Self-regulation in ethnic minority children : associations with academic performance and the transition to formal schooling

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General introduction

Self-regulation and academic performance

Self-regulation plays an important role in the development of children's social and academic competence (Blair & Peters, 2003). Although there is a variety of definitions for the construct, it generally refers to the capacity to control and manage one's attention, thoughts, emotions, and behaviors for goal-directed actions (McClelland & Cameron, 2011). Self-regulatory capacities help one to sustain a positive sense of self, maintain good social interactions and to succeed at school or work (Blair & Diamond, 2008). Executive function that forms the cognitive basis of self-regulation (i.e., attention, memory skills, planning skills) has been found to make the process of learning more efficient, resulting in larger gains in reading and math development (Blair, & Razza, 2007; Welsh Nix, Blair, Bierman, & Nelson, 2010). Likewise, children who are able to regulate their motivation and engagement in classroom contexts have more positive relationships with teachers and peers, which increases school liking and commitment (Swanson, Valiente, & Lemery-Chalfant, 2012; Valiente, Lemery-Chalfant, Swanson, & Reiser, 2008). In the last decade, empirical evidence supporting the link between children's self-regulation and academic achievement has increased substantially (e.g., Best, Miller, & Naglieri, 2011; Bull & Scerif, 2001; McClelland et al., 2007), however, there are few studies focusing on this relation in ethnic minority children (e.g., McClelland, & Wanless, 2012; Welsh et al., 2010), who are considered to be academically at-risk (Andriessen & Phalet, 2002; Magnuson & Duncan, 2006). The current dissertation aims to provide more insight into the association between self-regulation and academic performance in Turkish minority children in the Netherlands.

Cognitive self-regulation

Traditionally, self-regulation has been studied either from a cognitive or behavioral/temperamental approach (Zhou, Chen, & Main, 2011). The cognitive approach to self-regulation focuses on executive function (EF) or cognitive control, indicating a set of higher-order, top-down cognitive processes needed for planning, problem-solving and goal-directed behavior (Carlson, 2003). For preschoolers, a unitary, single EF construct has been proposed due to the fact that the EF components between the ages two and six years are not yet clearly differentiated (Garon, Bryson, & Smith, 2008; Wiebe, Espy, & Charak, 2008; Wiebe et al., 2011). For school-age children and adolescents on the other hand, different theoretical conceptualizations have been proposed. The multiple-components model has been most widely used (Davidson, Amso, Anderson, & Diamond, 2006; Huizinga, Dolan, & Van der Molen, 2006; Lehto, Juujarvi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000; Van der Sluis, De Jong, & Van der Leij, 2007). According to this framework, the EF consists of three related but distinct components, which are inhibition of dominant or prepotent responses, updating and monitoring of working memory representations, and shifting between mental tasks (i.e., cognitive flexibility).

Instruments assessing executive function are mostly performance-based tasks. For instance, participants are asked to perform the opposite of a dominant response (e.g., naming the word “red” printed in blue ink on the Stroop task), to hold and manipulate information in a purposeful way (e.g., to repeat digits in the opposite order on a backward digit span task), and to take a new perspective by switching a previously learned mindset to a new one in the face of changing conditions (e.g., to sort cards according to different properties of objects such as color, shape or number on a card sorting task). Performance on inhibition and working memory tasks in particular consistently relates to performance in math and reading (Blair & Razza, 2007; Bull & Scerif, 2001; St. Clair-Thompson & Gathercole, 2006). Cognitive flexibility, on the other hand, has not been consistently linked to academic performance (Espy et al., 2004; Van der Sluis et al., 2007). Therefore, a systematic investigation regarding the association between cognitive flexibility (interchangeably used with shifting or flexible thinking in the current dissertation) and academic performance is needed.

Behavioral self-regulation

The behavioral or temperamental approach to self-regulation focuses on effortful control, which is defined as the capacity to control approach and withdrawal behavioral tendencies via attentional and inhibitory control (Rothbart & Bates, 2006). The construct is mostly assessed by temperament questionnaires filled out by parents or teachers (e.g., Children’s Behavior Questionnaire [CBQ], Putnam & Rothbart, 2006; Early Adolescent Temperament Questionnaire [EATQ], Capaldi & Rothbart, 1992) or behavioral measures of delay of gratification (Kochanska, Murray, & Harlan, 2000). There are some studies showing that adult reports and behavioral measures of effortful control are related to children’s school success (e.g., Blair & Razza, 2007; Valiente, Lemery-Chalfant, & Castro, 2007; Valiente et al., 2008). It has been argued that children with high effortful control are more able to sustain their motivation and attention for goal-directed learning, which promotes academic achievement (Meece, Anderman, & Anderman, 2006). A recent study revealed that the association between effortful control and academic achievement is fully mediated by children’s social competence, which refers to a set of skills needed to adjust to social standards, suppress inappropriate behavior and maintain positive interactions with friends in elementary school years (Valiente et al., 2011). In addition, early effortful control predicts later self-efficacy (Liew, McTigue, Barrois, & Hughes, 2008), which is defined as an individual’s beliefs and perceptions of their own competence to achieve a goal (Bandura, 1977). Self-efficacy is reciprocally related to academic achievement (Marsh, Trautwein, Ludtke, Koller, & Baumert, 2005) as well as to motivation, and persistence (Bandura, 1977). Overall, the findings highlight the importance of effortful control for psychosocial well-being and the neccessity of taking psychosocial competence into account in examining the links between self-regulatory capacities and school success.

Self-regulation across development

Self-regulatory capacities show a gradual development from infancy (Bernier, Carlson & Whipple, 2010) into adolescence (Crone, 2009), and the major gains occur in the preschool years (Wiebe, Espy, & Charak, 2008; Wiebe et al., 2011). By the age of five, children are able to perform complex problem solving tasks (e.g., "If it is the color game, put the red square here; but if it is the shape game, put the red square there.") that require cognitive control (Best & Miller, 2010; Müller, Liebermann, Frye, & Zelazo, 2008). The maturation of the prefrontal cortex, which is the brain region responsible for self-control, is highly dependent on social experience (Hughes, 2011). In other words, starting from the early years of life, self-regulatory capacities shape how individuals function in daily life, but they are also shaped by what they experience. There is growing evidence that the development of self-regulatory capacities is influenced by parenting practices (Conway & Stifter, 2012; Dilworth-Bart, Poehlmann, Hilgendorf, Miller, & Lambert, 2010), qualities of the home environment and economic resources (Noble, Farah, & McCandliss, 2006; Noble, McCandliss, & Farah, 2007; Sarsour et al., 2011), and cultural values (Lewis et al., 2009). Likewise, the transition to formal schooling, which is a critical developmental milestone for cognitive development, shapes the unfolding of children's executive function (Hughes, Ensor, Wilson, & Graham, 2010). In this period, children are exposed to new rules and expectations that are substantially different from those at home and kindergarten. The transition to formal education is also characterized by changes in context and content of learning. There are large individual differences in self-regulatory capacities when children start elementary school. Some argued that children who are less equipped may catch up with their more equipped peers in cognitive control across the school transition (Hughes et al., 2010). In this regard, the school transition seems to be a critical period of life as it may help children to improve their self-regulatory capacities, which in turn affect their long-term academic trajectories.

Self-regulation in ethnic minority children

As a group ethnic minority children grow up in a different sociocultural context compared to majority middle class children. They are exposed to limited socieconomic resources, acculturative challenges, and socially and psychologically segregated living conditions even if social mobility is possible, which put them at risk for a number of cognitive, emotional and educational outcomes (Garcia Coll et al., 1996). Developmental processes cannot be considered independent from the dynamic interaction between the child and the socioeconomic context in which he grows up (Raver, 2004). Examining self-regulation in children growing up under conditions of risk is critical for understanding adaptive and maladaptive functioning (Lengua, Bush, Long, Kovacs, & Trancik, 2008).

In the current dissertation, the two empirical studies were conducted in Turkish ethnic minority children in the Netherlands. The empirical data presented in these studies are drawn from the Dutch part of the SIMCUR (Social Integration of Migrant Children: Uncovering Family and School Factors Promoting Resilience) project that was carried out in three European countries; the Netherlands, Germany and Norway. The project uses a longitudinal two-cohort design with three waves: before, during and after the transition to primary or secondary school. It is also important to note the historical background of migrant children and their families. In the 1960s and 1970s, Turkish guest-workers came to Europe from the rural areas of the lowest socioeconomic regions of Turkey to fill the shortages of the labor market temporarily. Although they were expected to return to Turkey within a couple of years, most of them decided to bring their families to the host country and settle down permanently (Yaman, 2009). Eventually, the Turkish became the largest ethnic minority group in the Netherlands, and their population is still growing with second and third generation children (Distelbrink & Hooghiemstra, 2005). It is known that first and second generation immigrants are overrepresented in lower socieconomic classes (Planbureau, 2009), they experience acculturative stress, have limited contact with members of the host society, prefer to marry within their own ethnic group and maintain their own ethnic language (Crul & Doomernik, 2003; Planbureau, 2009, 2011).

Aim and outline of the dissertation

The general aim of the studies presented in this dissertation is to provide more insight into the association between self-regulation and academic outcomes, with special attention to these issues in ethnic minority children. Following a systematic meta-analysis on the association between cognitive self-regulation and academic achievement regardless of ethnic group, two empirical studies focus on self-regulation and aspects of education in ethnic minority children specifically, examining self-regulatory capacities in relation to educational attainment, and the relation between the transition to primary school and the development of self-regulation.

In Chapter 2, children's cognitive flexibility is examined in relation to their performance in math and reading in two meta-analyses. In Chapter 3, two different aspects of self-regulation, executive function and effortful control are examined in relation to educational attainment in secondary school tracks in Turkish minority preadolescents. The main focus of Chapter 4 is the longitudinal changes of speed and accuracy in cognitive flexibility performance in Turkish minority kindergarteners before and after the transition to formal education in the Netherlands. Thus, Chapters 2 and 4 exclusively focus on a particular component of cognitive self-regulation (i.e., executive function): flexible thinking. In chapter 3, a broader perspective on the construct of self-regulation is employed by examining both cognitive and behavioral indicators. Finally, Chapter 5 presents a general discussion of the main findings reported in this dissertation. In addition, limitations, theoretical and practical implications and suggestions for further research are adressed in this chapter.

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2

Shifting ability predicts math and reading performance in children: A meta-analytical study

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ABSTRACT

Empirical evidence on the association between the shifting component of executive functioning and academic performance is equivocal. In two meta-analyses children's shifting ability is examined in relation to their performance in math (k = 18, N = 2330) and reading (k = 16, N = 2266). Shifting ability was significantly and equally associated with performance in both math (r =.26, 95% CI =.15, .35) and reading (r =.21, 95% CI =.11, .31). Intelligence was found to show stronger associations with math and reading performance than shifting ability. We conclude that the links between shifting ability, academic skills, and intelligence are domain-general.

Keywords: Shifting, Executive function, Math, Reading, Meta-analysis

INTRODUCTION

The ability to shift between conceptual representations is critical for the selection and maintenance of appropriate strategies and disengagement from irrelevant ones, and represents skills that are necessary to successfully perform academic tasks (Best, Miller, & Jones, 2009). It has been argued that this ability is particularly important for performance on complex academic tasks requiring alternation between different aspects of problems or arithmetical strategies (Agostino, Johnson, & Pascual-Leone, 2010; Blair, Knipe, & Gamson, 2008; Van der Sluis, De Jong, & Van der Leij, 2007). This suggests that shifting ability (or cognitive flexibility) would be mainly related to performance in subjects like math, which has indeed been reported in several studies (e.g., Bull & Scerif, 2001; Clark, Pritchard, & Woodward, 2010; Mayes, Calhoun, Bixler, & Zimmerman, 2009), although others have failed to find this association (e.g., Espy et al., 2004; Lee, Ng, & Ng, 2009; Monette, Bigras, & Guay, 2011). Although there is a less strong theoretical case for a link between shifting ability and reading performance, several studies have examined this association, with some reporting significant results (e.g., Latzman, Elkovitch, Young, & Clark, 2010; Van der Sluis et al., 2007), but others showing no link between the two (e.g., Mayes et al., 2009; McLean & Hitch, 1999). In the current study, a set of meta-analyses is performed to investigate whether shifting ability is significantly related to performance in math and reading performance in children.

Shifting and academic performance

A growing body of evidence shows that executive function (EF) is a crucial contributor to school achievement (Best et al., 2009; Müller, Liebermann, Frye, & Zelazo, 2008). EF refers to higher-order cognitive processes necessary for goal-directed problem solving in novel situations and planning. The term may encompass at least three separate but related components: inhibition, working memory and shifting (Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000). Broadly speaking, shifting refers to changing the mental set that has been learned to a new one. The first step of shifting is to develop a representation of a rule (i.e., a particular strategy for problem solving) in working memory and the second one is to shift to a new rule, which requires the inhibition of the rule that has been already formed (Best & Miller, 2010; Garon, Bryson, & Smith, 2008). Although there is a substantial amount of research linking EF to academic achievement, most studies have focused on the contribution of working memory (Gathercole & Pickering, 2000; Passolunghi, Mammarella, & Altoe, 2008; Swanson, 2006).

Previous meta-analyses by Carretti and colleagues (2009), Swanson and Jerman (2006) and Swanson, Zheng, and Jerman (2009), found clear evidence for lower working memory capacity of children with math and/or reading disabilities compared to their peers without such disabilities. In addition, a review by Raghubar, Barnes and Hecht (2010) supports the role of working memory in math performance. Regarding inhibition, recent confirmatory factor analyses show that EF measures load on two latent factors that might best be called working memory and set-shifting (Huizinga, Dolan, and van der Molen, 2006). Therefore, we focused on shifting as an important but not yet systematically reviewed component of EF in relation to academic outcomes. In this study, the role of shifting in math and reading achievement is investigated through a set of meta-analyses. Further, possible factors that may influence the association of shifting with these two academic domains are examined via moderator analyses to find out what contributes to the divergence of findings.

Moderators

Divergent findings regarding shifting and academic achievement may result from heterogeneity of (1) shifting tasks, (2) shifting task scoring, (3) sample characteristics, and (4) whether the impact of intelligence is controlled for in statistical analyses. One of the sources of heterogeneity in shifting tasks is variation in their level of complexity. Clark and colleagues (2010) for instance, found that the Flexible Item Selection Task showed robust correlations with later achievement scores whereas the Shape School-Switch Condition demonstrated no association with achievement in preschool children after controlling for verbal intelligence, working memory and inhibition. The researchers explained the mixed results with academic achievement by pointing out the difference in the level of linguistic complexity between these two shifting tasks. Like other EF measures, shifting tasks may also differ in terms of the cognitive processes operating in addition to shifting, which may affect the relations with academic scores. Furthermore, shifting tasks differ in terms of rule presentation. On some tasks, the rule is explicitly presented to the child (e.g., trail making), whereas the sorting criterion is not explicitly revealed in most of the card sorting tasks (see Dimensional Change Card Sorting for exception) in which the rule should be deduced from the feedback on the trials. The distinction in rule presentation may change the load of nonexecutive processes (e.g., language, intelligence) or other executive components (working memory or inhibition), which may in turn moderate the relation of shifting with academic outcomes.

A second potential explanation for the heterogeneity of findings is the type of scoring of shifting tasks. Different tasks provide different scores such as reaction time, accuracy, or efficiency. In addition, some tasks provide difference scores (e.g., RT difference between the Part A and B of Trail Making Task) whereas others give raw scores (e.g., total RT to complete the task). Despite a wealth of research on EF tasks, it is unclear whether different scores measure the same construct and whether tasks with multiple scores differ from those with a single score in terms of measuring shifting. Davidson and colleagues (2006) provided striking evidence that score type matters for different age groups. In their study with 4- to

13-year-olds and young adults, accuracy was found to be a more sensitive measure for young children than reaction time. Children were more impulsive than adults, so their reaction time resisted changing with an accuracy cost on difficult trials whereas adults tended to slow down (increasing their reaction time) to be able to give accurate responses. Scoring type of shifting tasks may thus moderate the relation between shifting and academic achievement.

Third, diverging outcomes may also result from the variety in age, gender, and SES of the samples in different studies. Shifting shows a long developmental progression, as even 13-year-old children do not reach the adult level (Davidson et al., 2006). It is unclear whether the relation between shifting and academic achievement differs across age. On the one hand, it has been found that shifting in preschool does not contribute to math skills at the age of 6 when the effect of age is controlled for (Espy et al., 2004). On the other hand, in another study with third and fourth graders, Trail Making Task, which is a commonly used shifting measure, showed significant correlations with math and reading scores, controlling for age (Andersson, 2008). It is possible that the relation between shifting and academic outcomes changes for preschoolers and school-aged children partly because of changing structure of EF with development. Some studies, for instance support the unitary structure of EF in preschool years (Wiebe, Espy, & Charak, 2008; Hughes et al., 2010; Wiebe et al., 2011) as opposed to the fractionated nature of the same construct in school-aged children (Huizinga, Dolan, & van der Molen, 2006; Lehto, Juujarvi, Kooistra, & Pulkkinen, 2003). Gender has been reported to have no effect on the relation between executive functions in general and academic domains (e.g., Bull, Espy, & Wiebe, 2008; Clark et al., 2010). However, to our knowledge, there are no studies that specifically focus on the potential moderating effect of gender for the relation between shifting and academic achievement. There is also evidence that SES is related to both shifting ability and academic achievement, with children from low SES backgrounds performing less well than children from higher SES backgrounds (Alexander, Entwisle, & Dauber, 1993; Ardila, Rosselli, Matute, & Guajardo, 2005; Davis-Kean, 2005; Noble, McCandliss, & Farah, 2007). Whether the relation of shifting with academic outcomes differs for children coming from low-income families compared to their socio-economically more advantageous peers has not yet been explored.

The impact of intelligence

The fourth and last methodological issue is related to the question whether the association between shifting ability and academic performance is independent from the impact of intelligence on academic achievement. The literature provides some evidence that shifting and intelligence are associated in children (Ardila, Pineda, & Rosselli, 2000; Van der Sluis et al., 2007). Further, some studies have shown that the relation between shifting and academic achievement disappears after controlling for verbal intelligence in preschoolers (Espy et al.,

2004) and school-aged children (Bull & Scerif, 2001). On the other hand, there has been research showing that shifting measured in kindergarten remains a significant predictor of academic performance in first grade independent of covariates such as verbal intelligence, social skills and current academic achievement (George & Greenfield, 2005). An analysis of shifting ability in relation to academic achievement will thus have to take into account the potential confounding influence of intelligence.

Current study

In sum, empirical evidence on the association between shifting and academic achievement is equivocal. In this study we investigate shifting in relation to math and reading achievement in two meta-analyses. The association between shifting and math seems to have empirical support, whereas there is a less strong case for the association between shifting and reading. Some studies also reported that children with reading disability perform similarly to a control group on shifting measures (Klorman et al., 1999; Van der Sluis, De Jong, & Van der Leij, 2004), which supports the idea that there may be no relation between shifting and reading. Therefore, we hypothesize that shifting is positively associated with math performance, but not associated with reading. We also search for explanations of the mixed findings by testing the effects of procedural moderators, including rule presentation (whether the rule is explicitly revealed versus kept implicit to be deduced by the participant), scoring type of the shifting task (accuracy, reaction time, efficiency, or combined), study design (longitudinal versus concurrent), and time period between the assessment of shifting and academic skills, as well as sample moderators, including age, grade level (preschool versus primary/secondary school), gender ratio, and socio-economic status (SES). To evaluate the effect sizes obtained in the first analyses in light of associations of our main variables with intelligence, we will also present the results of four additional meta-analyses to assess the associations of intelligence with math and reading, the associations between shifting and intelligence; and between math and reading.

METHOD

Literature search

Three search methods were used to identify relevant studies. First, we searched the electronic database Web of Science by using the keywords "*executive funct**", *shift**, "*set shift**" "*task switch**", "*cognitive flexib**", "*mental flexib**"combined with *academ** and *school*. Second, we searched online dissertations via the database Proquest Dissertations and Theses with the same keywords. The search was finalized in August 2011. Third, the reference lists of the collected articles and dissertations and of the book chapter by Müller and colleagues (2008) were checked for relevant studies. Studies were included if they reported on the relation between shifting ability and any type of academic achievement. Five additional inclusion criteria were used. (1) We included studies with shifting tasks, which require changing the mental set to a newer one which conflicts with the first; (2) shifting was analyzed as a predictor of an academic outcome, or both constructs were measured concurrently. If the academic assessment was conducted prior to the measurement of shifting ability, the study was excluded; (3) the sample consisted of children from the general population. When information about the screening procedure was not provided, the study was included; (4) both for shifting and academic performance, only the studies with performance-based tasks were included. We excluded studies using only questionnaires and studies using only observations; (5) we focused on math and reading as academic outcomes since there were not sufficient results relating shifting to other types of academic skills such as writing.

