $p = .072$, $\eta_p^2 = 0.07$
H2 (SRL)	$F(1, 42) = 10.20$, $p = .003$, $\eta_p^2 = 0.20$	$F(1, 45) = 9.49$, $p = .004$, $\eta_p^2 = 0.17$
H3 (SRL)	$F(1, 83) = 4.36$, $p = .040$, $\eta_p^2 = 0.05$	$F(1, 91) = 2.74$, $p = .102$, $\eta_p^2 = 0.03$
H4 (SRL)	$F(1, 42) = 2.73$, $p = .106$, $\eta_p^2 = 0.06$	$F(1, 45) = 1.37$, $p = .010$, $\eta_p^2 = 0.14$
H5 (SR)	$F(1, 38) = 5.59$, $p = .023$, $\eta_p^2 = 0.13$	$F(1, 41) = 12.65$, $p < .001$, $\eta_p^2 = 0.24$
H6 (SR)	$F(1, 81) = 1.37$, $p = .246$, $\eta_p^2 = 0.02$	$F(1, 84) = 2.68$, $p = .106$, $\eta_p^2 = 0.03$

Note. Effects are considered significant if $p < .050$.

Table 5
Descriptive statistics of the pretest scores, posttest scores and the differences between posttest score and pretest score on the HTKS by condition.

Group	HTKS pretest: *M* (*SD*)	HTKS posttest: *M* (*SD*)	HTKS diff: *M* (*SD*)
Training group	59.41 (18.58)	71.05 (11.23)	11.64 (17.58)
Active control group	65.57 (14.67)	71.93 (15.06)	6.38 (11.58)

Note. HTKS diff = difference between posttest score and pretest score on the HTKS.

For hypothesis 5, which assumes a general increase in SR competencies over time, we performed the analysis using data from the active control group (since not all subjects agreed to perform the HTKS, $n = 42$). We calculated a repeated measures ANCOVA with the within-subject factor time (pretest SR vs. posttest SR) and considered this factor's main effect. The ANCOVA revealed a significant main effect, $F(1, 38) = 5.59$, $p = .023$, $\eta_p^2 = 0.13$. Accordingly, children in the active control group showed an improvement in their SR competencies over time.

For hypothesis 6, according to which a stronger increase in SR competencies is assumed for the SRL training group than for the active control group, our analysis was based on data from both training conditions (since not all subjects agreed to perform the HTKS, $n = 86$). We conducted a repeated measures ANCOVA with the within-subject factor time (pretest SR vs. posttest SR) and the between-subject factor training condition (SRL training group vs. active control group), and we considered the interaction effect of the factors time and training condition; we did not find a significant interaction, $F(1, 81) = 1.37$, $p = .246$, $\eta_p^2 = 0.02$. Accordingly, the SRL training group and the active control group did not differ in terms of growth in SR competencies. The data analyses on the SR-related hypotheses, without taking into account the control variables, led to changes in effect sizes but not in significances (see Table 4).

4. Discussion

This study was aimed at exploring the short-term development, trainability and transferability of self-regulatory abilities – namely, SRL and SR – during preschool age. We conducted combined SRL training for preschool teachers and preschoolers in the training group and used data from the active control group to check for short-term developmental changes in SRL and SR. We compared changes in SRL and SR in the training group and the active control group to check for training and transfer effects of the SRL intervention. We additionally divided the sample according to pretest performance in the SRL test as a training measure to check for differential short-term developmental and training-related progressions in SRL. The results showed that only the low-SRL preschoolers improved in their SRL competencies without training, while training led to a strengthening of SRL competencies across groups. For SR, we found that the competencies increase short-term developmentally but cannot be additionally strengthened by SRL training.

4.1. Discussion of results

4.1.1. SRL

For the SRL measure, we did not find statistical evidence for a general developmental increase during the study period of approximately six weeks. Instead, we found that there were group-differential short-term developmental trajectories: only the group that started at a low SRL level improved over time. These results contradict the assumption of a Matthew effect found in preschool children on precursor reading and writing skills (e.g., Hooper et al., 2010) and instead support the assumption of a developmental compensation effect (Montroy et al., 2016; Wanless et al., 2016): the group of preschoolers with initially strong SRL performance may have already achieved the preschool developmental goal prior to the pretest, while for the group of preschoolers with initially weak SRL performance, there may still have been room for maturation at the time of the pretest. Accordingly, findings on SR showing that interindividual differences decrease between the fifth and sixth year of life (Montroy et al., 2016; Wanless et al., 2016) seem to be transferable to SRL. The factors that Montroy et al. (2016) found to influence the development of SR also appear to be important for SRL development: preschoolers with initially strong SRL performance were more likely to be female, to have higher SES – here as parental education – and to have stronger verbal abilities.

Regarding the trainability of SRL, we found that a combined intervention consisting of a workshop for preschool teachers and training for preschoolers can strengthen children's SRL competencies. Thus, preschoolers' SRL can be supported by playful practice of previously modeled SRL strategies as hypothesized in Zimmerman's (2000) model, namely planning and reinforcing self-efficacy before an action, pausing, self-motivation, dealing with distraction, and self-monitoring during an action and reflection and causal attribution after an action, and additional encouragement of strategy use by kindergarten teachers in everyday life. This agrees with previous findings that SRL interventions for preschoolers are effective (Dörr & Perels, 2019; Kim & Nor, 2019).

In contrast to the results on short-term developmental changes in SRL, we found no evidence for interindividual differences in training-related gains, as both the group with initially weak SRL performance and the group with initially strong SRL performance were equally able to increase their SRL competencies. These results contrast with findings from studies that investigated differential SRL trainability in other target groups and found training-related compensatory effects (González-Pienda et al., 2014; Venitz & Perels, 2019). Thus, the question arises as to why the compensation effect occurs without an intervention for preschoolers and through an intervention for people of other ages but not through an intervention for preschoolers. A possible answer to this question can be derived from the conceptual framework of cognitive plasticity presented by Lövdén et al. (2010). The authors assume that cognitive resources are available in limited amounts and that plasticity occurs when individuals are challenged beyond these limits over a long period of time. In the context of training, improvements in the trained abilities are achieved through prolonged beyond-the-limits demands on the trained abilities. Since the promotion of self-regulatory abilities is included in the educational plans[1] of the German federal states as a goal for preschool educational institutions (Drexl et al., 2012), it can be assumed that demands on self-regulatory competencies are also made in kindergarten. This assumption is supported by the finding that preschool teachers already exhibit behaviors that promote child SRL even without training (Perry et al., 2002). For preschoolers who have not yet reached a high SRL level, these behaviors (as well as a targeted SRL intervention) may have made sufficiently high demands to induce plasticity. For preschoolers whose SRL competencies were already at a high level, on the other hand, it may be that only targeted SRL intervention set high enough demands to induce plasticity. The substantially lower SRL demands placed on preschoolers without training may not have been sufficient to induce plasticity for this group of children, which could explain the compensatory effect without implementation of training. To test the hypothesis that the behaviors preschool teachers exhibit stimulate plasticity in children with weak SRL performance, a study comparing children attending kindergarten with children not attending kindergarten would be necessary. Given that 92.5 % of three-to-six-year-old children in Germany attend kindergarten (Statistisches Bundesamt, 2020), recruiting the control group for such a study would be extremely

[1] Educational plans (in German: *Bildungspläne*), which are formulated separately for each federal state, serve as a concretisation of the educational and upbringing mandate for kindergartens, which is regulated by law nationwide.

difficult.

