Cognitive Development 31 (2014) 35–47

Contents lists available at ScienceDirect

Cognitive Development

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

Nihal Yeniad, Maike Malda, Judi Mesman*, Marinus H. van IJzendoorn, Rosanneke A.G. Emmen, Mariëlle J.L. Prevoo

Centre for Child and Family Studies, Leiden University, Leiden, The Netherlands

ARTICLE INFO

Keywords:
Flexibility
Shifting
Executive function
Speed
Accuracy
Longitudinal patterns

ABSTRACT

Longitudinal research exploring the development of cognitive flexibility is lacking. In this study we investigated the speed-accuracy pattern in cognitive flexibility performance in 87 5–6-year-olds across the transition to formal education. Overall, 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-accuracy kindergartners only gained in speed. These results suggest an important role of formal schooling in cognitive flexibility in narrowing the performance gap between more and less able children. The findings also identify existence of diverse paths in development of flexible thinking.

1. Introduction

Flexible thinking in the face of ever-changing situations is crucial. This ability, known as the shifting or cognitive flexibility component of executive function (EF), involves switching between multiple and conflicting representations, strategies or responses as task demands change (Miyake et al., 2000). It

* Corresponding author at: Centre for Child and Family Studies, Leiden University, PO Box 9555, 2300 RB Leiden, The Netherlands. Tel.: +31 71 527 3482; fax: +31 71 527 3945.

E-mail addresses: yeniadn@fsw.leidenuniv.nl (N. Yeniad), m.malda@fsw.leidenuniv.nl (M. Malda), mesmanj@fsw.leidenuniv.nl (J. Mesman), vanijzen@fsw.leidenuniv.nl (M.H. van IJzendoorn), emmenrag@fsw.leidenuniv.nl (R.A.G. Emmen), prevoomjl@fsw.leidenuniv.nl (M.J.L. Prevoo).

http://dx.doi.org/10.1016/j.cogdev.2014.02.004

may entail a compromise between quick and correct choices (Bogacz, Wagenmakers, Forstmann, & Nieuwenhuis, 2010). Responding quickly risks error (Ivanoff, Branning, & Marois, 2008). Although accuracy and speed are related (Pachella, 1974), it is unclear whether they involve the same processes (Cragg & Chevalier, 2012) or whether they always work in opposite directions across conditions and across people (Salthouse, 2010).

The speed-accuracy tradeoff in executive function (EF) develops over time (Davidson, Amso, Anderson, & Diamond, 2006). Unlike adults, young children are too impulsive to trade speed for correctness. Such shifting ability shows greatest gain in the preschool years but continues to develop to adulthood (Cragg & Chevalier, 2012). The first year of formal education, during which children need to adjust to a set of standards likely to be substantially different than those in early school settings and at home, provides children with opportunities to use and practice EF skills (Diamond, Barnett, Thomas, & Munro, 2007). The major aim of the present study is to examine patterns in children's speed-accuracy trade-offs in cognitive flexibility performance before and after the transition to formal education.

Cognitive flexibility enables us to see the world from a new and different perspective and is vital for adaptation and creativity (Davidson et al., 2006). We construct particular representations of different circumstances and switch between competing responses by activating and modifying representations in a dynamic way when circumstances change unpredictably (Deak & Narasimham, 2003). Doing so involves a complex cognitive mechanism comprising 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. There is evidence that working memory, rather than inhibition, mostly accounts for cognitive flexibility in young children (Blackwell, Cepeda, & Munakata, 2009; Cepeda & Munakata, 2007). Having stronger working memory representations of the current task enhances successful switching, which cannot be explained by inhibitory abilities, motivation or general cognitive ability. Although the nature of cognitive flexibility is not yet fully understood, there is some consensus that cognitive flexibility cannot be reduced to a single component or be explained by the combination of inhibition and working memory (Cragg & Chevalier, 2012). Chevalier et al. (2012) claims that the contribution of inhibition and working memory to flexibility in 4–5-year-olds may occur through goal representation or activation.