We found 20 studies with 34 outcomes that met our search criteria with sample sizes ranging from 36 to 255 (see Table 2). Fourteen of the studies provided separate outcomes for math and reading. Four studies provided only math outcomes and two studies provided only reading outcomes. Thus, 18 studies reported on shifting and math ($N = 2330$) and 16 studies reported on shifting and reading ($N = 2266$). The coding system for sample characteristics and study methods is presented in Table 1. To assess intercoder reliability, all studies were coded by two coders. Cohen's kappa was computed for categorical variables, and intraclass correlations were computed for continuous variables. The average agreement was .74 (86%) across the categorical variables and .94 for the continuous variables. The coders discussed disagreements in order to reach a consensus.

Moderators

We coded two types of moderators: sample and procedural characteristics. Sample moderators included *age of the children* as a continuous variable and as a categorical variable (recoded into three categories by using the 33rd and 67th percentile scores as "younger than 6", "between 6 – 10 years" and "older than 10 years"); *grade level* (recoded into two categories as preschool/kindergarten vs. primary/secondary school); *gender ratio* (% of girls), and *socio-economic status* (recoded into three categories as low, middle and high). The predominant SES category of the sample was coded. Age of the children, grade level and gender ratio were estimated for studies that do not provide information for these moderators. Grade level was estimated based on the mean age of the children. Similarly, age of children was estimated based on the grade (e.g., 9 years for children in the grades 3 to 5). Gender ratio of girls was estimated as 50%. Procedural moderators included *study design* (longitudinal vs. cross-sectional), *time period* between shifting assessment and academic testing, *rule presentation* (explicit versus implicit), and *scoring type of the shifting task* (accuracy, reaction time, efficiency, or combined).

Table 1
Coding System for Studies on Shifting and Academic Achievement

Variable	Coding System
Academic outcome	1 = math
	2 = reading
	3 = other
	4 = aggregate
Sample	
Mean age at T1	Continuous
Mean age at T2	Continuous
Grade level	1 = preschool/kindergarten
	2 = primary/secondary
Gender ratio (% girls)	Continuous
Socio-economic status	1 = high
	2 = middle
	3 = low
	4 = not reported or mixed
Procedure	
Research design	1 = concurrent
	2 = longitudinal
Time period between the measurement of shifting and of academic achievement	Continuous
Rule presentation in the shifting task	1 = explicit
	2 = implicit (rule deduction by the participant)
The type of shifting scoring I	1 = accuracy or errors
	2 = reaction time
	3 = efficiency
	4 = combined
The type of shifting scoring II	1 = raw
	2 = difference / cost
Covariates used in the statistical analyses?	1 = yes (partial correlations)
	2 = no (zero-order correlations)
Sample size	Continuous

We coded the shifting tasks based on rule presentation. For instance, the cards on the Wisconsin Card Sorting Test are sorted by color, shape, or number of the objects. However, the sorting rule is not revealed and remains implicit. The child has to deduce the correct sorting principle by using the feedback (right or wrong) after each trial. However, on most other shifting tasks the rule to sort and/or switch is given explicitly. Thus, we coded the tasks as having either explicit or hidden rules. One of the studies (Monette et al., 2011) was coded as mixed since it included two tasks; one coded as explicit and the other as implicit (hidden).

The shifting tasks also showed a great deal of variety in terms of scoring. Some studies used reaction time and others calculated the number of correct responses as measures of performance Likewise, some used difference or costs between the versions of the task (e.g., RT difference between the Part A and B of Trail Making Task) whereas others provided only raw score. The task scoring is crucial to decide whether the effect is in the hypothesized direction or not. We categorized the shifting scores as reaction time, accuracy or errors, efficiency (number of correct responses divided by reaction time) or combined (when the task provided two or more different scores or when multiple shifting tasks with a single score were used). When the task score was reaction time or errors, the effect sign was reversed (i.e., higher shifting scores in these cases would be expected to relate to lower academic achievement). We coded the type of scoring also for raw versus difference categorization. In the case of multiple correlation coefficients (e.g., when there were multiple shifting scores and/or multiple academic scores), these were averaged. If the averaged shifting scores were combinations of various shifting indices (like accuracy and efficiency), then the scoring type was coded as "combined". In three studies, shifting was measured by the Wisconsin Card Sorting Test (WCST), which simultaneously assesses multiple cognitive processes related to shifting. We averaged the WCST scores in order to obtain one single effect size for the association between shifting and academic outcome (excluding "failure to maintain set", because this is considered to be independent of cognitive flexibility, see Greve et al., 2002; Greve, Stickle, Love, Bianchini, & Stanford, 2005).

Intelligence

Intelligence was measured only by a verbal (e.g., Peabody Picture Vocabulary) or a nonverbal (e.g., Raven's Matrices) test in some studies, whereas in other studies, a single quotient was estimated based on multiple subtests of a battery to indicate general intelligence. We coded different types of intelligence, but due to the lack of studies tapping each type of intelligence we were unable to use this moderator in the analyses.

Table 2
Studies Included in Meta-Analyses

Study	Effect sizes for[a] Math	Reading	Shifting task[b]	Shifting scoring I[c]	Shifting scoring II	Shifting rule	Sample size[b]	Mean age (mo) T1	Mean age (mo) T2	% girls	Grade[d]	Time period (mo)	Concurrent vs Longitudinal	SES	IQ measure
Andersson (2007)	.59***	.41***	Trail Making	Reaction time	Difference	Explicit	69	119.5		48	2, 3 & 4	0	C	No info	Raven's (NV)
Andersson (2008)	.61***	.42***	Trail Making	Reaction time	Difference	Explicit	141	124		59	3 & 4	0	C	Middle	Raven's (NV)
Andersson (2010)[f]		.33**	Trail Making	Reaction time	Difference	Explicit	95	125	141	65	3 & 4	16	L	No info	Raven's (NV)
Bull et al. (1999)[j]	.17		Wisconsin	Combined†	Raw	Implicit	44	87		41	3	0	C	Low	
Bull and Scerif (2001)	.21*		Wisconsin†	Combined	Raw	Implicit	93	88		46	3	0	C	No info	Wechsler Block Design & Vocabulary (G)
Mayes et al. (2009)	.02	.00	Wisconsin†	Combined	Raw	Implicit	214	103.2		53	K – 5	0	C	No info	WASI (G)
Blair and Razza (2007)	.26**	.19*	Flexible Item Selection	Accuracy	Raw	Explicit	141	61	74.4	47	Pre-school	13	L	Low	Raven's & PPVT (NV & V)
Turner (2010)	.35***	.14	Flexible Item Selection	Accuracy	Raw	Explicit	138	60		53	Pre-school[i]	0	C	High	Expressive Vocabulary (V)
Mazzocco and Kover (2007)[h]	.13	.12	Contingency Naming†	Combined	Raw	Explicit	177	80.4		52	Primary school	0	C	No info	Wechsler Abbreviated (G)
Latzman et al. (2010)	.48***	.55***	D-KEFS	Combined	Raw	Implicit	151	163.68		0	Middle school[i]	0	C	High	KBIT-2 Verbal & Nonverbal (G)
Bull et al. (2008)[g]	.29**	.29**	Shape School, Switch	Efficiency	Raw	Explicit	82/83	54	92.52	52	Pre-school	38	L	Middle	
Vitiello (2009)	.29***	.17*	Something's the same	Accuracy	Raw	Explicit	179	51.4	52.4	50	Pre-school	1	L	Low	PPVT (V)
Altemeier et al. (2006)		.00	Wolf Rapid Automatized	Reaction time	Raw	Explicit	228	108[i]		55	3 & 5	0	C	High	
Clark et al. (2010)	.32**	.25*	Flexible Item Selection & Shape School, Switch	Combined	Raw	Explicit	102	48	72	50[i]	Pre-school	24	L	Middle	WPPSI-R (G)

Table continues on the next page

Table continued

Lee et al. (2009)[k]	-.11	-.09	Number Letter & Plus Minus	Reaction time	Difference	Explicit	255	134.4		48	5	0	C	Low	Wechsler Vocabulary (V)
Espy et al. (2004)	-.08		Spatial Reversal (SR)& SR Irrelevant cues	Combined †	Raw	Implicit	96	50		57	Pre-school	0	C	High	WJ Picture Vocabulary (V)
Agostino et al. (2010)[e]	.31***		Trail Making & Contingency naming	Combined	Both	Explicit	155	122.1		56	3 – 6	0	C	No info	
McLean and Hitch (1999)	.23	-.06	Trails Written, Verbal, Color & Crossing Out	Reaction time	Raw	Explicit	36	108.96		58	3 & 4	0	C	No info	
Monette et al. (2011)	.06	.13	Trails-P & Card sorting	Accuracy†	Raw	Mixed	85	70	82	54	Pre-school	12	L	High	
Van der Sluis et al. (2007)	.24**	.38***	Trails making, Object-S, Symbol-S, & Place-S	Efficiency	Raw	Explicit	172	128.08		51	4 & 5	0	C	No info	Raven's & RAKIT Verbal Analogies (G)

[a] Academic outcomes were grouped as M = Math, R = Reading.

[b] Shifting tasks and sample size as included in meta analyses. Those with † refer to the tasks, for which scores were aggregated in order to obtain one single effect size for the association between shifting and academic outcome. When the correlation between a single score and the academic outcome was reported as nonsignificant, it was estimated as zero.

[c] Coding of the shifting task scores is described in detail in the text. Those with † refer to the latent factors.

[d] For longitudinal studies, the reported grade refers to the grade in which children were assessed for the first time.

[e] In the study by Agostino et al. (2010), academic outcome was based on the total sample and one attribute part of Contingency Naming Task.

[f] In the study by Andersson (2010), reading performance on both foreign and native language tests was used.

[g] In the study by Bull et al. (2008), the sample size is 83 for reading and 82 for math due to one missing case. The correlations of shifting with the 3rd wave academic scores were included.

[h] In the study by Mazzocco and Kover (2007), the research design is longitudinal but the concurrent associations between the CNT and the academic scores were used.

[i] Age of the children, grade level and gender ratio were estimated (see Method section).

[j] In the study by Bull et al. (1999), IQ was assessed, but the correlations of intelligence with academic scores and with shifting are not reported.

[k] In the study by Lee et al. (2009), Block Design and Vocabulary subtests of WISC-III were used. However, only the correlations of Vocabulary with the variables of interest were reported.

*p < .05, **p < .01, ***p < .001.

Statistical analyses

First, two meta-analyses were carried out, namely, one for the relation between shifting and math, and one for the relation between shifting and reading. Second, we conducted two additional sets of meta-analyses to investigate the relation between intelligence and the two academic domains within the selected publications, which provided outcomes regarding the association of intelligence with math and/or reading. Third, we meta-analyzed the associations between shifting and intelligence, and between math and reading within the set of selected studies. The meta-analyses were performed using the Comprehensive Meta-Analysis (CMA) program (Borenstein, Rothstein, & Cohen, 2005). For each outcome, an effect size (correlation) was calculated.

Effects in the hypothesized direction (i.e., a positive association between cognitive flexibility and academic achievement) were given a positive sign. Effects indicating an association opposite to the hypothesized direction were given a negative sign. Studies reporting no exact statistics but reported a non-significant finding were assigned a conservative non-significant zero effect size (included using the study's sample size and p = .50) (Mullen, 1989).

Using CMA, combined effect sizes were computed. Significance tests and moderator analyses were performed through random effects models as the preferred mode of analysis (Borenstein, Hedges, & Rothstein, 2007). Random effects models allow for the possibility that there are random differences between studies that are associated with variations in procedures, measures, settings, that go beyond subject-level sampling error, and thus point to different study populations (Lipsey & Wilson, 2001). To test the homogeneity of the sets of effect sizes, we computed Q-statistics (Borenstein et al., 2005). In addition, we computed 95% confidence intervals (CIs) around the point estimate of each set of effect sizes. Q-statistics and p-values were also computed to assess differences between combined effect sizes for specific subsets of study effect sizes grouped by moderators. Contrasts were only tested when at least two of the subsets consisted of at least four studies (Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2003).

Funnel plots for both sets of studies were examined in order to detect possible publication bias. A funnel plot is a plot of each study's effect size against its standard error (usually plotted as 1/SE, or precision). It is expected that this plot has the shape of a funnel, because studies with smaller sample sizes (larger standard errors) have increasingly large variation in estimates of their effect size as random variation becomes increasingly influential, whereas studies with larger sample sizes have smaller variation in effect sizes (Duval & Tweedie, 2000b; Sutton, Duval, Tweedie, Abrams, & Jones, 2000). However, smaller studies with nonsignificant results or with effect sizes in the nonhypothesized direction are less likely to be published. Therefore, a funnel plot may be asymmetrical around its base. The degree of asymmetry in the funnel plot was examined by estimating the number of studies, which have no symmetric counterpart on the other side of the funnel. The ‘‘trim and fill’’ method was used to test the influence of possible adjustments of the sets of studies for publication bias (Duval & Tweedie, 2000a,b).

For each study, Fisher's Z scores were computed as equivalents for correlations. Fisher's Z scores have better distribution characteristics than correlations, in particular better estimates of the standard error (Lipsey & Wilson, 2001; Mullen, 1989). All Fisher z transformed effect sizes and all sample sizes were examined for outliers (defined as standardized z-values exceeding +/- 3.29 (Tabachnick & Fidell, 2001). No outliers were detected.

Further, the 85% CIs were compared to explore whether the combined effect sizes of six different sets of effect sizes were significantly different (Van IJzendoorn, Juffer, & Poelhuis, 2005). The sets of effect sizes were partly based on the same subjects and therefore direct statistical tests were not warranted. The absence of overlap between 85% CIs indicates a statistically significant difference since producing 85% confidence intervals guarantees that if the confidence intervals around the combined effect sizes of the two sets of meta-analyses do not overlap then the level of statistical significance between the two groups would be 5% or lower (Goldstein & Healy, 1995; Julious, 2004; Payton, Greenstone, & Schenker, 2003). So, we used the 85% CI around the point estimate as a conservative way of testing whether the difference in effect sizes for the two comparison groups (intelligence versus shifting as the predictor) for each of the academic skills (math and reading) was significant (see Figure 1). Using 95% CIs did not change our findings and conclusions.

RESULTS

Shifting and academic outcomes

The meta-analysis concerning the relation between shifting and math included 18 studies, with a total sample of 2330 children. The results of the meta-analyses for math and reading are presented in Table 3. The combined effect size for the relation between shifting and math was substantial and significant (r = .26, 95% CI = .15 - .35, p < .01) in a heterogeneous set of studies (Q = 113.31, p < .01). Overall, higher levels of performance on shifting tasks were related to higher levels of performance on math tests.

Table 3

Meta-Analytic Results of Studies Relating Shifting with Math, and with Reading

		Math						Reading					
		k	*n*	*r*	95%CI	*Q*[a]	*p*	*k*	*n*	*r*	95%CI	*Q*[a]	p
Total set		18	2330	.26	[.15, .35]	113.31	.00	16	2266	.21	[.11, .31]	90.85	.00
Sample Characteristics													
Age						.66	.72					3.30	.19
	Youngest	7	823	.22*	[.04, .39]	12.88*		6	728	.20*	[.03, .35]	2.02	
	Medium	6	633	.23**	[.03, .42]	23.03**		5	724	.09	[-.09, .28]	12.01*	
	Oldest	5	874	.32**	[.12, .50]	73.23**		5	814	.32**	[.15, .47]	59.10**	
Grade						.23	.63					.04	.84
	Preschool / K	7	823	.22*	[.05, .38]	12.88*		6	728	.20*	[.02, .36]	2.02	
	Primary / Secondary	11	1507	.27**	[.13, .40]	100.26**		10	1538	.22**	[.08, .34]	88.78**	
SES[b]						1.26	.26						
	High / Middle	7	795	.32**	[.14, .47]	29.92**		7	928				
	Low	4	619	.15	[-.09, .38]	24.41**		3	575				
Procedure Characteristics													
Study Design						.00	.92					.07	.79
	Concurrent	13	1682	.26**	[.16, .41]	108.00**		10	1581	.20**	[.07, .33]	86.39**	
	Longitudinal	5	648	.25*	[.04, .43]	4.14		6	685	.23*	[.06, .38]	3.08	
Rule presentation[c]						1.72	.42						
	Explicit	12	1647	.30**	[.17, ..42]	80.51**		13	1816				
	Implicit	5	598	.18	[-.04, .38]	27.32**		2	365				
Shifting scoring I						.98	.61					.92	.63
	Accuracy / Errors	4	543	.25*	[.01, .46]	4.96		4	543	.16	[-.05, .36]	.33	
	Reaction time	4	501	.36**	[.12, .56]	74.51**		6	824	.18	[-.00, .34]	42.08**	
	Efficiency / Combined	10	1286	.22*	[.06, .36]	32.96**		6	899	.27**	[.11, .43]	39.78**	
Shifting scoring II												.33	.56
	Difference / costs	3	465					4	560	.26*	[.05, .45]	35.88**	
	Raw	14	1710					12	1706	.19*	[.07, .31]	54.94**	

[a]Q statistic for moderator stands for effect of contrasts (df = number of subgroups - 1), Q statistic for subgroup stands for homogeneity (df = k - 1).

[b]The studies that do not report SES information were excluded.

[c]The study by Monette et al. (2011) was excluded.

Using the trim and fill method (Duval & Tweedie, 2000a,b), we did not find evidence for publication bias. The fail-safe number for this set of studies was 614, i.e., it would take 614 null results to cancel out this significant combined effect size.

The meta-analysis concerning the relation between shifting and reading included 16 studies with a total of 2266 children. The combined effect size for the relation between shifting and reading was moderate and significant (r = .21, 95% CI = .11 -.31, $p < .01$) in a heterogeneous set of studies (Q = 90.85, $p < .01$). Overall, higher levels of performance on shifting tasks were related to higher levels of performance on reading tests. Using the trim and fill method (Duval & Tweedie, 2000a,b), no asymmetry was found in the funnel plot; therefore evidence for publication bias was absent. The fail-safe number for this set of studies was 344.

We examined the papers included in our meta-analyses for reliability estimates. We used the Spearman's (1904) correction for attenuation formula based on the reliabilities of the measures. The mean reliabilities were as follows: .74 for the shifting measures (k = 4), .82 for the math measures (k = 4), .86 for the reading measures (k = 2). We found "true" population effect sizes for the association between shifting ability and math performance of .33 and for the association between shifting ability and reading performance of .26. Since a very small number of studies reported reliability estimates of the measures on the sample involved, the results based on this correction should be interpreted tentatively.

Moderators

We tested whether moderators regarding sample characteristics (age, grade level, gender ratio and socio-economic status) and procedure (study design, time period between shifting and academic testing, rule presentation and scoring type in shifting tasks) were associated with effect size separately for math and reading (Table 3). For exploring the effect of a continuous variable, weighted regression models were used. None of the sample characteristics and none of the procedural moderators showed significant effects on the association between shifting and math or reading performance. However, the lack of moderation effects is tentative due to the small number of studies in particular subsets. The moderating effects of SES (k = 3 low SES for reading), of rule presentation (k = 2 implicit for reading), shifting scoring as difference versus raw (k = 3 difference for math) and of a covariate used in the statistical analyses (k = 3 partial correlations for both math and reading) could not be tested due to an insufficient number of studies per subset i.e., less than four (Bakermans-Kranenburg et al., 2003).

Intelligence, shifting and academic outcomes

The meta-analysis concerning the relation between intelligence and math included 12 studies with a total sample of 1751 children showed a significant and large combined effect size (r = .47, 85% CI = .41 - .52) in a heterogeneous set of studies (Q = 40.86, p < .01). The CI around the point estimate for the relation between intelligence and math did not overlap with the CI for the relation between shifting and math (r = .26, 85% CI = .18 - .33), which means that the relation between intelligence and math was significantly stronger than between shifting and math. The meta-analysis concerning the relation between intelligence and reading, which included 11 studies with a total of 1657 children showed a significant and large combined effect size (r = .43, 85% CI = .37 - .49, p < . 01) in a heterogeneous set of studies (Q = 46.27, p < .01). The absence of overlapping 85% CI with the CI for the relation between shifting and reading (r = .21, 85% CI = .14 - .28) suggested the relation between intelligence and reading was significantly stronger than between shifting and reading.