At this point, it should be mentioned again that the results on trainability would have been different without the control variables active vocabulary, passive vocabulary and SES; there would have been no training effect independent of baseline performance, but rather a training-related compensatory effect. This suggests that those variables that influence the development of self-regulatory abilities (Montroy et al., 2016) also affect responsiveness to interventions for those same skills. Further research is needed to investigate the influence of verbal abilities and SES on the time course of SRL in more depth.

4.1.2. SR

For the SR measure, a different pattern of results emerged. In contrast to the SRL measure, we found evidence for a general increase in SR competencies independent of training. The SR competencies of the preschool children thus matured significantly during the study period of approximately six weeks. This finding agrees with previous research showing that children make substantial developmental gains in SR during their preschool years (McClelland et al., 2014; Montroy et al., 2016; Wanless et al., 2016).

The SR results also differ from those for SRL in terms of changeability through SRL training: the children in the training group did not improve their performance in the HTKS more than the children in the active control group. These results do not support the transferability of preschool SRL training to SR. However, the assumption of transferability should not be directly rejected on the basis of this result; transferability seems possible from a theoretical point of view due to the overlap of the two constructs, and the lack of a transfer effect could alternatively be attributed to methodological aspects. A (training-related) increase in competence can manifest itself on two levels: on the declarative level, which means that a person has acquired new verbalizable (factual) knowledge, and on the procedural, behavioral level, which means that a person succeeds better in action sequences or has learned new action sequences (e.g., Beeby et al., 2015). Whereas the SRL test is a measure for declarative SRL in the sense of knowledge regarding SRL strategies (Jacob et al., 2019), the HTKS as a measure for behavioral regulation measures procedural SR in terms of acting using SR (Ponitz et al., 2009). It is possible that the training (initially) only brought about changes at the declarative level that have not (yet) led to changes at the procedural level. Since the current study contains neither a procedural SRL measure nor a declarative SR measure (nor a follow-up test), this assumption cannot be verified on the basis of the available data. The difference between the measurement instruments could also explain why a general increase in short-term development was shown for SR but not for SRL: a cross-group increase in self-regulatory competencies may have occurred at the procedural, but not at the declarative, level during the study period. Thus, it might be possible that the ability to adapt behavior to goals as a procedural competence shows maturational processes within six weeks at preschool age, whereas gaining knowledge about SRL strategies as a declarative competence takes more time. Again, this assumption cannot be tested with the current study due to the lack of further procedural and declarative measures.

4.2. Limitations

The study has some limitations. Methodological limitations have already been addressed in the previous section: as mentioned above, the selected instruments do not allow any statements about the (training-induced) course of procedural SRL and declarative SR. Statements on the course of other self-regulatory components, for example delay of gratification, are also not possible on the basis of the present study. Because child executive functions were not recorded, the role of these precursor abilities in the time course of self-regulatory competencies remains unclear. Furthermore, due to the lack of a follow-up test, no conclusions can be drawn about long-term outcomes. With regard to the instruments used, it should be noted as a limitation that the internal consistency of the SRL test in the present sample was found to be only $\alpha = 0.68$. Further test development work is needed to achieve a more reliable test instrument, as we are not aware of any other direct test for assessing knowledge of SRL strategies at the preschool age (see below).

The measurement of SES by the book question should also be noted as a limitation, as it is only an indirect measure of parental educational status. Due to a low response rate of parent questionnaires of only 66 %, we were unable to use parental data as a measure of SES. However, the high correlations that Kipman (2018) found between the book question and parental educational status suggest that the book question can very well be used as an indicator of parental education. A measure that additionally takes parental income into account and thus takes a more holistic view of SES is the International Socio-Economic Index of Occupational Status (ISEI; e.g., Ganzeboom et al., 1992). In future studies examining self-regulatory abilities in the context of SES, this measure could be used for a more valid SES assessment.

Furthermore, the randomization in assigning participants to the training or active control group occurred with kindergartens instead of preschoolers, which reduces the representativeness of the data. As described above, small effects of kindergarten affiliation on self-regulatory abilities can be assumed.

With regard to group allocation, the division of subjects into a high-SRL and low-SRL group should also be critically examined. Since children above the mean were assigned to the high-SRL group and children below the mean to the low-SRL group, the SRL-stronger children of the low-SRL group hardly differ from the SRL-weaker children of the high-SRL group. However, if only extreme groups had been compared instead of this approach, the sample size within the subgroups would have been considerably reduced on the one hand, and the variance within the groups would have decreased substantially on the other hand, which is why we endorse the chosen approach.

Finally, we would like to critical examine the study sample: we had to exclude more than one third (38.2 %) of the children from the data analyses because they either attended too few training sessions or did not complete the tests included in the analyses due to comprehension, motivational or concentration deficits. This probably limits the representativeness of the results to the population of preschool children. The fact that the excluded children had significantly lower active and passive vocabulary and SR competencies than the included children supports this assumption. The differences in verbal abilities between the included and excluded sample could be attributed to a loss in motivation and attention of the (less verbally able) excluded children resulting from deficits in understanding the instructions given by the test administrators and trainers. The significantly lower SR competencies of the excluded preschoolers may have further enhanced this effect due to the importance of SR for attentional and motivational processes (Berhenke, 2013). Although this is a plausible explanation for the dropouts, the question remains to what extent the results of the study can be generalized to children with lower verbal abilities and SR competencies. The above-mentioned importance of verbal abilities for the development and trainability of self-regulatory abilities can be interpreted as a first indication that the results can only be generalized to said children to a limited extent. Providing alternative instructions in simpler language and scheduling breaks in each testing session could ensure that dropout due to difficulties in understanding and concentrating is reduced in future studies. This would increase the representativeness of the study results. It is also unclear whether the evaluated training is basically feasible for children with low SR skills or, for example, whether adjustments in session duration would be needed to allow children with lower SR skills to follow the training content well.

