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Profiles of self-regulation in elementary grades: Relations to math and reading skills☆

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ABSTRACT

This longitudinal study investigated the development of cognitive and behavioral aspects of self-regulation and their relations to math and reading skills at the beginning of elementary school. Planning and task-persistent behavior (as the cognitive and behavioral aspects of self-regulation) were assessed in the classroom context. Participants were 775 children (mean age at the beginning of school 7.46, $SD = 0.52$). Using a person-oriented approach, five developmental profile groups of self-regulation were differentiated. The results showed that the development of the cognitive and behavioral asrpects of self-regulation varies individually and that the associations between the cognitive and behavioral aspects of self-regulation differ at different time-points. Math and reading skills at the end of Grade 3 differed between these profile groups – the explained variance was greater for complex math and reading tasks (problem solving, reading comprehension) compared to the less complex tasks (calculation, word reading fluency).

Self-regulation skills that control and direct one's attention, thoughts, emotions and actions (McClelland & Cameron, 2012) contribute to children's academic outcomes across different age groups (Blair & Razza, 2007; Bull, Espy, & Wiebe, 2008; McClelland, Acock, Piccinin, Rhea, & Stallings, 2013; McClelland et al., 2014; Neuenschwander, Röthlisberger, Cimeli, & Roebers, 2012; Rueda, Checa, & Rothbart, 2010). Although self-regulation is a multidimensional construct with interrelated cognitive, emotional and behavioral components (Liew, 2012; McClelland & Cameron, 2011), these different components have often been studied in isolation. The focus of our study is on cognitive and behavioral components of self-regulation, which provide a foundation for adaptation in learning environment and are critical for early school success (Blair & Razza, 2007; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; McClelland et al., 2013). Cognitive self-regulation is known from studies of executive functions in the field of neuroscience and cognitive psychology; whereas behavioral self-regulation has been often explored in terms of temperament based effortful control in developmental, personal and educational psychology (McClelland & Cameron, 2011; Rueda et al., 2010). Cognitive and behavioral self-regulation should be viewed as mutually complementary constructs in order to better understand their role in learning and achievement (Liew, 2012; Neuenschwander et al., 2012). At the same time, cognitive and behavioral self-regulation may show differences and individual variation in their developmental trajectories (Hughes & Ensor, 2011; Li-Grining, Votruba-Drzal, Maldonando-Carreño, & Haas, 2010; Mägi et al., 2013; Romine & Reynolds, 2005; Zhou et al., 2007).

Mainly variable-oriented and correlational methods have been used when examining cognitive and behavioral aspects of self-regulation together (Blair, 2003; Brock et al., 2009; Fuchs et al., 2005; Neuenschwander et al., 2012). Thus, the possibility that subgroups of individuals may show profiles with different associations and interrelations between cognitive and behavioral aspects of self-regulation has rarely been taken into account. It is unclear how the cognitive aspects of self-regulation (often referred to as executive functions, executive control or cognitive control) and behavioral manifestations of self-regulation in classrooms (e.g. effortful control and the largely overlapping constructs like effortful engagement, attentional control or task-persistent behavior) are related and function as a coherent set within an individual across time. A pattern-centered analysis is critical in understanding the role of different aspects of self-regulation for learning and for possible interventions (Lan, Legare, Ponitz, Li, & Morrison, 2011).

Accordingly, this study employed a person-oriented approach (Bergman, Magnusson, & El-Khouri, 2003) to identify groups of children

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with different profiles of planning skills (a cognitive aspect of self-regulation) and task persistence (a behavioral aspect of self-regulation) at the beginning of school. We also investigated how the different self-regulation profiles are linked to math and reading skills in varying complexity. First and second grade children were chosen because the start of school sets high demands on children's self-regulation, and both the planning and task persistence show developmental changes during this period (Anderson, 2002; Aunola, Nurmi, Lerkkanen, & Rasku-Puttonen, 2003; Best, Miller, & Naglieri, 2011; Dally, 2006). Pre-skills were measured at the beginning of school and assessment of math and reading skills was carried out in the third grade because the academic difficulties can be already observed by this time (Culbertson & Edmonds, 2004).

1.1. Cognitive self-regulation and children's academic skills

Cognitive self-regulation encompasses higher-order cognitive processes that are collectively referred to as executive functions and needed for controlling, directing and coordinating one's thinking and behavior (Diamond, 2013; Miyake et al., 2000). Debate about conceptualization and components of executive functions is still ongoing (see summary of various models, definitions and elements of executive functions in Goldstein, Naglieri, Princiotta, & Otero, 2014; McCloskey & Perkins, 2013). Yet, researchers agree that executive functions engage in self-regulation and goal directed behavior via distinct and interrelated processes such as working memory, inhibition and attention (Hofmann, Schmeichel, & Baddeley, 2012; Liew, 2012; Miyake et al., 2000). These executive components are involved in planning (Baron, 2004; Chung, Weyandt, & Swentosky, 2014; Miyake et al., 2000) which is a complex higher-order executive function tied to cognitive control (Das, Naglieri, & Kirby, 1994; Luria, 1973) and reflects the combined contribution of different executive components.