The relation between shifting and intelligence was reported in 11 studies with a total sample of 1539 children. The combined effect size for the relation between intelligence and shifting was significant and substantial (r = .30, 85% CI = .18 - .41, p < .01) in a heterogeneous set of studies (Q = 107.54, p < .01). Last, we conducted a meta-analysis with 10 studies that provided results for the association between math and reading. The combined effect size within a total of 1283 children was significant and large (r = .56, 85% CI = .50 - .62, p <. 01) in a heterogeneous set of studies (Q = 22.24, p < .001). Comparison of the 85% confidence intervals of the meta-analyses regarding shifting and intelligence in relation to math and reading is presented in Figure 1.

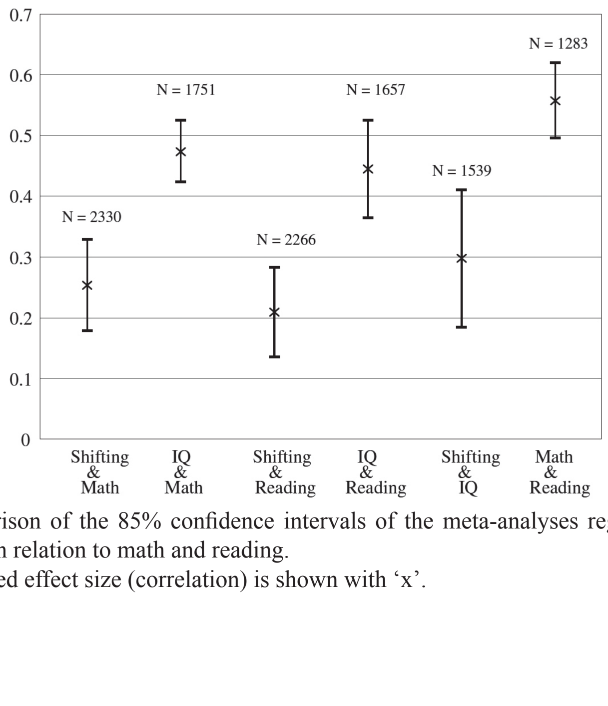

Figure 1. Comparison of the 85% confidence intervals of the meta-analyses regarding shifting and intelligence (IQ) in relation to math and reading.
Note. The combined effect size (correlation) is shown with 'x'.

DISCUSSION

Our meta-analyses showed that the association between shifting ability and math as well as the association between shifting ability and reading performance were substantial and significant. The variation in effect sizes between studies for the association between shifting and academic achievement was not related to differences in rule presentation or type of scoring on the shifting task, or to differences in research design, time period between the measurement of shifting and academic outcomes, children's age, grade level, SES or gender. Intelligence was found to be a stronger contributor to academic performance than shifting, and shifting was substantially associated with intelligence. Lower reliabilities of shifting measures compared to IQ assessments were not responsible for the weaker contribution of EF to school achievement compared to IQ. Even after correction for attenuation combined effect sizes for shifting were considerably smaller than those found for IQ.

First of all, the results of our main meta-analyses indicate that children with a higher capacity to switch a conceptual representation (i.e., goals, rules or strategies for problem solving) to a newer one, show better performance on math and reading. The combined effect sizes of the associations of shifting with math and with reading were quite similar. This is contrary to our hypothesis that shifting would be related to math but not reading. Whereas shifting is considered to be necessary for alternating between different strategies in complex mathematical problem solving (Agostino et al., 2010; Bull et al., 2008; Mayes et al., 2009; Van der Sluis et al., 2007), the literature does not offer a clear explanation for the relation between shifting and reading. Given the results of our meta-analysis of the association between math and reading skills, it is likely that our results are due to the substantial shared variance between the two constructs. Apparently, competence in both math and reading taps into a common more general cognitive ability. This is confirmed by our finding that the associations of math and reading skills with intelligence are very similar in size. These results all point to a domain-general interpretation of the links between shifting ability, academic skills, and intelligence. According to a new framework proposed by Miyake and Friedman (2012), each EF component involves a common (across all three EFs) and a specific part (unique to that particular ability). Taken this new conceptualization of the EFs into account, it might be possible that common EF may enable children to maintain the goal of a task, whereas shifting-specific abilities may contribute to particular domains of achievement (e.g., alternate between different arithmetical strategies in complex math tasks). Since in the included studies shifting ability was not decomposed as it is proposed by Miyake & Friedman (2012), the question of how the common and specific parts of shifting ability are related to achievement remains unanswered.

Second, the results of the moderator analyses did not support the hypothesis that the diverging outcomes regarding the relation between shifting and academic achievement may result from the heterogeneity of procedural or sample characteristics in different studies. It is important to note however, that the lack of moderation effects may be due to the small number of studies in particular subsets. The reasons for including most of these moderators (e.g., rule presentation and scoring type on the shifting task) were based on theoretical considerations rather than on empirical evidence, because the effect of these variables on the association between shifting and academic performance has never been investigated before. For a moderator like child age there has been some empirical work, but with contradicting results. Our meta-analyses therefore provide a much-needed clarification of the (lack of) effects of these moderators. However, we could not test the effects of all possible interfering variables for the association between shifting and academic performance in this study. For instance, it is important to note that the substantial variety in shifting tasks remains a methodological challenge mostly due to task impurity (Miyake et al., 2000). Shifting tasks, like other EF measures, differ in terms of complexity as a result of different amount of loadings on other executive (inhibition and working memory) and nonexecutive processes (e.g., linguistic skills). Unfortunately, the literature does not provide a well-defined framework to categorize shifting tasks by taking into account these levels of complexity. Instead, it has been proposed that the relatively pure EF components can be extracted by confirmatory factor analysis (Lehto et al., 2003; Miyake et al., 2000) and the nonexecutive processes operated by EF tasks should be accounted for by using control tasks, which are quite similar to their EF correspondents except that they do not require the operation of the given EF component (Van der Sluis et al., 2007). It is important to note that conclusions regarding the specific role of EF components in academic achievement without controlling for the common executive and nonexecutive (e.g., intelligence) variance are limited. Future studies that employ these kinds of methods may be more promising to overcome task impurity, and therefore to allow for more straightforward conclusions regarding the unique relations of EF components with academic performance.

Because to the best of our knowledge only one study reports on the association between shifting and academic outcomes correcting for IQ (Mayes et al., 2009), the literature did not provide enough evidence to disentangle the contributions of shifting and intelligence to academic outcomes. To gain at least some insight into the role of intelligence, we analyzed the associations of intelligence with math and reading using the publications selected for the main meta-analyses. Our results showed that the relations of intelligence with math and reading were significantly stronger than the relations of shifting with these academic outcomes. The large combined effect size between intelligence and the academic outcomes seems to support previous findings reporting high correlations between intelligence and achievement tests (Psychological Corporation, 2002). The similarity in the combined effect sizes for the associations of intelligence with math and reading supports the fact that intelligence is a higher-order, domain-free contributor to school achievement much like shifting ability.

What remains unclear however, is whether shifting ability predicts achievement beyond the effect of intelligence. In most of the previous studies, the association between academic and executive functions has been explored without controlling for intelligence. One study showed that the WCST perseverative responses score, a measure of the inability to shift, was one of the very few scores that predicted math (but not reading) beyond intelligence, which led the researchers to conclude that switching ability is necessary for math performance (Mayes et al., 2009). Consequently, the unique contribution of shifting to math independent of intelligence has some support, but needs replication. It remains to be seen whether shifting predicts reading in a similar fashion, when controlling for intelligence in general and verbal intelligence in particular.

Our findings showed a significant and substantial association between shifting and intelligence consistent with previous research (e.g., Ardila et al., 2000). In contrast, some studies have reported that the association of shifting with intelligence disappears when the intercorrelations among the three EF components are controlled for (Duan et al., 2010; Friedman et al., 2006). In these studies, working memory was the only EF component that remained significantly correlated with intelligence after controlling for the other components. In the present study, it was impossible to remove the variance of other EF components from the relation between shifting and intelligence. Nevertheless, our findings support the growing evidence reporting moderate to high correlations between EF components and intelligence scores (e.g., Blair & Razza, 2007; George & Greenfield, 2005; Latzman et al., 2010)

Limitations

It is important to note some limitations of this study. First, due to the small number of studies in particular subsets (e.g., implicit subset of rule presentation), we had to merge different subcategories into one subset in statistical analyses (e.g., efficiency and combined scoring of shifting tasks), which may have reduced the clarity of the results regarding the moderator effects. For the same reason, we were unable to test the moderating effects of SES (for reading), rule presentation (for reading), and covariates (for both math and reading). Second, due to the lack of studies including partial correlations controlling for intelligence (only the study by Mayes et al., 2009), we could not investigate whether shifting is associated with academic achievement beyond the influence of intelligence. Some studies reported regression analyses controlling for intelligence in addition to the effects of several other covariates such as age, maternal education or effortful control in predicting academic outcomes by EF components (e.g., Blair & Razza, 2007; Espy et al., 2004), thus making it more difficult to estimate the influence of intelligence on the association between shifting and academic outcome.

Implications

On a theoretical level, our results provide evidence that shifting ability is a domain-general cognitive process for predicting academic performance, as is the case for intelligence. However, more research is needed to explore the nonshared variance of these higher-order cognitive processes to determine whether they are unique predictors of achievement. There is an ongoing debate about the nature of shifting ability (Chavelier & Blaye, 2008). Based on the new unity and diversity framework (Miyake & Friedman, 2012), future studies decomposing shifting ability into common and specific parts and examining the associations of these parts with academic performance could provide a better understanding of the role of shifting in achievement. From a practical point of view, identifying the potential contributors to school success is necessary to improve the effectiveness of assessment at educational settings. Selecting assessment tools, which tap domain-general abilities contributing to achievement, may help practitioners and educators to evaluate children's competencies at the time of school entry that are important for later success. In this sense, measuring shifting ability may provide crucial information to target at-risk children, who may experience difficulties on reading or math performance. In addition, the knowledge about the contribution of shifting ability to achievement combined with evidence showing positive effects of some training programs on EF performance (Diamond et al., 2007; Dowsett & Livesey, 2000; Karbach & Kray, 2009) suggests that it is worthwhile to further investigate the potential effects of experimentally enhanced shifting ability on academic performance. However, there are some concerns regarding the utility of working memory training programs due to various methodological challenges (Melby-Lervag & Hulme, 2012; Shipstead, Redick, & Engle, 2012). Therefore, future work in this area should explore whether shifting ability can be improved independent of task-specific learning (Shipstead et al., 2012), whether this improvement can be long-lasting and transferable to other cognitive skills (e.g., intelligence), and how the presumed relations of common and specific parts of shifting ability are influenced by training.

Conclusion

In sum, our meta-analyses showed that shifting, the ability to flexibly switch between different rules, strategies or tasks, is a domain-free contributor to academic achievement, regardless of variations in samples and procedures. Although previous studies have shown that the working memory is an important contributor to academic success, the evidence was not that clear for the shifting component of EF. In addition, our analyses provide an insight into the relative contributions of intelligence and shifting to academic outcomes. By showing the substantial association between shifting and intelligence, the current study addresses the importance of taking into account the impact of intelligence in exploring the contribution of shifting and other EF components to academic performance.

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3

Behavioral regulation is associated with educational attainment through self-efficacy in ethnic minority preadolescents

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ABSTRACT

In the current study we investigated whether self-efficacy mediated the relation between self-regulation (effortful control and executive function) and educational attainment in secondary school tracks in 70 Turkish minority preadolescents in the Netherlands. Family SES and host language (Dutch) vocabulary were also included as predictors for educational attainment. Self-efficacy fully mediated the relation between effortful control and educational attainment, indicating that behavioral regulation provides children with self-confidence regarding their academic abilities and motivation, which in turn facilitates academic performance. Executive function, on the other hand was not linked to self-efficacy or educational attainment. Family socioeconomic status and Dutch vocabulary showed direct and indirect associations with educational attainment via self-efficacy. Overall, behavioral self-regulation contributes to positive academic adaptation and resilience in ethnic minority students in early adolescence.

Keywords: effortful control, executive function, self-regulation, achievement, education, ethnic minority

INTRODUCTION

Self-regulation is a broad construct consisting of cognitive and behavioral processes such as executive functions and temperamental effortful control that enable people to manage their attention, emotion, and cognition for adaptive and purposeful behaviors (Blair & Diamond, 2008). In recent years, self-regulation has received increasing attention as one of the important contributors to learning-related behavior such as working independently (Neuenschwander, Rothlisberger, Cimeli, & Roebers, 2012) and academic achievement (Blair & Razza, 2007; McClelland et al., 2007). There is some evidence showing that children's gains in cognitive skills that form the basis for self-regulation shape the way they perceive their academic efficacy (Hughes & Ensor, 2011; Roebers, Cimeli, Rothlisberger, & Neuenschwander, 2012), which in turn predicts their academic achievement (Marsh, Ellis, & Craven, 2002).

A significant gap in academic achievement between ethnic minority and majority children has been documented (Luyten, Bosker, Dekkers, & Derks, 2003; Magnuson & Duncan, 2006; McLoyd, 1998). Despite accumulating evidence showing a link between self-regulation and school success, previous research focusing on the role of these capacities for achievement in ethnic minority children is limited (McClelland, & Wanless, 2012; Welsh, Nix, Blair, Bierman, & Nelson, 2010). In addition, the number of studies focusing on the relation between self-regulation and achievement in middle childhood and adolescence is relatively small (Best, Miller, & Naglieri, 2011). In the current study we test the hypothesis that children's self-efficacy mediates the relation between self-regulation and educational attainment in secondary school in Turkish minority preadolescents in the Netherlands. Since socioeconomic risk factors (Garcia Coll et al., 1996) and difficulties in the host language (Morrison, Bachman, & Connor, 2005) are seen as important reasons for educational disadvantage of ethnic minority children, we include family SES and Dutch vocabulary as additional predictors for achievement. The current study might provide insight in the potential mechanisms to mitigate the educational disadvantage of minority children.

Formal schooling requires good self-regulatory skills involving attentional, emotional, cognitive and behavioral processes. Poor self-regulatory skills might make school challenging and unpleasant for children as they have difficulties focusing, sustaining and regulating their attention, motivation and behavior in class to accomplish assignments or other school tasks. As Blair and Diamond (2008) stated, teachers and classmates usually get frustrated with these children since they are unable to comply with school rules or meet school demands to the same extent as children with good self-regulatory skills. Repeated negative experiences at school resulting from poor self-regulation could lead these children to hold more negative perceptions of themselves as students, and decrease their sense of self-worth (Crocker, 2002). They may become less committed and more resistant about school. Thus, individual differences in self-regulation may shape the way these children are viewed by others and, therefore, the way they view themselves (Hughes & Ensor, 2011). Students with high perceived competence are inclined to see a new task as challenging rather than threatening, which may promote their success on performance-based tasks tapping into cognitive control and monitoring (Roebers et al., 2012). From this perspective, a positive self-concept may help children to regulate their attention, emotion and behavior in novel tasks. However, due to limited research, the exact nature of the relations between self-regulation, self-efficacy and academic achievement remains unclear. Therefore, it is important to examine these associations more closely, particularly in children at-risk for academic failure (Luyten et al., 2003; Magnuson & Duncan, 2006; McLoyd, 1998).

The construct of self-regulation has been studied from different research perspectives, including a behavioral/ temperamental approach focusing on effortful control, or a neurocognitive approach focusing on executive functions. Effortful control (EC) refers to voluntary control on behavioral activation or inhibition tendencies via attention (Rothbart & Bates, 2006). Executive functions (EF), on the other hand, are cognitive processes that we use in planning, problem solving and goal-directed action via inhibitory control, cognitive flexibility, and working memory (Miyake et al., 2012). Although the two concepts have some similarities, they have been rarely studied together, mostly because they resulted from traditionally different methods of measurement (for exceptions see Blair & Razza, 2007; Neuenschwander et al., 2012). Effortful control is generally assessed through parent or teacher reports whereas executive functions are generally measured using performance-based tasks (Neuenschwander et al., 2012). Research assessing both constructs revealed low to moderate intercorrelations, indicating that the constructs have some commonality, but that they are distinct kinds of regulatory mechanisms (Liew, 2012). In this regard, it has been argued that they should be considered complementary and studied together to obtain a clearer picture of children's self-regulation skills (Zhou, Chen, & Main, 2012).

There is a body of research showing that effortful control (e.g., Valiente et al., 2011; Zhou, Main, & Wang, 2010) and executive functions (e.g., Best et al., 2011; Jacobson, Williford, & Pianta, 2011; Van der Sluis, De Jong, & Van der Leij, 2007) are linked to school success in middle childhood and early adolescence. One of the very few studies focusing on both aspects of self-regulation revealed that effortful control and executive function predict different aspects of school adaptation in 7-year-old children (Neuenschwander et al., 2012). Effortful control was linked to achievement via learning-related behavior in class (i.e., listening to instructions, following directions, and accomplishment of tasks), whereas the relation between executive function and academic achievement was only partially mediated by learning-related behavior. The direct link between executive function and academic performance was explained by the domain-general role of EF in mastering novel tasks (i.e., standardized achievement tests) which is in line with previous arguments in literature (e.g., Yeniad, Malda, Mesman, Van IJzendoorn, & Pieper, 2013). Overall, these findings point to the importance of including both aspects of self-regulation in predicting academic outcomes in children.

Children from socioeconomically disadvantaged backgrounds are more likely to obtain lower scores on academic tests, go through more grade repetitions, and have a higher school dropout risk than those from socioeconomically advantaged backgrounds (McLoyd, 1998). The link between family socioeconomic status and academic achievement is explained by multiple mechanisms. Children from families with (more than) sufficient economic resources and highly educated parents are exposed to high cognitive stimulation and learning experiences at home (Bradley & Corwyn, 2002; Entwisle & Alexander, 1993), they have good role models who inspire their motivation for achievement (McLoyd, 1998), and their school-related needs are monitored well as their parents are more involved with children's school work (Barnard, 2004). All of these factors are known to promote children's success at school (Davis-Kean, 2005). In addition, there is accumulating evidence showing that sociodemographic factors may have effects on behavioral (Li-Grinning, 2007; Mezzacampa, 2004; Sektnan, McClelland, Acock, & Morrison, 2010) and cognitive regulation (Hughes, Ensor, Wilson, & Graham, 2010; Lipina, Martelli, Vuelta, & Colombo, 2005; Noble, Norman, & Farah, 2005). Exposure to poverty-related risks may hamper children's stress regulation, which limits their flexibility in attentional, emotional and behavioral competence (Evans, 2003). Furthermore, there is substantial evidence that the educational disadvantage of ethnic minority children is for a large part due to their generally higher levels of socioeconomic disadvantage (Magnuson & Duncan, 2006), pointing to the importance of accounting for family SES when examining predictors of achievement in these children.

Children's verbal ability is also linked to academic achievement (Duncan et al., 2007). There is a vast amount of evidence showing that children with better language-related skills outperform children with lower language-related skills on a variety of academic tasks (e.g., Kastner, May, & Hildman, 2001, McClelland, Morrison, & Holmes, 2000). Most ethnic minority children generally receive less exposure to the host language than children from monolingual families at home (Hoff et al., 2012). On the other hand, in many countries (including the Netherlands), schools do not provide education in the ethnic language and many schools even apply a rule stating that the children should speak the host language with each other when at school (Cummins, 2003; NLVF, 2006; Skutnabb-Kangas, 1995). Thus, for minority children, host language proficiency is critical for academic achievement as it influences children's capacity to understand lessons and assignments in school as well as to express themselves to their classmates and teachers. Therefore, we assessed host-language (i.e., Dutch) vocabulary, as an indicator of children's verbal ability and investigated its associations with academic achievement.

In the current study, we test the hypothesis that children's self-efficacy mediates the association between self-regulation in the last year of primary school and starting level in the secondary school tracks in 70 Turkish minority preadolescents in the Netherlands. We aim to extend previous research in several ways. First, our focus on ethnic minority children adds to the predominantly ethnic majority samples in most studies in this research area. Ethnic minority children are overrepresented in the lower tracks of secondary school in the Netherlands (Andriessen & Phalet, 2002), yet they are underrepresented in research examining the role of self-regulation in predicting academic achievement. Second, we examine whether children's perceptions about their efficacy in the transition to secondary school mediate children's self-regulatory capacities and their school success in the long run. There is very limited research focusing on the role of self-efficacy for the relation between self-regulation and achievement (Roebers et al., 2012). To the best of our knowledge, our study is the first one that is conducted in preadolescents. Third, we include both effortful control and executive function as indicators of self-regulation to examine whether self-regulation on the behavioral and cognitive level show different associations with child outcomes, which has been rarely studied in previous literature. We believe that this study will be helpful to obtain more insight regarding the potential factors related to minority children's performance in education.