4.3. Implications for practice and future research

The main practical implication of this study is that, consistent with previous research on combined SRL training that does not rely on caregivers' ratings as a training measure (Dörr & Perels, 2019), children

can improve their SRL skills through a combination of direct training (playful practice of previously modeled SRL strategies) and indirect intervention (strengthening kindergarten teachers in their role as SRL models and handing out tasks for everyday practice of SRL strategies; Perels et al., 2020). This multi-level approach has allowed children to gain knowledge about the use of SRL strategies. The knowledge acquired facilitates goal-oriented learning for school entry. This, in turn, could provide children with an early experience of success at school, motivating them for further learning and having a positive impact on their psychological well-being (e.g, Deci & Ryan, 2008; Moffitt et al., 2011). These longer-term impacts of effective SRL training should be investigated in future studies.

An implication of the present study that goes beyond previous research is that preschoolers with weaker SRL competencies benefit from the training to the same extent as preschoolers with stronger SRL competencies. Based on the assumption that everyday kindergarten life can also be seen as an SRL-promoting intervention, from which only preschoolers with weaker SRL competencies still benefit at preschool age, the following question for future research arises: would preschoolers with weaker SRL performance benefit more from training (as a more challenging intervention) if it took place once they have reached the level of SRL demands set in everyday kindergarten life? To answer this question, a study is needed that compares groups with low baseline levels who receive SRL training at different times.

The limitations described above also have implications for future research, such as the need for studies with additional SR(L) measures and for further development of the SRL test. Since the SRL test was not sufficiently reliable in our relatively small sample (and only acceptably reliable in the larger sample of Jacob et al., 2019), future research should aim to revise it by adding new items that selectively depict the construct SRL. SRL strategies that have not yet been considered in the Jacob et al. SRL test, such as the activation of task interest in the forethought phase, proceeding step-by-step in the performance and volitional control phase and initiating self-reactions in the self-reflection phase according to Zimmerman (2000), could be considered as content of new items. A more extensive test instrument could also allow SRL measurement at the level of reliable scales on the forethought phase, the performance/volitional control phase, and the self-reflection phase. This could be used in future studies of preschool SRL trainability to generate statements about which phases assumed by Zimmerman (2000) to have training-related improvements. Instruments from preschool metacognition research (e.g., Destan et al., 2014; Marulis et al., 2016) also offer potential starting points for developmental work to capture knowledge of strategies across all phases of the SRL process. For example, Marulis et al. (2016) developed an interview in which children are asked about their metacognitive knowledge related to a previously completed cognitively demanding task. A revision of this measurement instrument should include questions about motivation and cognition in addition to questions about metacognition to fully represent the components associated with SRL (Bronson, 2000).

Lastly, we would like to point out the need for a more detailed investigation of the influence of SES and verbal abilities on the development and trainability of SRL. The results of the present study can be interpreted as a first indication of the importance of these factors for the development and trainability of SRL, but repeated-measures studies using these factors as predictors rather than control variables are needed to more accurately judge their influence. The research on the influence of verbal abilities could have especially important implications for further training research on SRL and practice, as verbal abilities can be promoted directly through interventions for preschoolers (Hargrave & Sénéchal, 2000; Wasik & Hindman, 2014). It is possible that prior promotion of verbal abilities could lead to SRL trainings having particularly large effects.

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Declaration of competing interest

None.

Data availability

Data will be made available on request.

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Appendix A. Overview of the training sessions for the training group

Table A.1
Strategies and exercises to practice the strategies in the eight content sessions.

Session number	SRL strategy (action phase)	Content of frame story	Exercise task
2	Planning (forethought)	Mulle draws all his ideas for a Mother's Day gift and then marks the best idea. He decides to give her a bouquet of flowers. The flowers are in a meadow behind a fence, to which he has to dig a tunnel.	Planning for Mulle by means of colored markings on a painted collection of ideas: what tools he needs for digging, what provisions he can pack and what flowers he can pick in the meadow
3	Activating self-efficacy beliefs (forethought)	Mulle has doubts whether he can manage to dig a tunnel on his own. At night he dreams about how he succeeds in digging. He thinks of all his skills that will enable him to dig.	Reminding Mulle of past successes and his abilities by drawing pictures on a sheet of paper of those activities that Mulle is good at
4	Taking breaks and self-motivating (performance/ volitional control)	After Mulle has been digging for a while, he takes a little break, taking a deep breath. After the break, as he continues digging, he thinks of things to reward himself with after his work is done.	Perform abdominal breathing as a relaxation exercise during a break and select from a collection of cards depicting activities those that Mulle enjoys and can use as a reward after completing the tunnel
5	Dealing with deflectors (performance/ volitional control)	Mulles friends come over and want to play with him. Mulle remembers that he wants to finish digging and declines his friends' invitation.	Receiving a "stop" card to hold up when distracted to draw attention back to the activity; practicing holding it up as part of a game in which a puppet representing Mulle is moved through an

(*continued on next page*)

Table A.1 (*continued*)

Session number	SRL strategy (action phase)	Content of frame story	Exercise task
			illustration of the tunnel and the card is held up when his friends encounter him there and might distract him
6	Self-monitoring (performance/ volitional control)	While picking the flowers, Mulle ticks off on his plan which flowers he has picked.	Collecting cards lying on the floor, each with a flower on it, according to the plan from session 2 and ticking off on the plan which flowers have been collected
7	Reflecting goal achievement (self-reflection)	Mulle compares the packed food and tools and the picked bouquet of flowers with the corresponding plans he made.	Using green and red stickers to mark on the plans from session 2: what Mulle had thought of and what had been forgotten and must therefore be taken care of in the future
8	Causal attribution (self-reflection)	Mulle fails to paint a vase for the bouquet and cut the flowers. His friend tells him that this was not because of him, but because of the pens and the old scissors he used.	While listening to the story, indicating whether Mulle is responsible for the failed actions by holding up one of two cards showing Mulle pointing either toward himself or away from himself
9	All	*Instead of reading another story section aloud, all strategies Mulle had used were repeated and children were simultaneously shown the stickers they received in the corresponding training session.*	Pasting the stickers on a new illustration of the phase model in the order corresponding to the model

Appendix B. Overview of the reflection tasks in the training sessions

Table A.2
Reflection tasks on the strategies of the eight content sessions.