A number of studies have shown the importance of planning in academic achievement, including math (Blair & Razza, 2007; McClelland et al., 2007; Monette, Bigras, & Guay, 2011) and reading (Sikora, Haley, Edwards, & Butler, 2002). Moreover, longitudinal research suggests bidirectional relations between planning and math or reading (Bull et al., 2008; Geary, Hoard, & Nugent, 2012; Locascio, Mahone, Eason, & Cutting, 2010; Mazzocco & Kover, 2007; Reiter, Tucha, & Lange, 2005; Sikora et al., 2002). Some authors propose that complex executive functions such as planning are related to computation (Naglieri & Johnson, 2000), learning of basic facts (Kroesbergen, Van Luit, & Naglieri, 2003), word reading and reading comprehension (Eason, Goldberg, Cutting, Young, & Geist, 2012; Sesma, Mahone, Levine, Eason, & Cutting, 2009). Further, Sesma et al. (2009) demonstrated that planning ability contributes significantly to reading comprehension, but not to single word reading. Differences in findings about the role of planning can be explained by the complexity of the tasks (Davies, 2005). For example, decoding the letters and reading one-syllable words, summing up one-digit numbers or finding a picture-pair of identical objects are rather simple tasks and can be solved in working memory. More complex and challenging tasks, such as reading and comprehending text, carrying out a mental transformation from words, selecting and applying an appropriate strategy or following rules, require besides working memory also planning and inhibition (Marton, 2008; Zevenbergen, Dole, & Wright, 2004). Thus, planning may be more important for comprehension of more complex texts (Eason et al., 2012). Best et al. (2011) reported variations in relationships between different planning and academic tasks – the correlations were stronger with math problem solving and text comprehension tasks than with calculation or word reading tasks. Similar effect of executive functions on word problem solving but not calculation was shown by Jõgi and Kikas (2015). In contrast, in a study with third graders, the effect of planning alongside other cognitive functions on different math domains (tasks related to recalling, computing, word problems and problems solving) was not confirmed (Männamaa, Kikas, Peets, & Palu, 2012).

1.2. Behavioral self-regulation and academic skills

The actual skill of consciously controlling one's behavior – behavioral self-regulation – is developing during the preschool and school years with the capacities of effortful control (Rothbart & Hwang, 2005). Effortful control is temperament-based and refers to voluntary control over approach (activation) or withdrawal (inhibition) behavioral tendencies via attentional (shifting and focusing) and inhibitory control mechanisms (Bridgett, Oddi, Laake, Murdock, & Bachmann, 2012; Eisenberg, Spinrad, & Eggum, 2010; Lengua, Bush, Long, Kovacs, & Trancik, 2008; Rothbart & Bates, 2006). Thus, effortful control comprises the outward manifestation of executive functions in real-world behavior (McClelland, 2012, 2014).

Rothbart and Hwang (2005) have proposed that an important aspect of effortful control is the ability to persist at task. Task-persistent behavior is most relevant in learning and classroom contexts where children are constantly faced with the need to inhibit or activate motivation- and emotion driven behavioral responses to teachers' instructional demands and learning tasks. It reflects the child's capacity to engage consistently in challenging tasks without losing focus or becoming irritable even in the presence of internal and external distractions (Drake, Pelsky, Pasco, & Fearon, 2014). By resisting distraction, managing frustration, focusing attention, and persisting at a difficult task, children with better self-regulatory abilities are more likely to experience a sense of efficacy in dealing with challenge, gain greater intrinsic (satisfaction) and extrinsic rewards (e.g., praise) from their successes and manage more effectively the emotions associated with setbacks (Drake et al., 2014). These kinds of experiences are likely to increase their motivation to engage in learning.

A number of studies have shown the importance of task persistence and the related constructs (e.g., task-focused behavior, inattentive behavior, effortful engagement, low task avoidance) for academic outcomes in math (Aunola et al., 2003; Fuchs et al., 2005, 2006, 2014; Hirvonen, Tolvanen, & Nurmi, 2012; Kikas, Peets, Palu, & Afanasjev, 2009; Mägi, Häidkind, & Kikas, 2010; Lan et al., 2011; Li-Grining et al., 2010; Onatsu-Arvilommi & Nurmi, 2000) and reading (Aunola, Nurmi, Niemi, Lerkkanen, & Rasku-Puttonen, 2002; Georgiou, Manolitsis, Nurmi, & Parrila, 2010; Hirvonen, Georgiou, Lerkkanen, Aunola, & Nurmi, 2010; Li-Grining et al., 2010; Onatsu-Arvilommi & Nurmi, 2000). However, the reverse is also true – better academic skills increase the likelihood that children stay on task when faced with obstacles (Aunola et al., 2003; Dally, 2006; Hughes, Luo, Kwok, & Loyd, 2008; Onatsu-Arvilommi & Nurmi, 2000). Hughes et al. (2008) have argued that children, who are not able to persist at difficult tasks, face difficulties in learning, may become discouraged and develop learned helplessness, which leads to even lower effort and engagement in learning.

There is some evidence that the effect of task persistence on skill development may depend on the complexity of the skill. Georgiou et al. (2011, 2010) have found that task-focused behavior is a stronger predictor of spelling skills and reading comprehension than reading fluency. Similarly for math, Fuchs et al. (2006) showed that teacher rated inattentive behavior was a stronger predictor for algorithmic computation compared to single-digit arithmetic. Further, Jõgi and Kikas (2015) found that task persistence predicted word problem solving but not calculation skills.

1.3. Developmental changes in self-regulation at the beginning of school

The child's cognitive and behavioral self-regulation capacity and skills such as working independently, inhibiting inappropriate behaviors, focusing on task, ignoring distractors, choosing and controlling relevant information, following teacher's instructions, learning to use strategies to complete the tasks are challenged in the transition to formal school environment (Dawson & Guare, 2010). There is evidence