We hypothesize that (1) self-efficacy mediates the association between self-regulatory capacities (i.e., effortful control and executive functions) and school attainment; (2) self-regulatory capacities, verbal ability and self-efficacy mediate the association between family SES and school attainment.

METHOD

Participants and Procedure

The sample consisted of 70 Turkish minority preadolescents (*M* = 12.34 years, *SD* = 0.43, range: 11.64-13.43) and their mothers in the Netherlands. All children were in the 6th and final grade of Dutch primary school. Forty-eight percent of the sample consisted of boys. The mothers had a mean age of 37.04 years (*SD* = 4.03). More than half of the mothers (51.5%) had a low education level (i.e., basic primary school education or low-status vocational education), 37.5% of them had a middle education level (i.e., high-status vocational education), and 8.9% had a high education level (i.e., university degree or above). Similarly, 50% of fathers were low educated, 31.8% of them were middle-educated and 18.1% were high educated. Most children lived in two-parent families with both their biological parents (84%). The majority of children had one (48%) or two (43%) siblings. Fifty-five percent of the children were firstborns.

The mothers were recruited from municipal registers of several cities and towns in the western and middle region of the country. To ensure the homogeneity of the sample, mothers who were born in the Netherlands (with at least one of their parents born in Turkey) or moved to the Netherlands before the age of 11, were selected. Furthermore, if the child's father's background was not Turkish, the family was excluded. Forty-three percent of the mothers were born in the Netherlands and 36% of the mothers migrated to the Netherlands before the age of seven. Twenty percent of them migrated after the age of seven. The majority of the fathers (95%) were born in Turkey.

Eligible families were informed about the research project through an introduction letter and a brochure. All correspondence was in Turkish and Dutch. Families who did not respond the letters were visited personally. In total, 454 families were reached of whom 72 (15.9%) agreed to participate. A subgroup of mothers who did not want to participate (N = 116) provided some general information about their families by filling out a form. These families did not differ significantly from the participating families in age of mother, father and child, country of birth of mother and father, child's gender, mother's marital status, and the number of siblings (*p*s .45 to .91).

Participating families were visited at home for two hours by two trained research assistants to conduct interviews, child testing, and video observation of mother-child interaction as well as to let parents and children fill out questionnaires. The tasks of interest for the current study were administered to the child in a quiet room in the following order: the Expressive One Word Picture Vocabulary Test, Digit Span Backward and Hearts and Flowers. Children took a snack-break for 10 minutes. After the break, they were asked to fill out the questionnaires designed to assess self-efficacy.

Measures

School attainment. During the interview, mothers were asked to report the track advice of the primary school that their children received for secondary school as well as the score their children obtained on the national achievement exam (CITO) that they take at the end of primary school. The advice for secondary school is predominantly based on the score that children obtain on the CITO, which assesses children's language, math performance, interpretation abilities (i.e., graphs, tables and maps) and world knowledge (i.e., geography, history, biology). In addition to this exam score, the primary school administration takes into account the parents' and child's ideas about which school track fits his or her interests and capacities (Luyten et al., 2003). Academically least promising children usually continue to lower vocational education (LWOO). Most of the children move on to the vocational education track (VMBO). The group that is evaluated higher than this group follows the track of higher or professional education (HAVO). Academically most promising students enter the track of advanced scientific education (VWO + gymnasium). For eighteen children, the advice was not known at the time of the home visit. Mothers of these children were contacted by telephone when children started secondary school to obtain the information about their children's track. Twelve of these mothers were reached. For the remaining six children, the secondary school tracks were estimated based on their CITO scores, because these were highly correlated with children's attainment in the secondary school education track, $r(50) = .83$, $p < .01$. The tracks of the secondary school education were rated on a 10-point scale from (1) lower vocational (LWOO) to (10) advanced scientific education (VWO + gymnasium).

Self-efficacy. Child's self-efficacy was based on three scales assessing psychological stress, school motivation and commitment, and academic pressure.

Psychological stress was measured by the adolescent version of the Strengths and Difficulties Questionnaire (SDQ, Goodman, 1997) which is a brief behavioral screening questionnaire originally designed to be filled out by parents and teachers. In the current study, the self-report version of the SDQ that was designed for eleven- to sixteen-years-olds, was used. The psychological distress scale consists of five items (e.g., *I am nervous in new situations; I get easily scared; I worry a lot*) rated on a 3-point scale (not true, somewhat true, certainly true). Scores were reverse coded so that higher scores reflected lower psychological stress. The internal consistency of the scale was adequate (Cronbach's $\alpha = .70$).

School motivation was assessed by the What I Think About School (WITAS) measure that was obtained from the NICHD Study of Early Child Care and Youth Development (NICHD-SECCYD, 2000-2004). The WITAS consists of fifteen statements such as "*I do not do well in school", "My teacher thinks that I am good in school", "Learning subjects is easy for me"* which are rated on a scale from (1) *Not true* to (4) *Very true* by children. The negative items were reversely coded so that higher scores reflected higher levels of motivation and school commitment. The internal consistency of the scale was high (Cronbach's $\alpha = .87$).

Academic pressure was measured by six items reflecting children's difficulties at school that were obtained from the Daily Hassles Scale (Oppedal & Røysamb, 2004). Children were asked to indicate how often they had problems such as *feeling not smart enough*, *having difficulty to understand the teacher, having pressure to do well in school* on a 4-point scale from (1) *never* to (4) *very often.* Scores were reversely coded so that higher scores reflected lower level of academic pressure. The internal consistency of the scale was marginal (Cronbach's $\alpha = .60$).

Psychological stress (SDQ) was highly correlated with school motivation, $r(68) = .44$, $p < .01$, and academic problems $r(68) = .57$, $p < .01$). School motivation was also related to academic pressure, $r(68) = .40$, $p < .01$. A Principal Component Analysis (PCA) was performed on the total scores of the three scales, showing that all three measures loaded on a single component (loadings .74 - .85). The sum of the standardized scores of these three scales was computed and used as an indicator of self-efficacy in further analyses. The internal consistency of the scale was high (Cronbach's $\alpha = .88$).

Effortful control. Children's temperamental effortful control was measured by mothers' ratings on three subscales of the Early Adolescent Temperament Questionnaire-Revised (EATQ-R, Putnam, Ellis, & Rothbart, 2001): activation control, inhibitory control and attentional focusing. The activation control subscale, consisting of seven items, assesses the children's ability to perform an action despite an impulse to avoid it (e.g., "*My child puts off his/her projects until due date*."). The inhibitory control subscale consisting of five items taps into the children's capacity to suppress inappropriate responses (e.g., "*My child has a hard time to wait for his/her turn.*"). The attentional focusing subscale consists of six items and measures children's capacity to sustain attention (e.g., "*My child forgets what he/she is doing when interrupted*."). The negative items were reversely coded so that higher scores reflected better effortful control. Activation control was highly correlated with inhibitory control, $r(59) = .41, p < .01$, and attentional focusing $r(59) = .57, p < .01$. Inhibitory control was also related to attentional focusing, $r(59) = .61, p < .01$. A PCA showed that the scores of the three subscales loaded on one factor (loadings .79 - .88). The internal consistency of the total scale was high (Cronbach's $\alpha = .85$).

Cognitive flexibility. The Hearts and Flowers task (Diamond, Barnett, Thomas, & Munro, 2007) was used to measure cognitive flexibility. The task was presented on a Dell laptop computer using E-prime 2 (Schneider, Eschman, & Zuccolotto, 2007) to present the stimuli and record responses for each trial. There were two types of stimuli; a red heart and a red flower appearing either on the right or the left side of the screen. Each stimulus was presented for 750 msec. The response button for the left side was the ‘‘Z’’ key on the computer keyboard, and the response button for the right side was the ‘‘M’’ key. The response buttons were indicated with a colored sticker.

The task consisted of three blocks: congruent-only, incongruent-only, and mixed. The first block (congruent-only) involved 12 trials in which the stimulus (a heart) appeared randomly on the right or left side of the screen. Participants were instructed to press the key that matched the side of the screen on which the heart appeared. The second block (incongruent-only) consisted of 12 trials, in which the stimulus was a flower. In this block, the participants were asked to press the key on the side opposite of the flower. The third and last block (mixed) included 16 congruent and 16 incongruent trials, which were semi-randomly mixed. Thus, participants performed the same task across trials in single blocks (i.e., only hearts or only flowers are shown), whereas they alternated between the two tasks (the same side and the opposite side) in the mixed block. In this regard, the mixed block requires working memory (i.e., keeping the two goals in mind), inhibition (i.e., suppressing congruent response when incongruent stimuli appear or vice versa), and cognitive flexibility (i.e., switching the tasks flexibly in response to unpredictably changing stimuli). For each block, instructions were presented on the computer screen and read aloud by the researcher to ensure that the child understood the requirements. Each of the first two blocks started with a block of four practice trials. Prior to the third block, no practice trials were conducted.

In the statistical analyses, responses faster than 200 msec were excluded from the analyses as they indicate a failure to wait for the upcoming stimulus or to release the button following the previous trial (Davidson, Amso, Anderson, & Diamond, 2006). Accuracy and reaction time of the practice items and the first trial in each block, which was considered as a warm-up, were excluded from the analyses. Trials following an error were not excluded from the analyses due to the limited number of trials in the blocks. Efficiency scores (the mean accuracy divided by median reaction time for correct responses) for the mixed block were used.

Working Memory. Digit Span Backward (Wechsler, 2003) was used as a verbal working memory test, in which the child hears a series of digits that were audio-recorded at a rate of one digit per second and is asked to repeat the digits in the opposite order. The digit clusters range from two to nine digits, and there are eight trials. Each trial contains two items with similar numbers of digits. The task is terminated when the child fails to repeat both items of a trial correctly. The total number of correct responses was used. The split-half sample reliability was .66. Items with zero variance were divided evenly across the two halves.

Dutch vocabulary. The Expressive One Word Picture Vocabulary Test (EOWPVT, Brownell, 2000) was translated into Dutch to measure Dutch expressive vocabulary. In this test, a picture is shown to the child on a computer screen and he or she is asked to name the picture in one word. The child's answers were recorded on a score sheet. In addition, the administration was audio-recorded to be able to decide on the scoring afterwards in case of ambiguous answers. Based on pilot assessments of the Dutch translation of this test, the map of the United States was replaced with a map of the Netherlands and the items 118 (*reel*), 146 (*prescription*) and 160 (*monocular*) were deleted since there were no appropriate Dutch translations. Item-response analyses (Furr & Bacharach, 2008) revealed that the increase in difficulty level of the items is similar to the increase in difficulty level of the items in the original English version. The raw scores that were computed according to the test manual were used. The split-half (odd/even) sample reliability was .99.

Socioeconomic status (SES). Family SES was based on the family's annual gross income and the highest completed educational level of both parents. The annual gross income was measured on a 7-point scale (1 = no income to 7 = more than €50,000). Parents' highest completed education was also measured on a 7-point scale (1 = no qualification to 7 = university level degree). Parental education level was recoded according to the international standard classification of education (ISCED; UNESCO, 2011). Because the factor analysis showed that maternal and paternal educational levels and annual family gross income loaded on a single factor (loadings of .71, .76, and .76 respectively), SES was computed as the mean of the standardized values of the income and education variables. For single mother families (n = 11), mother's educational level was counted twice. The missing values for mother education (n = 4), father education (n = 6), and family income (n = 13) were imputed through regression in which the available values for the SES variables were used as predictors.

Statistical analyses

There were no missing data on the outcome variable. Missing values on family SES (4.3%), self-efficacy (2.9%), vocabulary (11.4%), and effortful control (15.7%) were estimated by regression in which the available values for the variables of interest (family SES, child working memory, cognitive flexibility, effortful control, vocabulary, self-efficacy, and school attainment) were used in the Missing Value Analysis in IBM SPSS Statistics, version 19.0 for Windows. To answer our main research question we first computed correlations to explore the relations among the variables of interest. Second, a hierarchical regression analysis was conducted to investigate unique predictions of the predictors for school attainment. Third, path analysis was performed in EQS 6.1 (Bentler, 2001) to test the hypothesized model. The chi-square goodness of fit test, the Bentler-Bonnett Normed Fit Index (NFI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA) were used to evaluate the model fit. Finally, the Preacher and Hayes approach to test mediation was applied using the macro package for SPSS available on line to check the direct and indirect effects of the predictors on the outcome (Hayes, 2013). The Preacher and Hayes approach provides the option to test a mediation model including a single mediator and multiple predictors. It adopts the bootstrapping approach that does not assume that the sampling distributions of the indirect effects are normal, unlike the traditionally used Sobel test (Preacher & Hayes, 2004). Sampling distributions are estimated from random samples taken from the original data. Five thousand bootstrap resamples based on of the original data were computed and 95% confidence intervals that corrected for biases in the sampling distribution were used (Preacher & Hayes, 2008).

RESULTS

Descriptive statistics

Descriptive statistics of the main variables based on the original (nonimputed) data are reported in Table 1. All variables were inspected for possible outliers that were defined as values larger than 3.29 *SD* above or below the standardized mean (Tabachnick & Fidell, 2001). There were no outliers on any of the variables of interest. No gender differences were found on any of the variables (*p*s .26 to .95).

Table 1
Descriptive Statistics

	n	Range	M	SD
Family SES	67	-1.51 – 2.00	0.00	0.74
Cognitive flexibility	70	0.07 – 0.22	0.14	0.03
Working memory	70	5.00 – 13.00	8.41	1.69
Effortful control	59	2.31 – 4.53	3.44	0.55
Vocabulary	62	56.00 – 135.00	93.92	14.40
Self-efficacy	68	1.00 – 10.30	5.79	2.42
School attainment	70	1.00 – 10.00	5.64	2.45

Associations among the variables

Bivariate correlations among the variables of interest (Table 2) showed that family SES, child vocabulary, effortful control, and self-efficacy were all related to educational attainment in the expected direction. Family SES, child vocabulary, and effortful control were positively related to child self-efficacy. Working memory and cognitive flexibility scores were not related to any of the other variables. In the hierarchical regression analyses we entered child age, and family SES (step 1), working memory (step 2), cognitive flexibility (step 3), effortful control (step 4), vocabulary (step 5) and self- efficacy (step 6) as predictors of educational attainment. As shown in Table 3, family SES, child vocabulary and self-efficacy were significant predictors of school attainment in the final step. Effortful control was a significant predictor of educational attainment in the fifth step, but was no longer significant when self-efficacy was added in the final step.

Table 2
Correlations among Child Age, Background Characteristics, Self-regulatory Capacities, Vocabulary, Self-efficacy and Achievement

	1	2	3	4	5	6	7	8	9
1. Child age	-								
2. Generational status (mother)	-.20	-							
3. Family SES	-.18	.17	-						
4. Cognitive flexibility	.14	.07	.10	-					
5. Working memory	-.20	.12	.12	.01	-				
6. Effortful control	.04	.01	.12	-.17	.13	-			
7. Vocabulary	-.21	.17	.18	.21	.22	.10	-		
8. Self-efficacy	-.22	.17	.31*	.13	.07	.47**	.31**	-	
9. School attainment	-.23	.15	.41**	.19	.15	.33**	.63**	.56**	-

**p* < .05, ***p* < .01

Table 3
Hierarchical Regression Analysis Predicting School Attainment

Step and predictor variable	R^2	ΔR^2	β	*sr*
Step 1:	.19	.19**		
Child age			-.16	-.17
Family SES			.38**	.38
Step 2:	.20	.01		
Child age			-.14	-.15
Family SES			.37**	.38
Working memory			.08	.09
Step 3:	.23	.03		
Child age			-.17	-.19
Family SES			.35**	.36
Working memory			.07	.08
Cognitive flexibility			.18	.20
Step 4:	.34	.11**		
Child age			-.22*	-.24
Family SES			.30**	.34
Working memory			.03	.03
Cognitive flexibility			.25*	.28
Effortful control			.34**	.37
Step 5:	.56	.22**		
Child age			-.11	-.15
Family SES			.26**	.35
Working memory			-.05	-.08
Cognitive flexibility			.12	.17
Effortful control			.28**	.38
Vocabulary			.52**	.58
Step 6:	.60	.04*		
Child age			-.06	-.08
Family SES			.21*	.30
Working memory			-.03	-.04
Cognitive flexibility			.07	.10
Effortful control			.16	.20
Vocabulary			.48**	.56
Self-efficacy			.25*	.29

Note. *sr* = semipartial correlation.
$*p < .05$, $**p < .01$.

Testing the mediation model

Based on the hierarchical regression, we expected that effortful control might be linked to educational attainment via self-efficacy. Figure 1 shows the model that was tested. This model fit the data well, $\chi^2(2, 70) = 2.39$, $p = .30$, NFI = .98, CFI = 1.000, RMSEA = .05. The paths from SES to effortful control and vocabulary were not significant and were removed to obtain a more parsimonious model. Figure 2 shows the final model, which also fit the data well $\chi^2(4, 70) = 5.70$, $p = .22$, NFI = .94, CFI = .98, RMSEA = .08. Family SES , child effortful control and vocabulary were linked to educational attainment via self-efficacy. The direct paths from SES and vocabulary to educational attainment were also significant.

Using the SPSS macro package (Hayes, 2013), we tested whether family SES, child effortful control, and vocabulary (the independent variables) had indirect effects on school attainment (the dependent variable) via self-efficacy (the mediator). The indirect paths from

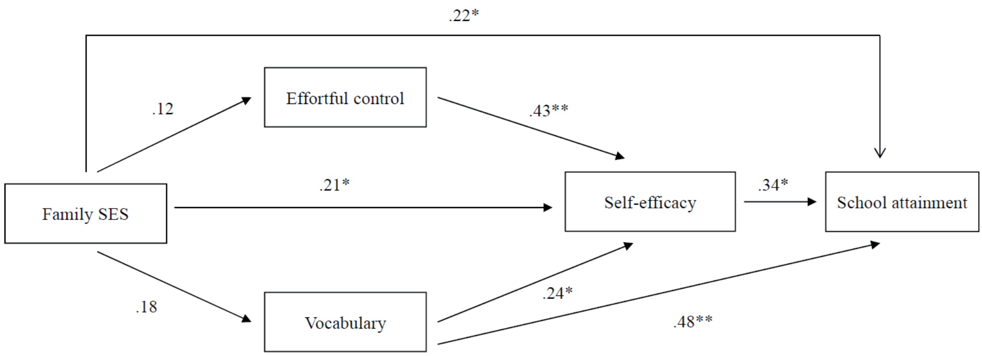

Figure 1. Path analysis on the associations between family SES, child effortful control, vocabulary, self-efficacy and school attainment (N= 70).
$^*p < .05$, $^{**}p < .01$.

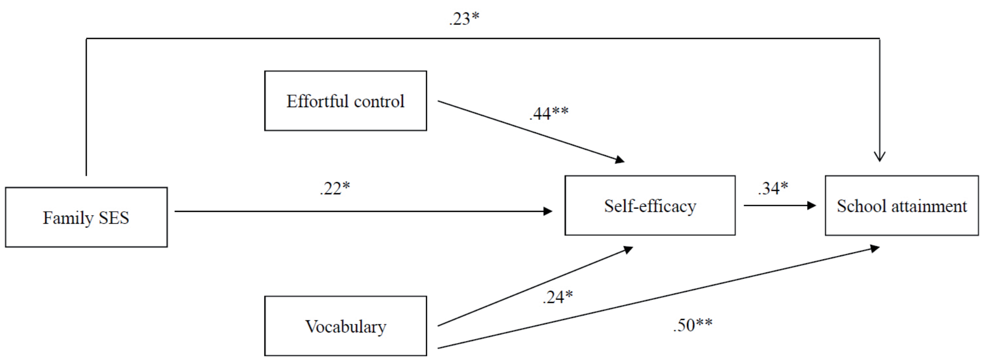

Figure 2. Path analysis on the associations between family SES, child effortful control, vocabulary, self-efficacy and school attainment (N= 70)
$^*p < .05$, $^{**}p < .01$.

SES [b = 0.20, SE = 0.12, CI = 0.002, 0.48], effortful control [b = 0.52, SE = 0.23, CI = 0.13, 1.02], and vocabulary [b = 0.01, SE = 0.006, CI = 0.0007, 0.022] through self-efficacy were significant. In addition, direct effects of SES [b = 0.73, SE = 0.28, $p < .05$], vocabulary [b = 0.07, SE = 0.01, $p < .001$], and self-efficacy [b = 0.28, SE = 0.10, $p < .01$] on school attainment were also significant.