Session number	SRL strategy	Problem scenario	SRL strategies	Non-SRL behaviors
2	Planning	Mulle wants to find out which clothes are best for digging the tunnel.	He first draws all the clothes he has at home. Then he circles only those that are comfortable. He says to himself: "What exactly do I have to do? I need to find clothes that I can wear underground. How can I do that? By picking out clothes that are allowed to get dirty."	As a precaution, he simply puts on all the clothes he has in his closet on top of each other. He says: "Those sandals look nice I'm definitely going to take them digging."
3	Activating self-efficacy beliefs	Mulle has to look for a shovel in the tool shed. But the shed is in total chaos! Everything is lying around in a wild mess.	Mulle knows that he has found things in the shed before. Therefore, he is sure that he can also find the shovel. Mulle says to himself: "I'm good at cleaning things up. So, I'm going to clean up quickly to find the shovel!"	Mulle thinks to himself that he will certainly not be able to find the shovel easily in this chaos. So, he rather takes any other tool for digging. Mulle says to himself: "Dad should do that, he will find the shovel faster than I do."
4	Taking breaks and self-motivating	Mulle is slowly getting tired and doesn't feel like digging the tunnel anymore.	Mulle says: "So far I've done a good job. But the digging is pretty exhausting. I'm going to have a cool glass of apple juice." Mulle sits down briefly and takes a few deep breaths. This gives him new strength for digging again. Mulle says to himself: "First I have to finish digging. Business before pleasure."	Mulle continues without a break. That way, he's sure to finish faster. Mulle says: "I will just buy a bouquet of flowers for mom, that's easier." Mulle thinks long and hard about what he should do. This makes him stop digging for the time being.
5	Dealing with deflectors	While digging, Mulle's friend Juli comes and asks if they can play for a bit and then he can continue digging.	Mulle makes himself a stop card and holds it up. First, he has to finish digging. After that, there surely will be time to play. Mulle takes out his plan, which has a big 10 on it. He counts and compares again and again with the big 10 how many times he still has to shovel now.	Mulle says to his friend: "I'd like to play with you first. Pleasure before business." Mulle says: "I can also shovel more than 10 times, then I just walk the rest back."
6	Self-monitoring	Mulle is not sure how far he has already dug. He has planned in advance that he will have to dig a total of 10 times.	Mulle says to himself: "Am I doing this right? I'll shovel once now. Right. Twice. Right. Three times. Right. Until I get to 10." Mulle asks himself: "Did I do everything right? I picked a bouquet of red and blue flowers - just as I had planned!"	Mulle does not check how many times he has already shovelled. He'll get to the other side of the fence eventually. Mulle exclaims: "The bouquet smells good! So the goal is achieved."
7	Reflecting goal achievement	Mulle holds the finished bouquet in his hand. He is thinking about whether he has achieved his goal.	Mulle compares if his bouquet looks exactly like he drew it on his plan.	Mulle quickly runs home with the bouquet to give it directly to his mom. No matter if there are a few other colours in the bouquet. He says to himself: "I'm just not a good artist. I'll just ask Molly the Mouse. She draws better than I do."
8	Causal attribution	Mulle is sad because he wanted to make a card for his mom and it didn't turn out very nice.	He tells himself: "I tried very hard, so it's not my fault." He knows that the crayons were not sharpened and therefore the card did not turn out nicely.	He thinks to himself that he will never draw a card for mom again.
9	All	*Since the purpose of this session was to repeat all strategies, no further reflection task was worked on.*	–	–

Note. The order in which the four proposed solutions to each scenario were given varied between sessions.

Appendix C. Comparison of the planning session frame story for the active control group and the training group

Active control group:
"Mulle the mole has recently started practicing digging and digging tunnels, and he has been really looking forward to that. Now it's time for Mulle to dig his first tunnel, because he wants to get to the other side of the fence. There are such beautiful, colorful flowers growing there! He would love to pick them and give them to his mom for Mother's Day."

Training group:
"Today, Mulle the mole would like to dig tunnels again. But then he remembers: He still has to get a gift for his mom, because tomorrow is Mother's Day. So he sits down under a tree and thinks about what is important BEFORE work. So what he could give to his mom: "What would mom be happy about? It's best to make a plan, a gift plan." Such a plan is a great thing BEFORE work. Because plans make work easier, Dad always does that too. It will certainly be easier to find a good gift that way. Mulle gets a sheet of paper and a pen from his backpack and starts by drawing all the ideas he can think of. He draws a cake, because he could bake her a cake. He draws pencils, because he could draw her a picture. He paints a bouquet of flowers, because he could give her a bouquet of flowers. Also, he could sing her a song, make her breakfast on Sunday, or help her set the table. So, he draws all his ideas on his plan. From this, he can now pick out the best idea."

Appendix D. Overview of the SRL test

Table A.3
Scenarios and items of the SRL test in pretest and posttest (Jacob et al., 2019).

SRL strategy	Problem scenario	Test item (SRL [+] or SRL [−])
Using prior knowledge	Lennie the Lion's friend Ellie the Duck is about to start school and Lennie wants to give her something special. But what would she like? wonders Lennie the lion. How can Lennie find a great gift for Ellie the Duck?	Lennie likes building blocks himself. That's why he intends to give Ellie building blocks. Although Ellie rarely plays with building blocks. (SRL [−])
Planning	Lennie has made a decision: He would like to make a school cone for his friend. But how should Lennie begin? What should he do first?	Lennie rashly takes everything out of the craft cupboard. It does not matter whether he needs all those things. (SRL [−])
Planning	Crafting is soon going to start. What else can Lennie do before he starts crafting?	Lennie says, "I'll get right to it. It's much faster without a craft book!" (SRL [−])
Activating self-efficacy beliefs	Making a great school cone is really hard! Lennie wonders how he'll be able to do it. What else does he think about before he starts crafting?	Lennie thinks that Mollie the Mouse is way better than him at cutting things out. So maybe she should make the school cone instead. (SRL [−])
Taking breaks	Lennie is sitting down at his table to make the school cone. But phew, it's taking a really long time! How can Lennie manage to finish making the school cone?	Lennie does not take a break. He's tired, but without a break it does not take so long. (SRL [−])
Self-motivation	After a while, Lennie is not in the mood to continue crafting anymore. How can Lennie manage to keep going despite the strain?	Lennie says to himself, "I'm fed up! I just have to move on quickly!" (SRL [−])
Self-motivation	Lennie keeps crafting. But soon he notices that it's difficult for him to hang in there. What can Lennie do?	Lennie could give crayons to Ellie. Then he does not have to continue crafting. (SRL [−])
Dealing with deflectors	Lennie's friends Mollie the Mouse and Tonie the Tiger come over and want to play soccer with him. What should Lennie do?	Lennie says: "Let's go! I'm going to play along with you!" Playing soccer is more fun than doing handicrafts. (SRL [−])
Self-monitoring	Lennie really wants for his school cone to be as amazing as the one in his book. How can Lennie achieve this?	Lennie tells himself: "I don't know if I do it exactly as it is said in the craft book." It takes far too long to look it up in the craft book! (SRL [−])
Reflecting goal achievement	Finally! Lennie has made it. The school cone for his friend is finished! What should Lennie do next?	Lennie does not check whether his school cone looks correct. He puts the school cone aside quickly and walks away to play. (SRL [−])
Causal attribution	The next day, Lennie notices that a glued-on star has fallen off the school cone. What could be the reason for this?	Lennie believes he is the reason – he's just not good at doing handicrafts. (SRL [−])

Note. The version of the test that the preschoolers completed in the pretest and posttest also contained an SRL [+] item for each problem scenario. The order of which item was given first was counterbalanced and reversed for the posttest. However, due to insufficient item difficulty, the SRL [+] items were not included in the data analyses.

Appendix E. Levels of the active vocabulary factor for the analyses of hypothesis 3

Table A.4
Descriptive statistics on the pre- and posttest SRL scores separated by group and active vocabulary.

Group	*n*	SRL pretest: *M (SD)*	SRL posttest: *M (SD)*
C_AV–	6	0.33 (3.01)	−2.00 (4.86)
C_AV-	18	1.11 (3.85)	2.56 (4.09)

(*continued on next page*)

Table A.4 (*continued*)

Group	*n*	SRL pretest: *M (SD)*	SRL posttest: *M (SD)*
C_AV+	6	1.67 (3.72)	3.33 (3.20)
C_AV++	17	2.41 (3.73)	2.88 (4.66)
T_AV–	16	−3.50 (5.09)	1.00 (6.37)
T_AV-	14	0.14 (5.36)	2.29 (4.27)
T_AV+	7	−0.43 (4.28)	1.86 (5.64)
T_AV++	10	0.80 (5.85)	4.60 (4.97)

Note. C_AV– = control group, very low vocabulary, C_AV- = control group, low vocabulary, C_AV+ = control group, high vocabulary, C_AV++ = control group, very high vocabulary, T_AV– = training group, very low vocabulary, T_AV- = training group, low vocabulary, T_AV+ = training group, high vocabulary, T_AV++ = training group, very high vocabulary.
Active vocabulary (AV) is classified according to the score in the recognizing terms test: 0–5 (very low), 6–8 (low), 9 (high), 10–12 (very high).

References

Bail, F. T., Zhang, S., & Tachiyama, G. T. (2008). Effects of a self-regulated learning course on the academic performance and graduation rate of college students in an academic support program. *Journal of College Reading and Learning, 39*(1), 54–73. https://doi.org/10.1080/10790195.2008.10850312

Becker, D. R., Miao, A., Duncan, R., & McClelland, M. M. (2014). Behavioral self-regulation and executive function both predict visuomotor skills and early academic achievement. *Early Childhood Research Quarterly, 29*(4), 411–424. https://doi.org/10.1016/j.ecresq.2014.04.014

Beeby, A., Castillo, L., Fox, O., Mañas, A. G., Albir, A. H., Kuznik, A., Massana, G., Neunzig, W., Olalla, C., Inés, P. R., & Romero, L. (2015). Results of PACTE's experimental research on the acquisition of translation competence: The acquisition of declarative and procedural knowledge in translation.The dynamic translation index. *Translation Spaces, 4*(1), 29–53. https://doi.org/10.1075/ts.4.1.02bee

Berger, A., Kofman, O., Livneh, U., & Henik, A. (2007). Multidisciplinary perspectives on attention and the development of self-regulation. *Progress in Neurobiology, 82*(5), 256–286. https://doi.org/10.1016/j.pneurobio.2007.06.004

Berhenke, A. L. (2013). *Motivation, self-regulation, and learning in preschool [Doctoral dissertation, University of Michigan]*. UM Library Digital Collections. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/97992/berhenke_1.pdf?sequence=1&isAllowed=y.

Bickel, R. (2007). *Multilevel analysis for applied research: It's just regression!* Guilford Press.

Boekaerts, M., & Cascallar, E. (2006). How far have we moved toward the integration of theory and practice in self-regulation? *Educational Psychology Review, 18*(3), 199–210. https://doi.org/10.1007/s10648-006-9013-4

Bohlmann, N. L., Maier, M. F., & Palacios, N. (2015). Bidirectionality in self-regulation and expressive vocabulary: Comparisons between monolingual and dual language learners in preschool. *Child Development, 86*(4), 1094–1111. https://doi.org/10.1111/cdev.12375

Bos, W., Lankes, E.-M., Prenzel, M., Schwippert, K., Valtin, R., & Walther, G. (2007). Erste Ergebnisse aus IGLU: Schülerleistungen am Ende der vierten Jahrgangsstufe im internationalen Vergleich. Sozialwissenschaftlicher Fachinformationsdienst soFid, Bildungsforschung 2007(1), 9–46. https://www.ssoar.info/ssoar/handle/document/20171.

Bronson, M. B. (1994). The usefulness of an observational measure of young children's social and mastery behaviors in early childhood classrooms. *Early Childhood Research Quarterly, 9*(1), 19–43. https://doi.org/10.1016/0885-2006(94)90027–2

Bronson, M. B. (2000). *Self-regulation in early childhood: Nature and nurture*. Guilford Press.

Bryce, D., Whitebread, D., & Szűcs, D. (2015). The relationships among executive functions, metacognitive skills and educational achievement in 5 and 7 year-old children. *Metacognition and Learning, 10*(2), 181–198. https://doi.org/10.1007/s11409-014-9120-4

Calkins, S. D., & Howse, R. B. (2004). Individual differences in self-regulation: Implications for childhood adjustment. In P. Philippot, & R. S. Feldman (Eds.), *The regulation of emotion* (pp. 307–332). Lawrence Erlbaum Associates Publishers.

Carriedo, N., & Alonso-Tapia, J. (1996). Main idea comprehension: Training teachers and effects on students. *Journal of Research in Reading, 19*(2), 128–153. https://doi.org/10.1111/j.1467-9817.1996.tb00093.x

Carver, C. S., & Scheier, M. F. (2017). Self-regulation of action and affect. In K. D. Vohs, & R. F. Baumeister (Eds.), *Handbook of self-regulation: Research, theory, and applications* (3rd ed., pp. 3–23). Guilford Press.