DISCUSSION

Our findings showed that in a sample of ethnic minority children, temperamental effortful control (EC) was related to educational attainment via children's self-efficacy, whereas executive function (EF) was not associated with self-efficacy or academic attainment. Family SES and children's host language vocabulary had both direct effects and indirect effects on achievement through self-efficacy.

Consistent with our first hypothesis, children's self-efficacy fully mediated the relation between effortful control and educational attainment in terms of their future track in secondary school. Our findings are in line with previous studies showing that academic performance is predicted by effortful control (Blair & Razza, 2007; Liew, McTigue, Barrois, & Hughes, 2008; Valiente, Lemery-Chalfant, & Castro, 2007) and self-efficacy (Pajares, 1996; Zimmerman, Bandura, & Martinez-Pons, 1992). It appears that effortful control provides children with self-confidence regarding their academic abilities and motivation, which in turn facilitates academic performance. One previous study investigated whether effortful control predicted math and reading performance two years later via self-efficacy in children with low literacy scores, but failed to find support for a mediation model (Liew et al., 2008). The self-efficacy measure used in the current study reflects a broader construct than the one used by Liew and colleagues, involving not only perceived academic competence, but also motivation and psychological well-being, which contribute to self-efficacy in adolescence and adulthood (Jerusalem & Schwarzer, 1992; Luszczynska, Gutierrez-Dona, & Schwarzer, 2005). Consequently, in line with Blair and Diamond (2008), we suggest that self-regulation on the behavioral level may shape the way how preadolescents are viewed by their significant others. This affects how they view their capabilities (i.e., self-efficacy), which in turn is linked to the extent to which they are engaged in learning opportunities at school.

Contrary to our expectations, EF was not related to self-efficacy or academic outcomes. Previous research regarding the link between EF and self-efficacy is limited and inconclusive. Whereas one study reported that *gains* in EF skills predicted perceived academic competence across the school transition (Hughes et al., 2010), another study found no relation between the two constructs in second graders (Roebers et al., 2012). Our findings also did not support such an association in preadolescence. It is striking that mother-reported EC was closely related to self-efficacy, whereas performance-based EF was not. Given the close association between effortful control and social functioning (Valiente et al., 2011), it is possible that children with high effortful control are perceived as more competent by their parents, and receive positive feedback for showing behavioral control. In contrast, EF skills that require conceptual thinking (updating mental representations and switching between them) may not be easily noticed and encouraged by others. Given the fact that self-efficacy is highly dependent on the feedback coming from parents and teachers in childhood and adolescence (Bandura, 1997), we suggest that behavioral regulation is more likely to be rewarded and internalized as a part of a child's self image, compared to cognitive regulation.

Previous research shows clear links between EF performance (i.e., cognitive control) and academic outcomes in early adolescence (Best et al., 2011; Latzman, Elkovitch, Young, & Clark, 2010; Van der Sluis et al., 2007). The lack of significant relations between executive function scores and academic attainment in our study may be due to the specific EF measures that were used. Some have suggested a domain-general relation between complex EF tasks and academic achievement (Best et al., 2011). In our study, EF performance was assessed by the mixed block of Hearts and Flowers, which taps into the ability to switch between two simple tasks (i.e., pressing on the same side with the heart and opposite side with the flower) and digit span backward, which requires the ability to manipulate digits in mental space. Compared to complex EF tasks such as the Wisconsin Card Sorting Task, requiring plan generation, deductive reasoning and problem solving, the tasks used in our study might be cognitively less demanding, and therefore not clearly related to achieving a high secondary educational track, which requires good performance on reasoning and problem solving by using multiple sources of knowledge. Using a battery of EF tasks with a great deal of variety in terms of their nonexecutive requirements (i.e., intelligence) may provide more robust findings.

In line with our second hypothesis, children from higher SES backgrounds had higher levels of self-efficacy, which was in turn related to higher secondary school tracks. Highly educated parents might be more inclined to provide a supportive environment in which they encourage their children's curiosity and effort to succeed that stimulates children's sense of mastery and self-efficacy (Pajares, 1996). These children are generally more exposed to and involved in learning opportunities, which positively affects their performance in academic settings. Based on previous studies it seems likely that factors on the parent level (e.g., parental academic aspirations, parental involvement with school, parental sensitivity) that were not measured in the present study could account for the direct effect of SES on children's achievement (e.*g.,* Barnard, 2004; Bradley & Corwyn, 2002; Entwisle & Alexander, 1993).

Contrary to our expectations, children's vocabulary did not mediate the relation between family SES and academic achievement. Specifically, family SES was not related to vocabulary and effortful control. There is clear evidence that family SES is closely linked to young children's vocabulary through maternal communication (Hoff, 2003), home literacy (Leseman & De Jong, 1998; Prevoo et al., 2013), maternal attitudes towards parenting and knowledge about child development (Bornstein, Haynes, & Painter, 1998). Although research focusing on this relation in older children is limited, the existing findings support the fact that children from socioeconomically disadvantaged backgrounds stay behind their peers in receptive and expressive language skills in early adolescence (Chorny & Webbink, 2010; Spencer, Clegg, & Stackhouse, 2012; Walker, Greenwood, Hart, & Carta, 1994). Despite the nonsignificant association between family SES and vocabulary, our finding is in the expected direction and not far from significance, and can thus be seen as consistent with previous results. Previous results regarding the link between family SES and child (parent-reported) temperamental effortful control in early adolescence are limited and mixed (Lengua, 2006). Some reported small to moderate correlations between SES and parent or teacher reports of effortful control in preadolescents (e.g., Eisenberg et al., 2005; Veenstra et al., 2006). Others argued that demographic risk might be linked to effortful control in early years but not in adolescence due to decreased time spent with parents and intense school-based and peer-group experiences in this period (Lengua, 2006). Overall, we are inclined to be tentative in interpreting the effect of family SES on self-regulatory capacities for ethnic minority children in the way that has been done for ethnic majority, middle class children as SES may not fully account for the risk or resilience that ethnic minority children may experience (Garcia Coll et al., 1996; Raver, 2004). Families with a comparable SES but from different ethnic backgrounds might be exposed to different life experiences. For instance, even if ethnic minority families are able to move up on the social status ladder with an increased income, they may still live in socially and psychologically segregated contexts that brings a number of other stressors (Garcia Coll et al., 1996). These children might still be at-risk in several domains of life as a result of their minority-specific experiences rather than socioeconomic adversity. In the same vein, there is some evidence showing that ethnic minority students may perform better than majority students, particularly in academic tasks, despite their higher socioeconomic risk (Garcia Coll & Marks, 2011; Motti-Stefanidi, & Mastern, 2013). Consequently, a cumulative account of risk and protective factors including minority-specific factors may provide a more nuanced understanding regarding developmental competence of ethnic minority children.

Differences in language skills are known to be an important reason for achievement gaps between ethnic minority and majority children (Oller & Eilers, 2002). Our findings show that children's verbal ability in Dutch (the host language) showed the strongest association with academic achievement, which is not surprising given the monolingual education system in the Netherlands (Extra, 2010). Dutch studies with ethnic minority groups revealed that there were no deficits in minority preschoolers' domain-general abilities (i.e., fluid intelligence, visuospatial working memory) compared to their majority peers (Scheele, Leseman, &

Mayo, 2010; Messer, Leseman, Boom, & Mayo, 2010). However they still lagged behind majority children in language skills even at the age of six despite their fast acquisition of Dutch vocabulary by the time they were enrolled in primary school (Scheele et al., 2010). Thus, compensatory *language-focused* education programs that are accessible to low-income, ethnic minority families could be a promising avenue to ameliorate academic trajectories of minority students (Leseman, 2002). In addition, vocabulary was related to achievement via children's self-efficacy, indicating that strong oral language skills play a very positive role in ethnic minority children's lives, enabling them to have positive beliefs about their capabilities, which in turn strengthen their academic achievement. A previous study with a Turkish ethnic minority adolescent sample showed that self-reported psychological well-being contributed to socioeconomic status in adulthood (Van Oort et al., 2007). Given that Turkish minority adolescents have also been found to be more anxious and withdrawn than their Dutch peers (Murad, Joung, Van Lenthe, Bengi-Arslan, & Crijnen, 2003), programs promoting language skills may not only be helpful for minority adolescents' academic trajectories but also for their self-esteem, which in turn can contribute to their long-term quality of life.

Implications

This study has several theoretical and practical implications. Theoretically, our findings support the assertion that behavioral and cognitive aspects of self-regulation are distinct processes relating differently to child outcomes (Blair & Razza, 2007; Neuenschwander et al., 2012). This may partly reflect the different methods of measurement of effortful control and executive function (questionnaire versus performance-based tasks). Assessing both aspects of self-regulation appears to be productive in uncovering their specific contributions to child development. As for the practical implications of the study, we suggest that promoting self-regulatory mechanisms may help academically at-risk children such as ethnic minorities who dramatically lag behind their ethnic majority peers (Andriessen & Phalet, 2002). Although ethnic minority children are considered to face a higher number of socioeconomic risks than ethnic majority children (Duncan, Brooks-Gunn, & Klebanov, 1994; Magnuson & Duncan, 2006), self-regulation has been shown to predict academic achievement regardless of such risk factors (McClelland & Wanless, 2012). Given some evidence demonstrating that positive teacher-student relationships may help children with low effortful control to perform as well as those with high effortful control (Liew, Chen, & Hughes, 2010), programs might aim at improving teachers' ability to accurately observe the needs of children with difficulties in behavioral regulation and offer timely academic support. This may maximize these children's academic progress, which is likely to result in better long-term academic outcomes.

Limitations

It is important to note some limitations of the current study. First, the study was based on data at one time point, limiting clear inferences about the direction of effects. Although the outcome variable indicates secondary school tracks, we obtained this information at the home visits that were conducted when children were in the last year of primary school, at a point that tracking was already decided upon. Second, despite the effort that was put in the recruitment process (e.g., personally visiting families who did not react to initial attempts), the response rate was low, which resulted in a rather small sample size. However, our low response rate is in line with those found in other studies of ethnic minorities in the Netherlands, especially families from low SES backgrounds (Feskens, 2007). Third, our study did not include an ethnic majority comparison sample, so we could not examine to what extent our ethnic minority sample's abilities and school performance differs from majority children. It should be noted however that it is a methodological challenge to recruit ethnic majority children who are comparable to minority children in terms of family background due to the disparity in family SES between ethnic minority and majority families (Suárez-Orozco & Suárez-Orozco, 2001).

Conclusion

In sum, behavioral self-regulation (i.e., effortful control) is related to academic achievement through self-efficacy, indicating that effortful control contributes to resilience in ethnic minority preadolescents. Children with high effortful control had more positive perceptions about their capabilities, which in turn promoted their academic performance enabling them to start at a higher level in secondary school. Thus, fostering behavioral self-regulation may encourage more demanding academic trajectories of at-risk groups.

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Cognitive flexibility in children across the transition to school: A longitudinal study

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ABSTRACT

Longitudinal research exploring the development of cognitive flexibility is lacking. In this study we investigated the speed-accuracy pattern in cognitive flexibility performance measured in the mixed block of a task switching paradigm in eighty-seven 5- to 6-year-old children before and after the transition to formal education. For the total group, longitudinal change was observed in accuracy but not in speed of responding. Children with low accuracy scores in kindergarten were faster than those with high accuracy scores, but the low-accuracy group showed a significant performance gain in accuracy over time, whereas high-accurate kindergartners only gained in speed. These results suggest an important role of formal schooling in cognitive control in narrowing the performance gap between less able children and their more able peers. The findings also show that diverse developmental paths in flexible thinking can be identified.

Keywords: flexibility, shifting, executive function, task switching, cognitive development, children

INTRODUCTION

Flexible thinking in the face of ever-changing situations is crucial for human cognition. This ability, known as the shifting or cognitive flexibility component of executive function (EF), refers to switching between multiple and conflicting representations, strategies or responses as task demands change (Miyake et al., 2000). This is a decision-making process in which a compromise is made between making quick and correct choices (Bogacz, Wagenmakers, Forstmann, & Nieuwenhuis, 2010). Some individuals tend to make fast decisions by taking the risk of making errors; others tend to use additional time to ensure that they make the right choice (Ivanoff, Branning, & Marois, 2008). Although accuracy and speed are interrelated (Pachella, 1974), it is unclear whether they capture the same processes (Cragg & Chevalier, 2012) or whether they always go in the opposite direction across conditions and across people (Salthouse, 2010). Previous research has shown that the speed-accuracy tradeoff in task switching develops over time (Davidson, Amso, Anderson, & Diamond, 2006). Young children are too impulsive to trade speed for making correct decisions in contrast to adults. The major gains in shifting ability occur in the preschool years although it shows a protracted development until adulthood (Cragg & Chevalier, 2012). The first year of formal education, during which children need to adjust to a set of standards that are likely to be substantially different from those in kindergarten and at home, provides children with several opportunities to use and practice EF skills (Diamond, Barnett, Thomas, & Munro, 2007). The main aim of this study is to explore children's speed-accuracy pattern in cognitive flexibility performance before and after the transition to the first year of formal education, which is an important milestone in children's cognitive development.

Cognitive flexibility

Cognitive flexibility enables us to see the world from a new and different perspective, which is vital for adaptation and creativity (Davidson et al., 2006). We build particular representations to different circumstances and switch between the competing responses by activating and modifying the representations in a dynamic way when circumstances change unpredictably (Deak & Narasimham, 2003). This is a complex cognitive mechanism involving multiple subprocesses. Diamond (2006) proposed that flexibility incorporates two other well-known EF components: working memory for keeping task goals actively in mind and inhibition for overriding the previous task set. On the other hand, there is some evidence showing that working memory, rather than inhibition, mainly accounts for cognitive flexibility in young children (Blackwell, Cepeda, & Munakata, 2009; Cepeda & Munakata, 2007). Accordingly, having stronger working memory representations of the current task enhances successful switching, which cannot be explained by inhibitory abilities, motivation or general cognitive ability. Nevertheless, the nature of cognitive flexibility is not yet fully understood. It involves other EF components to some extent, there seems to be a consensus that cognitive flexibility cannot be reduced to one single component or cannot be explained by the combination of inhibition and working memory per se (Cragg & Chevalier, 2012).

Task switching

In recent years, cognitive flexibility has been frequently assessed by the task-switching paradigm in school-age children (Crone, Bunge, van der Molen, & Ridderinkhof, 2006; Davidson et al., 2006; Huizinga, Burack, & Van der Molen, 2010; Karbach & Kray, 2007). In the task-switching paradigm, participants are asked to perform the same task across all trials in simple blocks whereas they must alternate between two tasks from trial to trial in mixed blocks. They switch their response when the rule changes from trial to trial (i.e., switch trials) and they repeat their response when the rule does not change (i.e., nonswitch trials). Comparing performance between single and mixed blocks (global switching) or performance between switch trials and nonswitch trials within mixed blocks (local switching) taps into the different processes specific to shifting ability (Cragg & Nation, 2010). The difference scores, namely costs in accuracy (or errors) and reaction time between different blocks (i.e., single versus mixed) or types of trials (i.e., switch versus nonswitch), are commonly used as indicators of shifting performance. It has been argued that age-related changes are more noticeable while comparing performance between the single and mixed blocks than comparing performance on different types of trials within the mixed block (Dibbets & Jolles, 2006; Karbach & Kray, 2007; Kray, Eber, & Lindenberger, 2004). There are however some concerns regarding the reliability of the difference scores due to the restricted range and variability of the scores which makes it difficult to detect individual differences (Eide, Kemp, Silberstein, Nathan, & Stough, 2002; Lee, Ng, & Ng, 2009; Strauss, Allen, Jorgensen, & Cramer, 2005).

The task score that is used as an indicator of cognitive flexibility (i.e., accuracy, reaction time or efficiency) mostly varies with the age of the participant. Whereas accuracy is typically used in preschoolers, reaction time is reported in older children and adults. It has been suggested to measure both to make valid comparisons between different age groups (Cragg & Chevalier, 2012). Studies comparing performance of distinct age groups have shown that slowing down responses for accurate shifting is an age-related improvement (Crone et al., 2006; Davidson et al., 2006). With increasing age, people are more likely to know that slowing down is sometimes necessary for accurate performance and to detect the situations where slowing down is more advantageous than maintaining speed. Longitudinal studies might be useful to obtain a more nuanced understanding regarding which aspects of performance on a shifting task change with age (Best & Miller, 2010). Although the early elementary school years represent a critical period in the development of cognitive flexibility (Roebers, Rothlisberger, Cimeli, Michel, & Neuenschwander, 2011), there seems to be no study examining speed-accuracy pattern on this ability longitudinally in these years.

Factors related to cognitive flexibility

There are a number of variables that might be related to the development of shifting ability. A strong association between language and cognitive flexibility has been reported although the mechanisms explaining the nature of the association are not exactly known (Jacques & Zelazo, 2005). Inner speech is considered to help one to form representations of the rules that are used to retrieve and activate the relevant goals of the task (Cragg & Nation, 2010). In a longitudinal study, the rates of change in a latent EF factor reflecting planning, inhibitory control, and working memory performance across the transition to school were predicted by children's verbal mental age (assessed by a vocabulary scale), indicating that school experience functioned as "an equalizing force" by helping verbally less able children to make the greatest gains and to catch up with their peers (Hughes, Ensor, Wilson, & Graham, 2010). The findings point to the importance of language for the development of executive control, but it is not clear whether this holds for cognitive flexibility.

In addition, previous research has shown that family socio-economic status (SES) is associated with children's cognitive outcomes as it affects the quality of stimulating resources and experiences in the home (Bradley & Corwyn, 2002). Research focusing on the potential relation between SES and shifting ability is scarce. There is some cross-sectional evidence showing that poverty affects performance on several EF measures including those requiring shifting ability in kindergarteners and school-age children (Noble, Norman, & Farah, 2005; Sarsour et al., 2011). Some findings also demonstrated that cognitive flexibility is affected by SES in infancy (Lipina, Martelli, Vuelta, & Colombo, 2005) and delays are stable over time (Clearfield & Niman, 2012). Hughes and colleagues (2010) reported that family income did not predict developmental changes in EF from the age of four to six years, indicating that children from poorer families continued to stay behind those from wealthier families following the transition. Thus, previous findings suggest that SES may have irreversible consequences in EF development, and hence needs to be taken into account in investigating the early development of cognitive flexibility.

Child characteristics such as gender may also lead to individual differences in performance on cognitive flexibility tasks, although the findings are ambiguous. Some studies showed that girls outperform boys on EF measures in the early years of life (Hughes & Ensor, 2005; Wiebe, Espy, & Charak, 2008), others reported no gender difference in preschoolers (Vitiello, Greenfield, Munis, & George, 2011) and school-aged years (Ardila, Rosselli, Matute, & Guajardo, 2005). It is likely that the gender effect on EF performance varies with children's age, tasks used to measure EF components of interest, or the score type of the task.

The current study

There is some evidence showing that flexibility is related to school readiness (Vitiello et al., 2011) and academic achievement (Yeniad, Malda, Mesman, Van IJzendoorn, & Pieper, 2013). In this regard, examining the development of this ability in diverse samples especially those who may have difficulties at school is crucial. Some studies demonstrated that ethnic minority children might be at risk in academic achievement due to several reasons such as coming from socioeconomically disadvantaged families (Suárez-Orozco & Suárez-Orozco, 2001), attending elementary schools with deprived resources and low academic focus (Crosnoe, 2005), having a low level of host language proficiency (Bhattacharya, 2000), and being less likely to be enrolled in center-based child care or preschool before formal education (Magnuson, Lahaie, & Waldfogel, 2006). The transition to formal schooling is an assessment point for educators to identify potential risk and protective factors that may influence children's long-term academic trajectories. Tracking the early development of cognitive flexibility in this population may provide some insight regarding potential assessment and prevention programs for academic difficulties.