Castro, S. L. (2002). Data analytic methods for the analysis of multilevel questions: A comparison of intraclass correlation coefficients, rwg(j), hierarchical linear modeling, within- and between-analysis, and random group resampling. *The Leadership Quarterly, 13*(1), 69–93. https://doi.org/10.1016/S1048-9843(01)00105-9

Causadias, J. M., Salvatore, J. E., & Sroufe, L. A. (2012). Early patterns of self-regulation as risk and promotive factors in development: A longitudinal study from childhood to adulthood in a high-risk sample. *International Journal of Behavioral Development, 36*(4), 293–302. https://doi.org/10.1177/0165025412444076

Coughlin, C., Hembacher, E., Lyons, K. E., & Ghetti, S. (2015). Introspection on uncertainty and judicious help-seeking during the preschool years. *Developmental Science, 18*(6), 957–971. https://doi.org/10.1111/desc.12271

Davis, H., Valcan, D. S., & Pino-Pasternak, D. (2021). The relationship between executive functioning and self-regulated learning in Australian children. *British Journal of Developmental Psychology, 39*(4), 625–652. https://doi.org/10.1111/bjdp.12391

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology/Psychologie Canadienne, 49*(3), 182–185. https://doi.org/10.1037/a0012801/

Destan, N., Hembacher, E., Ghetti, S., & Roebers, C. M. (2014). Early metacognitive abilities: The interplay of monitoring and control processes in 5-to 7-year-old children. *Journal of Experimental Child Psychology, 126*, 213–228. https://doi.org/10.1016/j.jecp.2014.04.001

Dignath, C., Buettner, G., & Langfeldt, H.-P. (2008). How can primary school students learn self-regulated learning strategies most effectively?: A meta-analysis on self-regulation training programmes. *Educational Research Review, 3*(2), 101–129. https://doi.org/10.1016/j.edurev.2008.02.003

Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. *Metacognition and Learning, 3*(3), 231–264. https://doi.org/10.1007/s11409-008-9029-x

Dignath-van Ewijk, C., Fabriz, S., & Büttner, G. (2015). Fostering self-regulated learning among students by means of an electronic learning diary: A training experiment. *Journal of Cognitive Education and Psychology, 14*(1), 77–97. https://doi.org/10.1891/1945-8959.14.1.77

Dörr, L., & Perels, F. (2019). Improving metacognitive abilities as an important prerequisite for self-regulated learning in preschool children. *International Electronic Journal of Elementary Education, 11*(5), 449–459. https://doi.org/10.26822/iejee.2019553341

Dörr, L., & Perels, F. (2020). Improving young children's self-regulated learning using a combination of direct and indirect interventions. *Early Child Development and Care, 190*(16), 2581–2593. https://doi.org/10.1080/03004430.2019.1595608

Dörrenbächer, L., & Perels, F. (2016). More is more? Evaluation of interventions to foster self-regulated learning in college. *International Journal of Educational Research, 78*, 50–65. https://doi.org/10.1016/j.ijer.2016.05.010

Drexl, D., Höke, J., Rehm, A., Schumann, I., & Sturmhöfel, N. (2012). Kindergarten und Grundschule gemeinsam denken? Didaktische Ansätze und systembedingte Verschiedenheit. *Diskurs Kindheits- und Jugendforschung, 7*(4), 443–455.

Farmus, L., Arpin-Cribbie, C. A., & Cribbie, R. A. (2019). Continuous predictors of pretest-posttest change: highlighting the impact of the regression artifact. *Frontiers in Applied Mathematics and Statistics, 4*, 64. https://doi.org/10.3389/fams.2018.00064

Ganzeboom, H. B., De Graaf, P. M., & Treiman, D. J. (1992). A standard international socio-economic index of occupational status. *Social Science Research, 21*(1), 1–56. https://doi.org/10.1016/0049-089X(92)90017-B

González-Pienda, J. A., Fernández, E., Bernardo, A., Núñez, J. C., & Rosário, P. (2014). Assessment of a self-regulated learning intervention. *The Spanish Journal of Psychology, 17*, E12. https://doi.org/10.1017/sjp.2014.12

Hamilton, B. L. (1977). An empirical investigation of the effects of heterogeneous regression slopes in analysis of covariance. *Educational and Psychological Measurement, 37*(3), 701–712.

Hanley, J. R., Cortis, C., Budd, M.-J., & Nozari, N. (2016). Did I say dog or cat? A study of semantic error detection and correction in children. *Journal of Experimental Child Psychology, 142*, 36–47. https://doi.org/10.1016/j.jecp.2015.09.008

Hargrave, A. C., & Sénéchal, M. (2000). A book reading intervention with preschool children who have limited vocabularies: The benefits of regular reading and dialogic reading. *Early Childhood Research Quarterly, 15*(1), 75–90. https://doi.org/10.1016/S0885-2006(99)00038-1

Harris, K. R. (1990). Developing self-regulated learners: The role of private speech and self-instructions. *Educational Psychologist, 25*(1), 35–49. https://doi.org/10.1207/s15326985ep2501_4

Heck, R. H., Thomas, S. L., & Tabata, L. N. (2013). *Multilevel and longitudinal modeling with IBM SPSS* (2nd ed.). Routledge. https://doi.org/10.4324/9780203701249

Hendrix, L. J., Carter, M. W., & Hintze, J. L. (1978). A comparison of five statistical methods for analyzing pretest-posttest designs. *The Journal of Experimental Education, 47*(2), 96–102. https://doi.org/10.1080/00220973.1978.11011664

Hentges, R. F., Shaw, D. S., & Wang, M. T. (2018). Early childhood parenting and child impulsivity as precursors to aggression, substance use, and risky sexual behavior in adolescence and early adulthood. *Development and Psychopathology, 30*(4), 1305–1319. https://doi.org/10.1017/S0954579417001596

Hooper, S. R., Roberts, J. E., Nelson, L., Zeisel, S., & Kasambira Fannin, D. (2010). Preschool predictors of narrative writing skills in elementary school children. *School Psychology Quarterly, 25*(1), 1–12. https://doi.org/10.1037/a0018329

Huang, F. L., Moon, T. R., & Boren, R. (2014). Are the reading rich getting richer? Testing for the presence of the Matthew effect. *Reading & Writing Quarterly, 30*(2), 95–115. https://doi.org/10.1080/10573569.2013.789784

Jacob, L., Benick, M., Dörrenbächer, S., & Perels, F. (2020). Promoting self-regulated learning in preschoolers. *Journal of Childhood, Education & Society, 1*(2), 116–140. https://doi.org/10.37291/2717638X.20201237

Jacob, L., Dörrenbächer, S., & Perels, F. (2019). A pilot study of the online assessment of self-regulated learning in preschool children: Development of a direct, quantitative measurement tool. *International Electronic Journal of Elementary Education, 12*(2), 115–126. https://doi.org/10.26822/iejee.2019257655

Jahromi, L. B., & Stifter, C. A. (2008). Individual differences in preschoolers'self-regulation and theory of mind. *Merrill-Palmer Quarterly, 54*(1), 125–150.

Jeong, J., & Frye, D. (2020). Self-regulated learning: Is understanding learning a first step? *Early Childhood Research Quarterly, 50*, 17–27. https://doi.org/10.1016/j.ecresq.2018.12.007

Kaplan, A. (2008). Clarifying metacognition, self-regulation, and self-regulated learning: What's the purpose? *Educational Psychology Review, 20*(4), 477. https://doi.org/10.1007/s10648-008-9087-2

Kelley, W. M., Wagner, D. D., & Heatherton, T. F. (2015). In search of a human self-regulation system. *Annual Review of Neuroscience, 38*, 389–411. https://doi.org/10.1146/annurev-neuro-071013-014243

Kim, S., & Nor, M. (2019). The effects of self-regulated learning strategies on preschool children's self-efficacy and performance in early writing. *International Journal of Education, 11*(2), 99–108. https://www.learntechlib.org/p/208997/.

Kipman, U. (2018). Einflussfaktoren auf die leistung in kombinatorik. In U. Kipman (Ed.), *Problemlösen* (pp. 139–150). Springer. https://doi.org/10.1007/978-3-658-22370-0_7.

Kochanska, G., Murray, K. T., & Harlan, E. T. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology, 36*(2), 220–232. https://doi.org/10.1037/0012-1649.36.2.220

Lee, K., Bull, R., & Ho, R. M. H. (2013). Developmental changes in executive functioning. *Child Development, 84*(6), 1933–1953. https://doi.org/10.1111/cdev.12096

Lee, K., & Ewert, A. (2013). Adventure programs and diverse family styles. *Journal of Experiential Education, 36*(2), 123–138. https://doi.org/10.1177/1053825913487886

Lövdén, M., Bäckman, L., Lindenberger, U., Schaefer, S., & Schmiedek, F. (2010). A theoretical framework for the study of adult cognitive plasticity. *Psychological Bulletin, 136*(4), 659–676. https://doi.org/10.1037/a0020080

Maas, C. J. M., & Hox, J. J. (2005). Sufficient sample sizes for multilevel modeling. *Methodology, 1*(3), 86–92. https://doi.org/10.1027/1614-2241.1.3.86

Marulis, L. M., & Nelson, L. J. (2021). Metacognitive processes and associations to executive function and motivation during a problem-solving task in 3–5 year olds. *Metacognition and Learning, 16*(1), 207–231. https://doi.org/10.1007/s11409-020-09244-6

Marulis, L. M., Palincsar, A. S., Berhenke, A. L., & Whitebread, D. (2016). Assessing metacognitive knowledge in 3–5 year olds: The development of a metacognitive knowledge interview (McKI). *Metacognition and Learning, 11*(3), 339–368. https://doi.org/10.1007/s11409-016-9157-7

McClelland, M. M., Cameron, C. E., Duncan, R., Bowles, R. P., Acock, A. C., Miao, A., & Pratt, M. E. (2014). Predictors of early growth in academic achievement: The head-toes-knees-shoulders task. *Frontiers in Psychology, 5*, 599. https://doi.org/10.3389/fpsyg.2014.00599

McDermott, P. A., Leigh, N. M., & Perry, M. A. (2002). Development and validation of the preschool learning behaviors scale. *Psychology in the Schools, 39*(4), 353–365. https://doi.org/10.1002/pits.10036

McNamara, D. S., & Kintsch, W. (1996). Learning from texts: Effects of prior knowledge and text coherence. *Discourse Processes, 22*(3), 247–288. https://doi.org/10.1080/01638539609544975

McWayne, C. M., Fantuzzo, J. W., & McDermott, P. A. (2004). Preschool competency in context: An investigation of the unique contribution of child competencies to early academic success. *Developmental Psychology, 40*(4), 633–645. https://doi.org/10.1037/0012-1649.40.4.633

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., Houts, R., Poulton, R., Roberts, B. W., Ross, S., Sears, M. R., Thomson, W. M., & Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences, 108*(7), 2693–2698. https://doi.org/10.1073/pnas.1010076108

Montroy, J. J., Bowles, R. P., Skibbe, L. E., McClelland, M. M., & Morrison, F. J. (2016). The development of self-regulation across early childhood. *Developmental Psychology, 52*(11), 1744–1762. https://doi.org/10.1037/dev0000159

Pandey, A., Hale, D., Das, S., Goddings, A.-L., Blakemore, S.-J., & Viner, R. M. (2018). Effectiveness of universal self-regulation-based interventions in children and adolescents: A systematic review and meta-analysis. *JAMA Pediatrics, 172*(6), 566–575. https://doi.org/10.1001/jamapediatrics.2018.0232

Perels, F., Dörrenbächer-Ulrich, L., Landmann, M., Otto, B., Schnick-Vollmer, K., & Schmitz, B. (2020). Selbstregulation und selbstreguliertes lernen. In E. Wild, & J. Möller (Eds.), *Pädagogische psychologie* (pp. 45–66). Springer. https://doi.org/10.1007/978-3-662-61403-7_3.

Perels, F., Merget-Kullmann, M., Wende, M., Schmitz, B., & Buchbinder, C. (2009). Improving self-regulated learning of preschool children: Evaluation of training for kindergarten teachers. *British Journal of Educational Psychology, 79*(2), 311–327. https://doi.org/10.1348/000709908X322875

Perry, N. E., VandeKamp, K. O., Mercer, L. K., & Nordby, C. J. (2002). Investigating teacher-student interactions that foster self-regulated learning. *Educational Psychologist, 37*(1), 5–15. https://doi.org/10.1207/S15326985EP3701_2

Pfost, M., Hattie, J., Dörfler, T., & Artelt, C. (2014). Individual differences in reading development: A review of 25 years of empirical research on Matthew effects in reading. *Review of Educational Research, 84*(2), 203–244. https://doi.org/10.3102/0034654313509492

Ponitz, C. C., McClelland, M. M., Matthews, J. S., & Morrison, F. J. (2009). A structured observation of behavioral self-regulation and its contribution to kindergarten outcomes. *Developmental Psychology, 45*(3), 605–619. https://doi.org/10.1037/a0015365

Ready, D. D. (2010). Socioeconomic disadvantage, school attendance, and early cognitive development: The differential effects of school exposure. *Sociology of Education, 83*(4), 271–286. https://doi.org/10.1177/0038040710383520

Ricken, G., Fritz, A., Schuck, K. D., & Preuß, U. (Eds.). (2007). *HAWIVA-III. Hannover-Wechsler-Intelligenztest für das Vorschulalter*. Huber.