In this study, we explore the development of cognitive flexibility performance in speed and accuracy in 5- to 6-year-old ethnic minority children across the transition to formal reading and writing education, taking into account the potential associations with vocabulary, working memory and SES. The contributions of this study are threefold. First of all, most of the previous research regarding cognitive flexibility has been conducted either in preschoolers (Chevalier & Blaye, 2008; Diamond, Carlson, & Beck, 2005; Yerys & Munakata, 2006) or school-age children (e.g., Cepeda, Kramer, & Gonzalez de Sather, 2001; Crone et al., 2006; Kray, Eber, Linderberger, 2004). Studies investigating the ability both in preschool and school-age years are scarce (e.g., Davidson et al., 2006; Karbach & Kray, 2007). Longitudinal research examining the development of flexible thinking during the transition to formal schooling is lacking. Our study is an attempt to obtain a nuanced understanding of which aspects of cognitive flexibility performance change in this period. Second, given some concerns regarding the question whether different types of scores tap into the same processes of executive control (Cragg & Chevalier, 2012) or whether they develop in the same pattern (Davidson, et al., 2006; Salthouse, 2010), we investigate developmental changes of task switching both in accuracy and reaction time. Third, our sample involves children with a Turkish ethnic minority background in the Netherlands. Given a body of research showing that ethnic minority children might have difficulties at school (Bhattacharya, 2000; Magnuson, et al., 2006), research on the development of cognitive flexibility that contributes to school readiness (Vitiello, et al., 2011) and achievement (Yeniad et al., 2013) could especially benefit this particular group.

METHOD

Participants and Procedure

Turkish immigrant mothers, who had 5- or 6-year old children in the 2^{nd} year of Dutch primary school—which corresponds to kindergarten in the U.S.—were recruited from the municipal records of several cities in the Netherlands. The sample consisted of 87 Turkish immigrant mothers and their children. To ensure the homogeneity of the sample, mothers who were born in the Netherlands (with at least one of their parents born in Turkey) or moved to the Netherlands before the age of 11, were selected. Furthermore, if the child's father's background was not Turkish, the family was excluded. Eligible families were informed about the research project through an introduction letter and a brochure. All correspondence was in Turkish and Dutch. In total, 639 families were reached of whom 113 (18%) agreed to participate. A subgroup of mothers who did not want to participate (N = 151) provided some general information about their families by filling out a form. These families did not differ significantly from the participating families in age of father, mother and child, child gender, country of birth of mother and father, mother's marital status, family situation, and the number of siblings (*p*s .12 to .89).

Participating families filled out questionnaires and they were visited at home at two different time points: when children were in the second semester of kindergarten (T1) and one year later, in the second semester of the first year of formal education (T2). Two trained research assistants conducted mother and child interviews, child testing and video observation during the 2-hour home visit. The tasks of interest for the current study were administered to the child in a quiet room in the following order: the Expressive One Word Picture Vocabulary Test, Digit Span Backward and Hearts and Flowers.

In kindergarten, the data for nine children were missing due to the technical problems. Of the 104 children participating in the study in kindergarten, 87 provided valid data for the variables of interest in the first grade of formal education. Children who dropped out after kindergarten did not differ in age, gender, number of siblings, birth rank, country of birth of parents, mother's marital status, family SES, working memory capacity, vocabulary performance and speed on the task switching paradigm (*p*s .12 to .87) from those who continued to participate in our study in the first grade. However, children who dropped out performed significantly worse on the task switching paradigm in the first wave of assessments, evidenced by fewer accurate responses in the mixed block ($p < .05$) compared to children who stayed in the study.

At the first time point of data collection (kindergarten), the children had a mean age of 6.07 years (SD = .30). Forty-one percent of the sample consisted of boys. The mothers had a mean age of 32.73 years (SD = 4.12). Most children lived in two-parent families with both their biological parents (94%). The majority of the children had one sibling (60.9%), 11.5% had no siblings and 27.5% had two or more siblings. Sixty percent of the children were the first-born child in their family.

Measures

Vocabulary. The Expressive One Word Picture Vocabulary Test (EOWPVT, Brownell, 2000) was translated into Dutch to measure Dutch expressive vocabulary. In this test, a picture is shown to the child on a computer screen and he or she is asked to name the picture in one word. The child's answers were recorded on a score sheet. In addition, the administration was audio-recorded to be able to decide on the scoring afterwards in case of ambiguous answers. Based on pilot assessments of the Dutch translation of this test, the map of the United States was replaced with a map of the Netherlands and the items 118 (reel), 146 (prescription) and 160 (monocular) were deleted since there were no appropriate Dutch translations. Item-response analyses (Furr & Bacharach, 2008) revealed that the increase in difficulty level of the items is similar to the increase in difficulty level of the items in the original English version. The raw scores that were computed according to the test manual were used. The split-half (odd/even) sample reliability was .97.

Working Memory. The Digit Span Backward (Wechsler, 2003) was used as a verbal working memory test, in which the child hears a series of digits that were audio-recorded at a rate of 1 digit per second and is asked to repeat the digits in the opposite order. The digit clusters range from 2 to 9 digits, and there are eight trials. Each trial contains two items with similar numbers of digits. The task is terminated when the child fails to repeat both items of a trial correctly. The total number of correct responses was used. The split-half (odd/even) sample reliability was .85.

Cognitive Flexibility (task switching). The Hearts and Flowers task (Diamond et al., 2007) was used to measure task switching. The task was presented on a Dell laptop computer using E-prime 2 (Schneider, Eschman, & Zuccolotto, 2007) to present the stimuli and record responses for each trial. There were two types of stimuli; a red heart and a red flower appearing either on the right or the left side of the screen. Each stimulus was presented for 1500 msec. The response button for the left side was the "z" key on the computer keyboard, and the response button for the right side was the "m" key. The response buttons were indicated with a colored sticker. The task consisted of three blocks; congruent-only, incongruent-only and mixed. For each block, instructions were presented on the computer screen and read aloud by the researcher to ensure that the child understood the requirements. Each of the first two blocks started with a block of four practice trials. Prior to the third block, no practice trials were applied.

The first block (congruent-only) involved 12 trials in which the stimulus (a heart) appeared randomly on the right or left side of the screen. Participants were instructed to press the key that matched the side of the screen at which the heart appeared. The second block (incongruent-only) consisted of 12 trials, in which the stimulus was a flower. In this block, the participants were asked to press the key on the side opposite of the flower. The third and last block (mixed) included 16 congruent and 16 incongruent trials, which were semi-randomly mixed. The congruent-only block requires remembering a rule (press on the same side as the heart) whereas the incongruent-only block requires inhibiting the previously learned rule in addition to keeping a new rule in mind (press on the opposite side of the flower). Participants perform the same task across trials in single blocks (i.e., only hearts or only flowers are shown), whereas the mixed block requires switching between the two tasks (the same side and the opposite side), which taps into cognitive flexibility (Diamond, et al., 2007). Two consecutive trials can be either nonswitch trials (i.e., both show a heart and both show a flower) or switch trials (i.e., one shows a heart and the other one a flower). The number of switch trials varied between and within individuals as a result of the semi-randomized design of the task.

In the statistical analyses, median reaction time for all items and mean accuracy scores were used. Reaction time of only correct items and reaction time of all items were highly correlated ($r = .93$, $p < .001$ in single, $r = .95$, $p < .001$ in mixed block at T1 and $r = .98$, $p < .001$ in single, $r = .97$, $p < .001$ in mixed block at T2). Responses faster than 200 ms were excluded from the analyses as they indicate a failure to wait for the upcoming stimulus or to release the button following the previous trial (Davidson et al., 2006). Accuracy and reaction time of the practice items and the first trial in each block, which was considered as a warm-up, were excluded from the analyses. Trials following an error were not excluded from the analyses due to the limited number of trials in the blocks. The mean accuracy and median reaction time scores of the congruent-only and incongruent-only blocks were averaged to compare performance between the single-task condition and the mixed condition. In addition to the absolute scores (aggregated accuracy and reaction time per block), we computed global (or general) switch costs as the difference between the single blocks versus all trials in the mixed block as previous research suggested that age-related changes are more profound in global comparison than local comparison (e.g.,Karbach & Kray, 2007).

Socioeconomic status (SES). Family SES was based on the family's annual gross income and the highest completed educational level of both parents. The annual gross income was measured on a 7-point scale (1 = no income to 7 = more than €50,000). Parents' highest completed education was also measured on a 7-point scale (1 = no qualification to 7 = university level degree). Parental education level was recoded according to the international standard classification of education (ISCED; UNESCO, 2011). Because the factor analysis showed that maternal and paternal educational levels and annual family gross income loaded on a single factor (loadings of .81, .83, and .78 respectively), SES was computed as the mean of the standardized values of the income and education variables. For the children of single mothers (n = 5), SES was based on mother's education level and income. There were no missing values for mother's education. The missing values for father education (n = 3) and family income (n = 7) were imputed through regression in which the available values in the SES variables were used as predictors.

Analyses

Statistical analyses were performed using SPSS 19 software. Longitudinal changes in accuracy and speed of cognitive flexibility performance from kindergarten (T1) to the first grade of formal education (T2) were explored in repeated measures ANOVAs. The first group of analyses was conducted with 'task blocks across time' as the within-subjects factor (T1Single, T1Mixed, T2Single, T2Mixed) and the absolute scores of the task blocks (mean accuracy and median reaction time aggregated per block) as separate dependent variables. The second group of analyses was performed with time (T1, T2) as the within-subjects factor and global switch costs in accuracy and reaction time as separate dependent variables to examine whether developmental changes were observed in the cost scores. Greenhouse-Geisser corrections were performed when necessary.

Covariates

To investigate whether the longitudinal changes in working memory or vocabulary performance explain the improvement of cognitive flexibility performance from kindergarten to the first grade, differences between T1 and T2 working memory and vocabulary scores were computed. These difference scores were used as covariates in addition to gender and SES in a second set of GLM analyses.

Accuracy groups

To understand the relation between accuracy and reaction time longitudinally, children were grouped by a median split based on the absolute accuracy scores in the mixed block at T1 (*median* = 0.60). The high-accuracy group (M = 990.70, SD = 202.70) were significantly slower than the low-accuracy group (M = 740.24, SD = 213.97) in the mixed block at T1 ($t(85) = -5.60$, $p < .001$). High accuracy children performed better (evident by more accurate responses) than low accuracy children both on the switch ($t(84) = -11.37$ $p < .001$) and nonswitch trials ($t(84) = -11.65$ $p < .001$) of the mixed block. Seventy percent of T1 high accuracy children scored higher than the median accuracy score of the mixed block at T2 (*median* = .70), χ^2 (1) = 15.75, $p < .001$, ǿ = .42. The mean number of switch trials was not significantly different between the groups, $t(85) = 0.88$, $p = .38$ at T1, and $t(85) = 0.13$, $p = .89$ at T2. In a third set of analyses, the "T1 accuracy groups" variable was included as additional between-subjects factor.

RESULTS

Descriptives

Descriptive statistics of the main variables at T1 and T2 are reported in Table 1. Bivariate correlations between the child's age, SES, working memory, vocabulary, and task switching scores were computed (Table 2). In line with the speed-accuracy tradeoff phenomenon, reaction time showed a positive correlation with accuracy in the mixed block of the task switching paradigm at both time points. Working memory was positively associated with absolute reaction time in the mixed block at T1. In addition, SES and vocabulary performance measured at T1 were positively correlated with absolute accuracy in the mixed block measured at T2. Gender differences were examined on the variables of interest. Boys were significantly faster than girls in the mixed block at T1, $t(85) = -2.06$, $p < .05$, and in the single block at T2, $t(85) = -2.40$, $p < .05$. No gender differences were found for global switch costs in accuracy or reaction time.

Table 1

Descriptive Statistics for Child's Age and Test Scores Before and After Transition to Formal Education

	Kindergarten (T1)			First grade (T2)		
	Total sample (N = 87)	T1 high-accuracy (N = 44)	T1 low-accuracy (N = 43)	Total sample (N = 87)	T1 high-accuracy (N = 44)	T1 low-accuracy (N = 43)
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Child age (months)	72.44 (3.65)	72.11 (3.99)	72.77 (3.27)	82.96 (3.33)	83.10 (3.53)	82.84 (3.15)
Working memory	3.59 (1.99)	4.20 (1.66)	3.30 (1.99)	4.64 (1.61)	4.86 (1.15)	4.41 (1.96)
Vocabulary	46.72 (12.11)	50.75 (14.32)	43.41 (9.35)	57.09 (11.96)	58.86 (12.27)	55.28 (11.51)
SES (standardized)	0.00 (0.80)	0.12 (0.78)	-0.12 (0.81)	-	-	-
TS Single Acc	0.91 (0.11)	0.93 (0.86)	0.88 (0.12)	0.91 (0.11)	0.93 (0.86)	0.89 (0.13)
TS Mixed Acc	0.65 (0.18)	0.80 (0.11)	0.49 (0.07)	0.70 (0.19)	0.78 (0.18)	0.61 (0.17)
TS Single RT	642.82 (202.52)	616.80 (187.88)	669.43 (215.43)	523.63 (145.48)	517.04 (136.65)	530.38 (155.34)
TS Mixed RT	866.91 (242.48)	990.70 (202.85)	740.24 (213.97)	788.95 (223.60)	803.50 (211.78)	774.08 (236.65)
Switch costs Acc	0.26 (0.18)	0.12 (0.10)	0.39 (0.14)	0.21 (0.19)	0.15 (0.18)	0.28 (0.19)
Switch costs RT	224.97 (118.16)	373.90 (205.30)	68.95 (250.26)	265.32 (188.16)	286.45 (173.95)	243.69 (201.43)

Note. TS = Task switching; Acc = Accuracy (mean); RT = Reaction time (median) in msec.

Table 2
Bivariate Correlations

	1. Age	2. SES	3. WM	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. T1 Age (months)	-																	
2. T1 SES	-.14	-																
3. T1 WM	.12	.14	-															
4. T1 Vocabulary	.31**	.27*	.22*	-														
5. T1 Single Acc	.11	.10	.15	.11	-													
6. T1 TS Mixed Acc	.09	.16	.16	.16	.27*	-												
7. T1 TS Single RT	-.13	-.09	-.15	-.20	.21*	-.06	-											
8. T1 TS Mixed RT	.09	.14	.28**	.20	.44**	.47**	.26*	-										
9. T1 Switch cost Acc	-.03	-.09	-.06	-.09	.32**	-.82**	.19	-.20	-									
10. T1 Switch cost RT	.19	.19	.37**	.33**	.23*	.46**	-.51**	.69**	-.32**	-								
11. T2 WM	.07	.14	.20	.20	.08	.08	-.12	.16	-.02	.23*	-							
12. T2 Vocabulary	.14	.31**	.24*	.70**	.12	.08	-.14	.18	-.01	.26*	.20	-						
13. T2 TS Single Acc	-.04	.13	.04	.09	.07	.19	-.17	.02	-.14	.15	.11	-.12	-					
14. T2 TS Mixed Acc	-.02	.24*	.15	.22*	.19	.44**	-.01	.30**	-.32**	.27*	-.04	.22*	.24*	-				
15. T2 TS Single RT	-.20	.03	-.11	-.18	.07	.02	.50**	.17	-.02	-.22*	.02	-.13	.05	.20	-			
16. T2 TS Mixed RT	-.02	.03	-.01	.03	.03	.06	.30**	.22*	-.04	.02	-.20	-.02	-.08	.57**	.55**	-		
17. T2 Switch cost Acc	.00	-.16	-.13	-.16	-.14	-.32**	-.09	-.28**	.23*	-.18	.10	-.14	.33**	-.83**	-.17	-.60**	-	
18. T2 Switch cost RT	.13	.01	.08	.18	-.02	.05	-.03	.13	-.07	.15	-.21*	.07	-.13	.53**	-.12	.76**	-.58**	-

Note. TS = Task switching; WM = Working memory; T1 = Kindergarten; T2 = First grade; Acc = Accuracy (mean), RT = Reaction time (median) in msec.
* $p < .05$, ** $p < .01$.

Longitudinal changes in the absolute scores and global switch costs

The first group of repeated-measures ANOVAs revealed a significant main effect of 'task blocks across time' factor (T1Single, T1Mixed, T2Single, T2Mixed) on mean accuracy $F(2.77, 238.94) = 93.52$, $p < .001$, $\eta^2_p = .52$ and median reaction time $F(2.48, 213.61) = 71.01$, $p < .001$, $\eta^2_p = .45$. Contrasts demonstrated that children performed worse in the mixed block than the single block, as shown by less accurate responses, $F(1, 82) = 64.51$, $p < .001$, $\eta^2_p = .66$ at T1, $F(1, 82) = 37.35$, $p < .001$, $\eta^2_p = .54$ at T2, and longer reaction times, $F(1, 82) = 20.00$, $p < .001$, $\eta^2_p = .40$ at T1, $F(1, 82) = 82.96$, $p < .001$, $\eta^2_p = .69$ at T2. From kindergarten to the first grade, children showed a significant increase in accuracy in the mixed block $F(1, 86) = 5.80$, $p < .05$, $\eta^2_p = .06$, but not in the single block. In addition, they showed a significant decrease in reaction time in the single $F(1, 86) = 38.07$, $p < .001$, $\eta^2_p = 0.31$, but not in the mixed block (Figure 1). The gain in the mixed block performance, which requires flexible responding to conflicting demands, was in accuracy, but not in reaction time. Controlling for the potential influences of gender, SES, the longitudinal differences in working memory and vocabulary in the repeated measures ANCOVA with 'task blocks across time' as within-subjects factor and absolute accuracy or reaction time as the dependent variables did not change the results. There were no significant interactions between time and any of the covariates. The second group of repeated-measures ANOVAs with time (T1, T2) as the within-subjects factor and global switch costs as separate dependent variables did not show significant changes for accuracy ($p = .10$) or reaction time ($p = .21$).

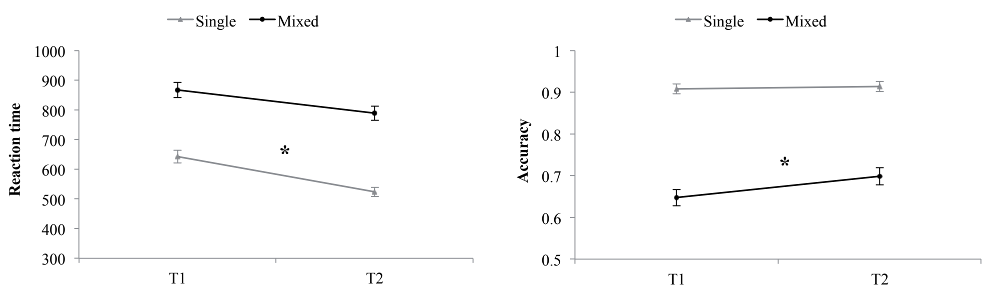

Figure 1. Longitudinal change in the single and mixed blocks of the task switching paradigm (± *SE*). Asterisk (*) indicates significant difference.

Longitudinal patterns of the accuracy groups in absolute scores

The repeated measures ANCOVA with 'task blocks across time' as within-subjects factor, T1 accuracy groups (low versus high accuracy) as between-subjects factor, gender, SES, the longitudinal differences in working memory and vocabulary as the covariates on absolute accuracy and reaction time as the dependent variables revealed a significant interaction between 'task blocks across time' and 'T1 accuracy groups' factors on accuracy, $F(2.54, 208.30) = 25.02$, $p < .001$, $\eta^2_p = 0.23$ and reaction time, $F(2.51, 206.32) = 13.58$, $p < .001$, $\eta^2_p = 0.14$. Within-subjects contrasts revealed that in kindergarten the T1 high-accuracy group showed a significant increase in reaction time from the single to the mixed block at T1, $F(1,39) = 52.21$, $p < .001$, $\eta^2_p = 0.57$ in contrast to the T1 low-accuracy group who did not change their speed from the single to the mixed block ($p = .41$). In the first grade however, both groups were able to slow down from the single to the mixed block (T1 high-accuracy group: $F(1,39) = 45.76$, $p < .001$, $\eta^2_p = 0.54$, T1 low-accuracy group: $F(1,38) = 31.12$, $p < .001$, $\eta^2_p = 0.45$). A glance on the longitudinal performance of the groups in the mixed block (Figure 2) demonstrated that the T1 high-accuracy group increased their speed, $F(1,39) = 11.66$, $p < .01$, $\eta^2_p = 0.23$ without any significant gain (or loss) in accuracy ($p = .73$). The T1 low-accuracy group, on the other hand increased their accuracy in the mixed block, $F(1,38) = 10.35$, $p < .01$, $\eta^2_p = 0.21$, without any significant change in speed ($p = .58$). Despite the accuracy gain of the T1 low-accuracy children over time, they were still significantly less accurate *(M* = 0.61, *SD* = 0.17) than T1 high- accuracy children *(M* = 0.78, *SD* = 0.18) in the mixed block at T2, $t(85) = -4.48$, $p < .001$.