Robson, D. A., Allen, M. S., & Howard, S. J. (2020). Self-regulation in childhood as a predictor of future outcomes: A meta-analytic review. *Psychological Bulletin, 146*(4), 324–354. https://doi.org/10.1037/bul0000227

Sasser, T. R., Bierman, K. L., & Heinrichs, B. (2015). Executive functioning and school adjustment: The mediational role of pre-kindergarten learning-related behaviors. *Early Childhood Research Quarterly, 30*(1), 70–79. https://doi.org/10.1016/j.ecresq.2014.09.001

Schiff, R., Nuri Ben-Shushan, Y., & Ben-Artzi, E. (2016). Metacognitive strategies: A foundation for early word spelling and reading in kindergartners with SLI. *Journal of Learning Disabilities, 50*(2), 143–157. https://doi.org/10.1177/0022219415589847

Schmider, E., Ziegler, M., Danay, E., Beyer, L., & Bühner, M. (2010). Is it really robust? Reinvestigating the robustness of ANOVA against violations of the normal distribution assumption. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences, 6*(4), 147–151. https://doi.org/10.1027/1614-2241/a000016

Schmitt, S. A., McClelland, M. M., Tominey, S. L., & Acock, A. C. (2015). Strengthening school readiness for head start children: Evaluation of a self-regulation intervention. *Early Childhood Research Quarterly, 30*(1), 20–31. https://doi.org/10.1016/j.ecresq.2014.08.001

Schneider, B. A., Avivi-Reich, M., & Mozuraitis, M. (2015). A cautionary note on the use of the analysis of covariance (ANCOVA) in classification designs with and without within-subject factors. *Frontiers in Psychology, 6*, 474. https://doi.org/10.3389/fpsyg.2015.00474

Schneider, W. (2008). The development of metacognitive knowledge in children and adolescents: Major trends and implications for education. *Mind, Brain, and Education, 2*(3), 114–121. https://doi.org/10.1111/j.1751-228X.2008.00041.x

Shing, Y. L., Lindenberger, U., Diamond, A., Li, S.-C., & Davidson, M. C. (2010). Memory maintenance and inhibitory control differentiate from early childhood to adolescence. *Developmental Neuropsychology, 35*(6), 679–697. https://doi.org/10.1080/87565641.2010.508546

Skibbe, L. E., Montroy, J. J., Bowles, R. P., & Morrison, F. J. (2019). Self-regulation and the development of literacy and language achievement from preschool through second grade. *Early Childhood Research Quarterly, 46*(1), 240–251. https://doi.org/10.1016/j.ecresq.2018.02.005

Statistisches Bundesamt. (2020). *Betreuungsquote von Kindern unter 6 Jahren nach Bundesländern*. March 1. DESTATIS. Statistisches Bundesamt https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Soziales/Kindertagesbetreuung/Tabellen/betreuungsquote-2018.html.

Sweet, S. A., & Grace-Martin, K. A. (2010). *Data analysis with SPSS: A first course in applied statistics* (4th ed.). Pearson.

Vazire, S. (2010). Who knows what about a person? The self–other knowledge asymmetry (SOKA) model. *Journal of Personality and Social Psychology, 98*(2), 281–300. https://doi.org/10.1037/a0017908

Venitz, L., & Perels, F. (2019). The promotion of self-regulated learning by kindergarten teachers: Differential effects of an indirect intervention. *International Electronic Journal of Elementary Education, 11*(5), 437–448.

Vohs, K. D., & Baumeister, R. F. (2004). Understanding self-regulation: An introduction. In R. F. Baumeister, & K. D. Vohs (Eds.), *Handbook of self-regulation. Research, theory and applications* (pp. 1–9). Guilford Press.

Wang, Y., & Sperling, R. A. (2020). Characteristics of effective self-regulated learning interventions in mathematics classrooms: A systematic review. *Frontiers in Education, 5*, 58. https://doi.org/10.3389/feduc.2020.00058

Wanless, S. B., Kim, K. H., Zhang, C., Degol, J. L., Chen, J. L., & Chen, F. M. (2016). Trajectories of behavioral regulation for Taiwanese children from 3.5 to 6 years and relations to math and vocabulary outcomes. *Early Childhood Research Quarterly, 34*(1), 104–114. https://doi.org/10.1016/j.ecresq.2015.10.001

Wasik, B. A., & Hindman, A. H. (2014). Understanding the active ingredients in an effective preschool vocabulary intervention: An exploratory study of teacher and child talk during book reading. *Early Education and Development, 25*(7), 1035–1056. https://doi.org/10.1080/10409289.2014.896064

Wolters, C. A., & Benzon, M. B. (2013). Assessing and predicting college students' use of strategies for the self-regulation of motivation. *The Journal of Experimental Education, 81*(2), 199–221. https://doi.org/10.1080/00220973.2012.699901

Woodward, L. J., Lu, Z., Morris, A. R., & Healey, D. M. (2017). Preschool self regulation predicts later mental health and educational achievement in very preterm and typically developing children. *The Clinical Neuropsychologist, 31*(2), 404–422. https://doi.org/10.1080/13854046.2016.1251614

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). Academic Press. https://doi.org/10.1016/B978-012109890-2/50031-7.

Zimmerman, B. J., & Schunk, D. H. (Eds.). (2011). *Handbook of self-regulation of learning and performance*. Routledge/Taylor & Francis Group.

Zuffianò, A., Alessandri, G., Gerbino, M., Luengo Kanacri, B. P., Di Giunta, L., Milioni, M., & Caprara, G. V. (2013). Academic achievement: The unique contribution of self-efficacy beliefs in self-regulated learning beyond intelligence, personality traits, and self-esteem. *Learning and Individual Differences, 23*, 158–162. https://doi.org/10.1016/j.lindif.2012.07.010