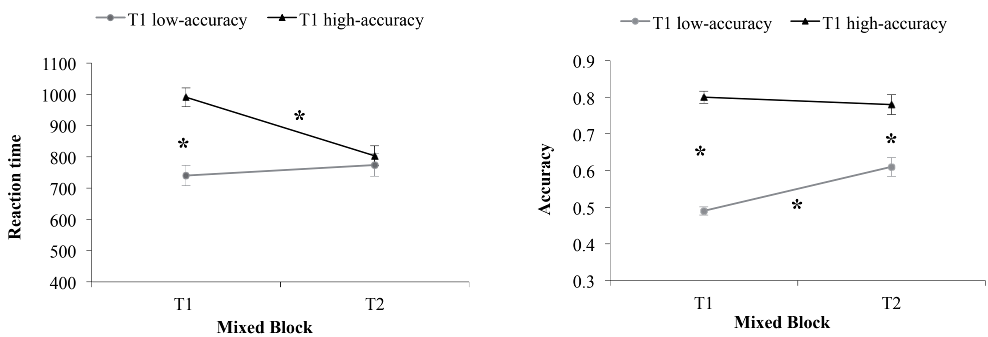

Figure 2. Longitudinal change of the T1 accuracy groups in the mixed block of the task switching paradigm (± SE). Asterisk (*) indicates significant difference.

DISCUSSION

The findings of our study showed that 5- to 6-year-old ethnic minority children showed increases in absolute accuracy scores on a cognitive flexibility task from kindergarten to first grade when they had to switch back and forth between two conflicting tasks that appeared randomly (i.e., the mixed block). In addition, children who showed high switching accuracy in kindergarten maintained their initial performance level from kindergarten to the first grade, whereas those in the low-accuracy group improved their performance substantially. The reaction time patterns revealed that children in the high-accuracy group became faster whereas reaction time in the low-accuracy group did not change. Additional analyses demonstrated no developmental changes in the decrease in performance between the single and mixed blocks (i.e., global switch costs) from kindergarten to first grade.

Taking a close look at absolute speed and accuracy scores of the mixed block in a cognitive flexibility task provided some insight in how children handle an ambiguous situation with continuously changing, conflicting and time-limited demands. Our findings based on the performance of the whole sample suggested that the developmental change in flexible thinking was observed only in accuracy but not in speed of responding from kindergarten to the first year of formal schooling after taking into account the potential effect of the covariates (the longitudinal differences in working memory, vocabulary in addition to SES and the child's gender). This result seems to be in line with previous findings that accuracy of responding is more sensitive to age-related differences in performance than reaction time, due to high variability of speed in the task-switching paradigm during early and middle childhood (Diamond & Kirkham, 2005; Hommel, Kray, & Lindenberger, 2011). In the literature, the scoring methods of flexibility measures vary. Different tasks provide different scores such as reaction time, accuracy, and efficiency. In addition, some tasks provide difference or cost scores (e.g., reaction time difference between Parts A and B of Trail Making Task), whereas others give absolute scores (e.g., total reaction time to complete the task). The current results support the idea that different score types could show different results and hence could lead to different conclusions (Davidson et al., 2006).

To obtain a deeper understanding of how accuracy and speed of flexible responding unfold longitudinally, we distinguished between children showing high and low accuracy in the mixed block in kindergarten (T1). As expected, T1 high-accuracy children were significantly slower than T1 low-accuracy children in the mixed block. However, the speed difference between the groups disappeared in the first grade because the T1 high-accuracy group increased speed whereas the T1 low-accuracy group did not change speed. In contrast, the accuracy gap between the groups remained significant in the first grade despite the significant gain in accuracy of T1 low-accuracy group. The T1 high-accuracy group showed no significant change in accuracy from the first to the second wave of assessment. It is likely that progress of more competent children (the high-accuracy group) may be more limited due to a ceiling effect. On the other hand, the T1 low-accuracy group was still less accurate than the T1 high-accuracy group in the first grade despite their gains in accuracy. These findings indicate that children in the two accuracy groups showed longitudinally different response patterns to ambiguity and conflict resulting from task switching. The transition to formal education is characterized by changes in context and content of learning as well as expectations regarding children's performance. Individuals differ in the level of adjustment to such changes. We suggest that children may have benefited from the transition period differentially in their development of flexible thinking, in line with previous research revealing that low performing children show greater gains in executive function during the transition to school (Hughes, Ensor, Wilson, & Graham, 2010).

The children's minority status might have specific implications for the interpretation of our results. Our study sample consisted of ethnic minority children who were all born in the Netherlands and most of whom have at least one parent who was born in the Netherlands as well. On average, ethnic minority children (even of the third generation) perform less well in some areas of learning (Kao & Tienda, 1995; Leventhal, Xue, & Brooks-Gunn, 2006), are more likely to drop out of school without a diploma (Rumberger, 1995), and tend to be from lower socioeconomic backgrounds than ethnic majority children (Suárez-Orozco & Suárez-Orozco, 2001). From this perspective, our findings are encouraging in that the school transition seems to have a positive effect on those who did not perform very well on task switching at kindergarten age. This finding can be seen as supportive of policies regarding early school entry for low-SES and ethnic minority children in the Netherlands comparable to the U.S. Head Start programs (Dominguez, Vitiello, Fuccillo, Greenfield, & Bulotsky-Shearer, 2011; Raver et al., 2011; Welsh, Nix, Blair, Bierman, & Nelson, 2010). Nevertheless, the *no-group difference hypothesis* states that although there may be mean-level differences in certain skills and behaviors between ethnic groups, developmental processes are not altered by culture-specific experiences (Rowe, Vazsonyi, & Flannery, 1994). Given that some of our main findings are consistent with general theoretical frameworks and findings from previous empirical work in ethnic majority families, the general developmental patterns found in this study are likely to reflect more than just group-specific patterns.

Our additional analyses showed no significant changes in global switch costs of accuracy and reaction time (comparing performance between the mixed and the single blocks) from kindergarten to the first grade. Previous research showed age-related differences in switch costs although the findings were mixed. Some found that global costs in reaction time increased whereas global costs in accuracy decreased from the age of six to young adulthood indicating that as children get older, they adjust their speed to preserve accuracy when they encounter an unpredictably changing situation (Davidson et al., 2006; Karbach & Kray, 2007). Others showed no change in the size of global costs with increasing age either in speed or accuracy (Crone et al., 2006) or only in accuracy (errors) but not in speed (Dibbets & Jolles, 2006). It is important to note that the switch costs in our study reflect the performance difference between single and mixed blocks in line with Karbach and Kray (2007), which differ from the switch costs in some studies that reflect the difference between nonswitch trials within the mixed block only (i.e., task repetitions) and all trials of the single blocks (e.g., Crone et al., 2006; Davidson et al., 2006). In addition, all the findings mentioned above are based on cross-sectional research and very few of them included children at kindergarten age (e.g., Dibbets & Jolles, 2006). To the best of our knowledge, there is no study exploring the longitudinal, within-subjects changes in switch costs across school-age childhood. In our study, no developmental changes were observed in the global switch costs in children during the school transition. It remains to be seen whether these findings are confirmed in future longitudinal research with multiple time points.

Implications

Our study has several implications. The different longitudinal patterns of accuracy and reaction time indicate that they may not capture the same processes of flexibility. The findings suggest that in the early elementary school years accuracy of responding is a more sensitive measure for age-related differences in flexibility in an ambiguous situation with changing and time-limited demands (i.e., the mixed block) than speed, supporting the idea that accuracy is a more reliable measure of performance in young children (Davidson et al., 2006; Diamond et al., 2007; Hommel et al., 2011). Second, formal education after the transition to school that provides a cognitively stimulating (i.e., lessons requiring abstract thinking) and structured (i.e., rules) learning context may have helped children who performed less well in kindergarten to move their cognitive flexibility performance to a more optimal level. We suggest that transition to school is an important assessment point for children's strengths and skills for improvement as our findings indicate that executive control might be malleable to changing environmental conditions during this period. Given the evidence that this ability is related to school readiness (Vitiello et al., 2011), academic learning (Yeniad et al., 2013), and behavioral outcomes (Riggs, Blair & Greenberg, 2003), it is worthwhile to explore whether the performance gap between the two groups can be narrowed further by some deliberate effort such as daily EF practices at school (e.g., simple games that aid "thinking out of the box", Diamond et al., 2007).

Limitations

It is important to note some limitations of this study. First, the response rate was low, although we used brochures both in Dutch and Turkish with culturally adapted pictures and we personally visited each family who did not respond to initial attempts via letters. However, our low response rate was not an exception, given that nonresponse among ethnic minorities in the Netherlands, especially families with low SES has been reported previously (Feskens, 2007). Second, if we had a mixed sample of ethnic majority and minority children, we would be able to examine how ethnic minority children perform in flexibility relative to majority children during the school transition. It should be noted however that it is a methodological challenge to recruit ethnic majority children who are comparable to minority children in terms of family backgrounds, due to the disparity in the socioeconomic status between minority and majority families (Suárez-Orozco & Suárez-Orozco, 2001). Third, our results regarding the development of flexibility are based on only one measure, the Hearts and Flowers task. Flexibility tasks, like other EF measures, differ in terms of complexity as a result of different amount of loadings on nonexecutive processes (e.g., intelligence), which leads to the well-known task impurity problem. Although the task switching paradigm is considered not to suffer from this risk with its minimum load on problem solving skills as opposed to complex shifting measures such as the Wisconsin Card Sorting Test (Huizinga & Van der Molen, 2011), future studies should include a battery of shifting measures for more robust findings.

Conclusion

In sum, our findings reveal that the ability to accurately adapt to constantly changing and conflicting demands improved from kindergarten to the first year of elementary school and children showed differential accuracy gains in this ability following the transition. The formal schooling context may have helped less able children to gain more in flexibility performance. The findings point to the malleability of cognitive control through environmental changes.

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5

General discussion

The current dissertation provides evidence for the important role of self-regulation in school performance and for the role of the transition to formal schooling in shaping the development of higher-order cognitive processes that contribute to self-regulation. The meta-analytic findings in Chapter 2 showed that flexible thinking, which is an important contributor to cognitive self-regulation (i.e., executive function), is positively and substantially related to math and reading performance. The results in Chapter 3 demonstrated that behavioral self-regulation (i.e., effortful control) is related to educational attainment with respect to secondary school tracks via self-efficacy in Turkish minority preadolescents. In Chapter 4, it was found that Turkish minority kindergarteners show differential gains in flexible thinking during the transition to the first year of formal schooling. The findings will be discussed in greater detail below.

Self-regulation and academic performance

In Chapter 2, associations between cognitive flexibility and academic outcomes were examined in a meta-analytic study. Cognitive flexibility was significantly and positively related to math and reading performance, indicating that children with a higher capacity to switch a conceptual representation (i.e., goals, rules or strategies for problem solving) to a different one show better performance in both math and reading. It has been suggested that cognitive flexibility facilitates math performance by helping children to switch between different arithmetical strategies (Agostino et al., 2010; Bull, Espy, & Wiebe, 2008; Mayes, Calhoun, Bixler, & Zimmerman, 2009; Van der Sluis, De Jong, & Van der Leij, 2007), whereas reading has been considered as a crystallized skill requiring automatic letter and phoneme identification (Blair & Razza, 2007), thus leaving no clear explanation for a link with flexible thinking. We found that the combined effect sizes of the associations of flexibility with math and reading were quite similar, indicating a domain-general contribution to academic achievement.

Our findings also showed a substantial association between math and reading performance, supporting the notion that these two academic domains have common underlying mechanisms. Specifically, the sequence of skill acquisition is the same in both domains: children learn to solve arithmetical tasks and read texts by effortful procedural strategies in the beginning, and with practice and experience, these strategies turn to automatic retrieval of information (e.g., word recognition or arithmetical facts) with high levels of accuracy and speed (Kulak, 1993). In line with this, a meta-analytic study showed that deficits in working memory and problem solving might be common processes underlying math and reading disabilities (Swanson, Jerman, & Zheng, 2009). Thus, previous findings support the assumption that math and reading performance share some variance that is accounted for by cognitive processes that are required both for encoding and retrieving information and strategies. We did find some evidence that cognitive flexibility may be one of the higher-order abilities contributing to the performance in both domains.

Although cognitive flexibility tasks show a great deal of variety in content and complexity, all of them have a similar requirement: children have to use a particular approach to respond correctly, then the rule is changed, so they have to adopt an alternative approach. In this regard, they use ‘if-then’ rule structures, which enables them to reflect upon the rule pairs (Jacques & Zelazo, 2005). The better children conceptually represent the rules, the easier they can switch between them, which is also required in academic tasks such as math assignments in which children need to switch from one arithmetic operation (e.g., addition) to another (e.g., subtraction). Flexible thinking may help children to integrate different sources of information, retrieve alternative learning strategies and sometimes switch attention between different components of an integrated whole (e.g., between grammar and semantic parts of a sentence), which in turn may promote academic performance.

In Chapter 3, the relation between self-regulation and educational attainment with respect to secondary school tracks was examined in Turkish minority preadolescents. Self-regulation is a multidimensional construct involving cognitive as well as behavioral (temperament-based) aspects (Liew, 2012). Although cognitive and behavioral self-regulatory capacities have some commonality (e.g., attentional and inhibitory control), they are distinct processes (Zhou, Chen, & Main, 2012). In this dissertation, computerized executive function tasks, assessing cognitive self-regulation and parent ratings of effortful control assessing behavioral self-regulation were used. Our findings suggest that behavioral self-regulation was related to educational attainment via self-efficacy, suggesting that effortful control provides children with self-confidence regarding their academic abilities, which in turn facilitates academic performance (Marsh, Trautwein, Ludtke, Koller, & Baumert, 2005). Temperamental characteristics such as persistence, motivation and freedom from distractability may let them receive positive feedback from parents and teachers (Silva et al., 2011), which increases their sense of competence (Blair & Diamond, 2008). Through this positive self-image, they may feel less threatened in cognitively challenging learning situations, and perform better in academic tasks, which may enable them start a higher level in secondary school. Given that the results in Chapter 3 are based on ethnic minority preadolescents, who were found to be more anxious and withdrawn than their Dutch peers (Murad, Joung, Van Lenthe, Bengi-Arslan, & Crijnen, 2003), intervention programs focusing on behavioral self-regulation may not only be helpful for their academic trajectories but also for their psychological well-being, which are critical predictors of long-term quality of life (Van Oort et al., 2006).

Contrary to the meta-analytic evidence in Chapter 2, the findings in Chapter 3 did not support a link between executive function (cognitive flexibility and working memory), and educational attainment with respect to secondary school tracks. A possible explanation for this lack of convergence might be that performance on complex executive function tasks require a cognitively demanding sequence of actions such as planning, monitoring and problem solving, which are important for academic performance in middle childhood (Best, Miller, & Naglieri, 2011). The EF tasks used in Chapter 3 may not be as demanding as traditionally used complex EF tasks and therefore may not have tapped into the domain-general skills that children need to achieve a high secondary educational track. The cognitive flexibility measure used in Chapter 3 for instance is a version of the task switching paradigm, which requires switching between two simple tasks (pressing on the same side as the heart and pressing on the opposite side as the flower), therefore it does not require as much in terms of problem solving skills compared to complex shifting measures such as the Wisconsin Card Sorting Test (Huizinga & Van der Molen, 2011). It is also likely that the contribution of Dutch proficiency to educational attainment was substantial which might have overshadowed the role of executive function. Using multiple tasks assessing the same EF skills (Müller, Liebermann, Frye, & Zelazo, 2008), controlling for 'nonexecutive demands' of these tasks (Van der Sluis et al., 2007), and including an ethnic majority, monolingual sample would enable us to examine whether executive function would contribute more to achievement.

In addition, the findings in Chapter 3 showed that Dutch vocabulary was positively related not only to educational attainment, but also to self-efficacy; indicating that preadolescents with better verbal ability had higher levels of academic achievement and more positive beliefs about their capabilities. This finding is particularly meaningful given that our study consisted of an ethnic minority sample, for whom host language difficulties have been reported as an important reason for educational disadvantage (Morrison, Bachman, & Connor, 2005; Oller & Eilers, 2002). Specifically, there is some evidence that Turkish minority children lag behind their native Dutch peers in the host language at the beginning of formal education (Scheele, Leseman, & Mayo, 2010). In the Netherlands, after 1980s, Dutch government policies emphasized the monolingual education in schools (Extra & Yağmur, 2010) to reinforce the sociocultural integration of immigrants (Driessen, 2000). Compensatory community-based programs (i.e., Pre- and Early Primary School Education, VVE) were designed to improve linguistic development of low income, ethnic minority children, in line with Head Start programs in the U.S. (Leseman, 2002). Some researchers investigated whether minority children's verbal competence can be improved by training parents' communication skills with their children at the kindergarten age through a long-term, home-based and structured intervention (Leseman & Van Tuijl, 2001). The intervention did not result in gains in children's Dutch vocabulary probably due to the fact that the mothers chose to administer the curriculum in Turkish. Nevertheless, it improved children's cognitive and pre-academic skills, which are important for their later achievement. Thus, what parents provide children in dialogue mattered for their cognitive development, however the gains in the ethnic language did not transfer to the host language (Cummins, 1991). There is accumulating evidence that multilingual children perform better in executive function tasks, particularly in those requiring conflict resolution and cognitive flexibility, than monolingual children when they are matched with respect to family background characteristics (Bialystok, 1999; Bialystok, 2011; Bialystok & Martin, 2004). Although multilingualism has been found to lead to low proficiency in both languages, it might facilitate cognitive development in children (Bialystok, 2009), which in turn predicts academic achievement. Based on this evidence, it may be suggested that compensatory activities fostering children's ethnic *and* host language skills might be helpful for ethnic minority children's overall language proficiency, their academic achievement and self-efficacy.

Self-regulation and intelligence as predictors of academic outcomes

It is important to consider to what extent self-regulation overlaps with intelligence as both of the constructs are considered to be crucial predictors of academic achievement. Although brain structures and neural functioning that underlie cognitive control overlap substantially with those that underlie general intelligence (Barbey et al., 2012; Roca et al., 2010), these two higher-order cognitive processes are distinct (Blair, 2006; Blair, Zelazo, & Greenberg, 2005). The distinction has been shown both by factor-analytic evidence from typically developing children (Espy, Kaufmann, McDiarmid, & Glisky, 1999), and by findings in samples of children with developmental disorders (e.g., attention deficit hyperactivity disorder, phenylketonuria, specific learning disabilities) who performed poorly on executive function measures despite the fact that their general intelligence scores were in the normal range (Barkley, 1997; Diamond, Prevor, Callender, & Druin, 1997; McLean & Hitch, 1999).

In Chapter 2, to specifically explore the overlap between cognitive flexibility and intelligence, the correlation coefficents between flexibility and intelligence performance across studies that were previously selected for the relation between flexibility and achievement were examined. The combined effect size for the relation between cognitive flexibility and intelligence was positive and substantial, supporting the overlap between the two constructs. However, it is still unclear whether cognitive flexibility is related to academic performance beyond the impact of intelligence. As the number of studies reporting on the correlations between flexibility and academic performance and correcting for intelligence was insufficient, it was impossible to disentangle the contributions of cognitive flexibility and intelligence to academic performance. Nevertheless, the results provided insight into the relative contributions of cognitive flexibility and intelligence to academic outcomes. Intelligence showed a stronger association with academic performance than cognitive flexibility, which is in line with previous findings suggesting that general intelligence is one of the strongest predictors of academic achievement (Steinmayr, Ziegler, & Trauble, 2010). Given previous evidence reporting that executive function adds to the prediction of school performance beyond general intelligence (Blair, & Razza, 2007; Bull & Scerif, 2001; Clark, Pritchard, & Woodward, 2010), further research should investigate whether flexible thinking specifically shows incremental validity in predicting achievement like other components of cognitive control.

There is a concensus that a revised and well-defined theory of general intelligence is needed as in the last decades the current, 'monolithic' one has lost its explanatory utility due to a lack of specificity (Blair, 2006). Two commonly used indicators of general cognitive ability are fluid and crystallized intelligence. The former refers to problem solving and inductive reasoning in novel situations while the latter pertains to acquired knowledge measured commonly by vocabulary tests (Jensen, 2002). There is some evidence that crystallized intelligence is a stronger predictor for performance on standardized academic tasks and college admission exams than fluid intelligence (Rohde & Thompson, 2007). In the meta-analytic study presented in Chapter 2, it was not possible to use the type of intelligence as a moderator for the relation between intelligence and academic performance due to the lack of studies in particular subcategories. Nevertheless, the results in Chapter 3 showing a strong association between vocabulary and educational attainment with respect to secondary school tracks seem to be line with previous evidence suggesting the important role of crystallized intelligence for achievement (Rohde & Thompson, 2007).

Self-regulation across the school transition

Self-regulation is important for students' school perfomance, but its development may also be shaped by what they experience at school. The main focus of Chapter 4 was the development of cognitive control, specifically cognitive flexibility, during the transition from kindergarten to the first year of formal schooling as this period may provide opportunities facilitating cognitive development. The positive effect of schooling on cognitive control was shown in a study reporting that third graders performed better on cognitive flexibility and planning than second graders of the same age (McCrea, Mueller, & Rauno, 1999). We found that children showing high accuracy in cognitive flexibility performance in kindergarten maintained their initial performance level from kindergarten to the first grade, whereas those in the low-accuracy group improved their performance substantially. On the other hand, children in the high-accuracy group became faster whereas the speed of flexible responding in the low-accuracy group did not change longitudinally. In other words, the low-accuracy group gained in accuracy and the high-accuracy group gained in speed of flexible responding following the school transition. The transition experience, with its cognitive challenges, may have played a compensatory role for the performance of less flexible thinkers whereas it may have added to the performance of more flexible thinkers by helping them to respond faster.

The results suggest that the transition to formal schooling may have helped children who performed less well in kindergarten to move their cognitive flexibility performance to a more optimal level, therefore narrowed the performance gap in flexible thinking between more able children and their less able peers. It has been suggested that higher-order self-regulatory processes are "penetrable" by experience (Carlson, 2003). Empirical evidence also showed that positive parenting, particularly maternal scaffolding and autonomy-support, positively affects the development of executive function in young children by helping them to conceptualize rules, shifting attention flexibly, and think in a reflective manner mostly through play (Bernier, Carlson, & Whipple, 2010). In the same vein, negative experiences put high demands on automatic stress reactivity that is higly related to cognitive processes (Cicchetti, 2002; Welsh, Nix, Blair, Bierman, & Nelson, 2010). In formal education, cognitively stimulating material (i.e., lessons requiring abstract thinking) and structured learning context (i.e., rules) in classroom may provide great opportunities for children to use their attention and executive function skills (Ursache, Blair, & Raver, 2012). In this sense, the way how the school transition is experienced by children may matter for the development of self-regulation. The findings presented in Chapter 4 are encouraging in that some cognitive processes that contribute to self-regulation may be open to change through school experience; therefore the transition to formal education might be a period that future intervention programs and educational policies should target.

From research to practice

The school might be a resource of compensation for children who are developmentally less equipped than their peers. The critical question is what types of activities across the school transition can narrow the gaps further between more able and less able children in self-regulation. There is some empirical evidence showing that self-regulatory capacities can be improved by intervention programs integrated to the classroom curricula. For instance, Raver and colleagues (2011) tested the Chicago School Readiness Project (CSRP) program in a sample of low-income, Head-Start preschoolers in a randomized control trial. The intervention included extensive teacher training and consultation with an emphasis on children's emotion regulation and behavioral management. The main objective was to improve teachers' resources for a well-managed classroom context that reduces tension and stressful atmosphere in class. The CSRP supported the development of self-regulatory skills, specifically of executive function, but not *performance-based* effortful control (delay of gratification task designed to assess emotion regulation). In addition, gains in executive function mediated the relation between the impact of the program and gains in academic outcomes. The researchers stated that effortful control may moderate rather than mediate the effect of interventions. In other words, high effortful control may maximize the impact of intervention programs targeted to improve cognitive aspects of self-regulation. Relatedly, some studies demonstrated that a positive teacher–student relationship interacts with effortful control in predicting future academic achievement; indicating that children with low effortful control can academically perform as well as those with high effortful control if they receive a high level of support (Liew, Chen, & Hughes, 2010; Silva et al., 2011). Similar to the CSRP, there are other intervention programs (i.e., Tools of the Mind, see Diamond, Barnett, Thomas, & Munro, 2007; and PATHS Promoting Alternative Thinking Strategies, see Riggs, Greenberg, Kushe, & Pents, 2006), showing the possibility that self-regulatory capacities, particularly cognitive ones can be challenged and improved by simple, cost-effective, and teacher- and peer-assisted activities (e.g., pretend play, activities that require private speech and reflective thinking). It should be noted however that there are still some concerns about whether the gains in cognitive control can be generalized to academic learning (Welsh et al., 2010) and whether they promote long-lasting effects (Melby-Lervåg & Hulme, 2012) independent of task-specific learning (Shipstead et al., 2012).

Implications and policies for ethnic minority children

The disadvantaged position of ethnic minority students in education is a salient societal issue in almost all Western countries. These students perform less well on academic tasks, are overrepresented in lower educational tracks, less able to transfer to higher school tracks, and eventually show higher drop-out rates, which make them a target group for compensotary education programmes (Andriessen & Phalet, 2002; Magnuson & Duncan, 2006). The results in the current dissertation suggest that self-regulation and verbal ability are two important paths to a more successful academic trajectory. Given previous evidence reported in intervention studies, improving teachers' professional skills to render an optimal learning environment in class, which positively affects children's self-regulation (Raver et al., 2011), and supporting minority parents as the experts of their children's language and cognitive development (Leseman & Tuijl, 2001) seem to be promising attempts to foster positive academic trajectories of ethnic minority children. In addition, given growing evidence showing the positive links between multilingualism and cognitive control (e.g., Bialystok, 1999), and between cognitive control and academic achievement (e.g., Blair & Razza, 2007), promoting multilingual learning in minority students may improve academic performance through gains in cognitive control, an issue that deserves further research attention.

The transition to formal schooling may create a greater discontinuity between home and school for ethnic minority children, as lessons become more (host) language dependent, rules are more defined (by the host cultural expectations) and academic requirements are more demanding, meaning that parental support might be more needed but less available. From this perspective, minority children may experience the school transition to formal education more challenging and stressful than their majority peers, which may hinder the development of self-efficacy and the adaptive development of self-regulation. A smooth transition may help them to benefit from stimulation and engagement to a greater extent, which in turn positively affects the development of their self-regulatory capacities (Blair & Ursache, 2011).

Limitations and future directions

It is important to note some limitations of the current dissertation. First, although the meta-analytic results presented in Chapter 2 provide a systematic examination regarding the relation between cognitive flexibility and academic outcomes, some of the moderators could not be tested due to the small number of studies, therefore the results regarding the moderator effects should be considered tentatively. For instance, there were very few studies reporting on the efficiency score, therefore these studies were combined with those reporting multiple scores in the analyses, which might have obscured a potential moderating effect of shifting scoring. Given that EF research is rapidly growing, future meta-analyses which include a larger set of empirical studies on this topic may allow for more valid tests of the moderators that could not be fully tested in Chapter 2.

Second, in the studies reported in Chapters 3 and 4, the response rate was low (18% for kindergarteners and 15.9% for preadolescents), which resulted in modest sample sizes. As previously reported, it is difficult to recruit nonwestern immigrants in the Netherlands, especially those with low SES for research purposes (Feskens, 2007; Yaman, 2009). However, it is important to note that the participating families did not differ from nonparticipating ones in terms of background characteristics. We did not include comparison groups of ethnic majority children in these studies. Therefore, it is unclear whether ethnic minority children's self-regulatory capacities differ from those in majority children. The main reason for not including a comparison sample is the fact that it is extremely difficult to recruit ethnic majority children who are comparable to ethnic minority children with respect to family background, as ethnic minority families are overrepresented in lower socieconomic classes (Andriessen, Phalet, & Lens, 2006) and they often live socially segregated lives (Garcia Coll et al., 1996). Recruiting participants in cooperation with schools with multiethnic student profiles, rather than municipal records might be helpful in future research to recruit minority and majority families with similar socioeconomic backgrounds.

Third, in Chapters 3 and 4, each cognitive construct (i.e., cognitive flexibility and working memory) was measured by a single task. Particularly cognitive flexibility measures vary in the amount of instruction given to children (i.e., rule is kept implicit so that the child induces it by trial and error or it is explicitly given to the child), which led some researchers to make a distinction between deductive versus inductive measures of cognitive flexibility (Jacques & Zelazo, 2005). This may change the number of nonexecutive demands of the task, which is known as the so called 'task impurity problem' in the executive function literature. Using a battery of tasks and examining their interrelations to form latent factors would allow for more robust conclusions. In addition, different scores of the same performance may show different patterns over time, as shown in Chapter 4. Therefore, taking both scores into account in future research may provide a more nuanced understanding of the development of cognitive control that is measured by performance-based tasks. Future studies may also include hot executive function tasks, which assess emotion regulation in motivationally significant situations (Zelazo & Carlson, 2012) for a broader perspective on the relation between self-regulation and academic achievement, as there is evidence that emotion regulation, measured by delay of gratification tasks in childhood predicted educational level 20 years later beyond the impact of intelligence (Casey et al., 2011).

Fourth, in Chapter 4, only two time points were available to assess the development of cognitive flexibility. Future studies would ideally include three time points, allowing for the use of latent growth models, which make it possible to look at variation in growth (i.e., slopes) and at potential predictors of this variation (e.g., verbal ability, see Hughes, Ensor, Wilson, & Graham, 2010), to examine whether the school transition leads to a particular acceleration in flexible thinking.

Finally, ethnic minority students are mostly enrolled in disadvantaged schools, which may widen the inequality between ethnic minority and majority children by providing fewer opportunities to be exposed to cognitively stimulating material and supportive teaching experiences (Crosnoe, 2005; McKown, 2013). Our studies did not include measures of the school context. Future studies focusing on the development of self-regulation in minority samples should take school characteristics into account.

Conclusion

In conclusion, the findings of the current dissertation confirm that cognitive self-regulation, and more specifically flexible thinking, is positively related to math and reading performance, indicating that the ability to switch between different mental representations and to take multiple perspectives simultaneously in response to changing task demands contributes to academic achievement across domains, as is the case for intelligence. In addition, behavioral self-regulation, specifically temperamental effortful control, is positively associated with educational attainment via self-efficacy (i.e., sense of competence). Temperamental characteristics such as persistence, motivation and freedom from distractability may shape the way children view their capabilities, which is in turn related to their engagement with learning opportunities at school. The results also revealed that children showed differential gains in flexible thinking from kindergarten to formal schooling, as less able children made more progress following the transition. Thus, cognitive stimulation in formal schooling may play a compensatory role for children who are less equipped regarding self-regulatory capacites at school entry. Facilitating these capacities may promote self-efficacy and school success in ethnic minority children.

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Samenvatting (Summary in Dutch)

Zelfregulatie verwijst naar het vermogen om aandacht, gedachten, emoties en doelgericht gedrag te controleren en organiseren. Zelfregulatie speelt een belangrijke rol in de ontwikkeling van schoolcompetenties van kinderen. Omgekeerd geldt dat de ontwikkeling van *zelfregulatie* ook gevormd kan worden door ervaringen op school. In de studies beschreven in dit proefschrift wordt het verband tussen zelfregulatie en schoolresultaten, en de ontwikkeling van zelfregulatie tijdens de overgang van groep 2 naar groep 3 onderzocht, met speciale aandacht voor kinderen van een etnische minderheid die behoren tot een risicogroep wat betreft schoolprestaties. Na een systematische meta-analyse van het verband tussen cognitieve zelfregulatie en schoolprestaties, onafhankelijk van etnische afkomst, volgen twee empirische studies specifiek gericht op zelfregulatie en school-gerelateerde variabelen bij kinderen van een etnische minderheid, waarin zelfregulatie-vaardigheden in relatie tot schoolprestaties, en de relatie tussen de overgang naar groep 3 en de ontwikkeling van zelfregulatie worden onderzocht.

In hoofdstuk 2 bleek dat zelfregulatie in de vorm van cognitieve flexibiliteit positief en substantieel samenhing met prestaties op het gebied van rekenen en lezen. De gecombineerde effectgroottes van de verbanden van flexibiliteit met rekenen en met lezen waren vrijwel gelijk, wat duidt op een domein-generieke invloed op schoolprestaties. Er was daarnaast ook sprake van een substantiële onderlinge relatie tussen reken- en leesprestaties, waarmee de stelling ondersteund wordt dat gezamenlijke onderliggende mechanismen ten grondslag liggen aan deze twee domeinen. Er wordt gesteld dat de volgorde van het verwerven van vaardigheden gelijk is in beide domeinen (Kulak, 1993), waarvoor een proces van hogere orde zoals werkgeheugen nodig is (Swanson, Zheng, & Jerman, 2009). Cognitieve flexibiliteit zou één van de processen kunnen zijn die bijdraagt aan de prestaties in beide domeinen.

De resultaten in hoofdstuk 3 laten zien dat bij Nederlandse pre-adolescenten met een Turkse achtergrond zelfregulatie van gedrag via *self-efficacy* (een vorm van zelfvertrouwen, geloof in het eigen kunnen) gerelateerd is aan het schoolniveau van de middelbare school. Eigenschappen als doorzettingsvermogen, motivatie en concentratievermogen, kunnen leiden tot het ontvangen van positieve feedback van ouders en leerkrachten (Silva et al., 2011), waardoor het gevoel competent te zijn vergroot wordt (Blair & Diamond, 2008). Door dit positieve zelfbeeld kunnen kinderen zich minder angstig voelen in cognitief uitdagende leersituaties en beter presteren op schooltaken, waardoor ze de mogelijkheid hebben op een hoger niveau te starten op de middelbare school. Turkse pre-adolescenten met een betere

Nederlandse woordenschat bleken ook een hoger schoolniveau en positievere gedachten over hun capaciteiten te hebben. Deze bevinding is vooral belangrijk in het licht van onze etnische minderheidssteekproef, voor wie problemen in de tweede taal een belangrijke reden voor onderwijsachterstanden kunnen zijn (Morrison, Bachman, & Connor, 2005; Oller & Eilers, 2002).

In hoofdstuk 4 werd gevonden dat Nederlandse kleuters met een Turkse achtergrond tijdens de overgang naar groep 3 een verschillende groei in cognitieve flexibiliteit laten zien. Kinderen die al in groep 2 weinig fouten maakten in een taak die cognitieve flexibiliteit vereist, behielden dit niveau tussen groep 2 en groep 3, terwijl degenen die bij de eerste meting meer fouten maakten hun prestatie substantieel verbeterden. Kinderen die bij de eerste meting weinig fouten maakten, daarentegen, waren in groep 3 sneller, terwijl er geen longitudinale verandering optrad in de reactiesnelheid van de laag scorende groep. Met andere woorden, na de schoolovergang verbeterde de laag scorende groep in accuratesse en de hoog scorende groep in reactiesnelheid. De ervaring van de overgang en de cognitieve uitdagingen die gepaard gaan met de overgang naar formeel leren kan een compenserende factor geweest zijn voor de minder flexibele denkers, terwijl het voor de meer flexibele denkers heeft bijgedragen aan hun prestatie doordat ze sneller gingen reageren. De resultaten suggereren dat de overgang naar groep 3 bevorderlijk is geweest voor de kinderen die in groep 2 lager scoorden om hun cognitieve flexibiliteit te optimaliseren, en dat zo de afstand in flexibel denken tussen meer en minder bekwame kinderen verkleind is.

De minder bevoorrechte positie van leerlingen van etnische minderheden in het onderwijs is een belangrijk maatschappelijk probleem in bijna alle westerse landen. Deze leerlingen presteren minder goed op schooltaken, zijn oververtegenwoordigd in lagere schoolniveaus, maken minder vaak de overgang naar een hoger schoolniveau, en stoppen vaker voortijdig met school dan kinderen van de etnische meerderheidsgroep (Andriessen & Phalet, 2002; Magnuson & Duncan, 2006). Hierdoor vormen zij een doelgroep voor interventies die erop gericht zijn deze achterstand te herstellen. De resultaten uit dit proefschrift suggereren dat zelfregulatie en taalbeheersing twee belangrijke wegen zijn naar een meer succesvolle schoolloopbaan. Het verbeteren van de professionele vaardigheden van leraren om een optimale leeromgeving te creëren (Raver et al., 2011) en het ondersteunen van ouders uit minderheidsgroepen als experts op het gebied van de taal- en cognitieve ontwikkeling van hun kinderen (Leseman & Van Tuijl, 2001) lijken veelbelovende manieren om een positief verloop van de schoolloopbaan bij kinderen van etnische minderheden te bevorderen.

De overgang naar groep 3 kan leiden tot een grotere afstand tussen thuis en school voor kinderen van etnische minderheden, omdat de lessen meer afhankelijk worden van de (tweede) taal, er strengere regels gelden (in overeenstemming met de verwachtingen uit de meerderheidscultuur), en de verwachtingen binnen het onderwijs hoger zijn, waardoor ondersteuning door de ouders wellicht meer nodig maar minder toegankelijk wordt. Vanuit dit oogpunt zouden kinderen van etnische minderheden de overgang naar groep 3 als moeilijker en stressvoller kunnen ervaren dan hun leeftijdgenoten, waardoor de ontwikkeling van *self-efficacy* en zelfregulatie gehinderd zou kunnen worden. Een vloeiende overgang kan hen helpen meer te profiteren van stimulatie en betrokkenheid, waardoor vervolgens de ontwikkeling van zelfregulatie-vaardigheden positief wordt beïnvloed.

Samenvattend toont dit proefschrift de belangrijke rol van zelfregulatie voor schoolprestaties en de rol van de overgang naar groep 3 in de vorming van de ontwikkeling van hogere cognitieve processen die bijdragen aan zelfregulatie. Het bevorderen van zelfregulatie-vaardigheden kan *self-efficacy* en schoolsucces van kinderen van etnische minderheden vergroten.

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Curriculum vitae

Nihal Yeniad Malkamak was born on November 23rd 1983 in Istanbul, Turkey. After graduating from Kabataş Erkek Lisesi in 2001, she obtained her Bachelor of Art degree in psychology at Boğaziçi University, Istanbul in 2006. In the last year of college, she attended psychiatry sessions with children suffering from developmental disorders at the Child Psychiatry Clinic of Istanbul Medicine Faculty. In 2009, she obtained her Master of Art degree in clinical psychology with high honor at Boğaziçi University with a thesis titled 'A study for the Wisconsin Card Sorting Test with 6- to 7-year-old Turkish children'. For her Master study, she won the National Achievement Scholarship for Graduate Students from the Scientific and Technological Research Council of Turkey (TUBITAK). She completed her clinical internship in Boğaziçi University Center for Psychological Research and Services and Bakırköy Mental Health Hospital. Following her Master study, she worked as a clinical psychologist in private practice. In December 2009, she joined the Centre for Child and Family Studies at Leiden University as a PhD student within the research team conducting the SIMCUR (Social Integration of Migrant Children: Uncovering Family and School Factors Promoting Resilience) project supervised by Prof. Dr. Judi Mesman and Prof. Dr. Marinus van IJzendoorn. The results of Nihal's PhD research are presented in this dissertation. In 2013, she moved back to Istanbul to continue her academic and clinical career there.

Lijst van publicaties (List of publications)

Yeniad, N., Malda, M., Mesman, J., Van IJzendoorn, M. H., & Pieper, S. (2013). Shifting ability predicts math and reading performance in children: A meta-analytical study. *Learning and Individual Differences, 23*, 1-9. doi: http:// dx.doi.org/10.1016/j.lindif.2012.10.004

Prevoo, M. J. L., Malda, M., Mesman, J., Emmen, R. A. G., Yeniad, N., van IJzendoorn, M. H., & Linting, M. (2013). Predicting ethnic minority children's vocabulary from socioeconomic status, maternal language and home reading input: Different pathways for host and ethnic language. Journal of Child Language, FirstView, 1-22. doi: 10.1017/S0305000913000299.

Emmen, R. A. G., Malda, M., Mesman, J., Van IJzendoorn, M. H., Prevoo, M. J. L., & Yeniad, N. (in press). Socioeconomic status and parenting in ethnic minority families:Testing a Minority Family Stress Model. *Journal of Family Psychology.*

Ingediende manuscripten (Submitted manuscripts)

Yeniad, N., Malda, M., Mesman, J., Van IJzendoorn, M. H., Emmen, R A.G., & Prevoo, M J.L. (2013). Cognitive flexibility in children across the transition to school: A longitudinal study. Manuscript under review.

Yeniad, N., Malda, M., Mesman, J., Van IJzendoorn, M. H., Prevoo, M J.L. & Emmen, R A.G. (2013). Behavioral regulation is associated with educational attainment through self-efficacy in ethnic minority preadolescents. Manuscript submitted for publication.