Cognitive flexibility tasks are varied in content and complexity but all have a similar characteristic: Children must use a particular approach to respond correctly; then the rule is changed, requiring them to adopt an alternative approach (Jacques & Zelazo, 2005). In recent years, cognitive flexibility has frequently been assessed by the task-switching paradigm in school-aged 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 within simple blocks, but they must alternate between two tasks from trial to trial in mixed blocks. They must switch response when the rule changes from trial to trial (i.e., switch trials) and repeat the same response when the rule does not change (i.e., nonswitch trials). The mixed block taps into all executive functions and in particular to cognitive flexibility as it requires children to switch between two different perspectives (Diamond et al., 2007).

The indicator of cognitive flexibility (i.e., accuracy, reaction time or efficiency) varies with the age of the participant. Whereas accuracy is typically used with preschoolers, use of reaction time is reported among older children and adults. Measuring both has been suggested to allow valid comparisons across 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). Although the early elementary school years represent a critical period in the development of cognitive flexibility (Roebers, Rothlisberger, Cimeli, Michel, & Neuenschwander, 2011), to our knowledge there is no study examining the speed-accuracy pattern across these years. In most studies, the development of executive function has been examined by comparing performance of different age groups in cross-sectional designs (Crone et al., 2006; Davidson et al., 2006). Longitudinal studies reduce irrelevant variance stemming from cohort effects by examining changes within persons. In this respect, the present longitudinal study promises to be useful to obtain a more nuanced understanding regarding age change in performance on a cognitive flexibility task (Best & Miller, 2010).

There is some evidence showing that flexibility is related to school readiness (Vitiello, Greenfield, Munis, & George, 2011) and academic achievement (Yeniad, Malda, Mesman, Van IJzendoorn, & Pieper, 2013). In this regard, examining development of this ability in diverse samples, especially those who may have difficulties at school, is crucial. Ethnic minority children may be at risk with respect to academic achievement due to factors such as socioeconomic disadvantage (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 prior to 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 the present study we explore the development of cognitive flexibility in speed and accuracy in 5–6-year-old ethnic minority children across the transition to formal reading and writing education. The potential contribution of the study is threefold. First, it remedies the lack of longitudinal research on the development of flexible thinking during the transition to formal schooling and undertakes to obtain a nuanced understanding of which aspects of cognitive flexibility performance change during this period. Second, given the question of whether different types of scores tap the same processes of executive function performance (Cragg & Chevalier, 2012) or whether they develop in the same pattern (Davidson et al., 2006; Salthouse, 2010), we investigate developmental changes in cognitive flexibility with respect to both 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 may 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 such ethnic minority groups.

Finally, we examine potential covariates in the development of cognitive flexibility across the school transition. Based on the literature we included family socioeconomic status (Noble, Norman, & Farah, 2005; Sarsour et al., 2011), gender (Hughes & Ensor, 2005; Wiebe, Espy, & Charak, 2008), child vocabulary (Hughes, Ensor, Wilson, & Graham, 2010), and working memory (Davidson et al., 2006).

2. Method

2.1. Participants

Turkish immigrant mothers of 87 5–6-year-olds in the 2nd 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. To ensure homogeneity of the sample, mothers 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. 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 (*ps* .12–.89).

At T1 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 biological parents (94%). The majority of 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 first-borns.

2.2. Procedure

Participating families filled out questionnaires and were visited at home at two time points—when children were in the second semester of kindergarten (T1) and one year later, during children's 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 each 2-hour home visit. The tasks of interest for the present 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.

Data for nine children at T1 were missing due to equipment problems. Of the 104 children at T1, 87 provided data for variables of interest at T2. Children who did not participate at T2 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 or speed on the task switching paradigm (*ps* .12–.87) from those who did participate at T2. However, children who dropped out performed significantly worse in cognitive flexibility at T1, evidenced by fewer accurate responses in the mixed block ($p < .05$) compared to children who continued to T2.

2.3. Measures

2.3.1. Vocabulary

The Expressive One Word Picture Vocabulary Test (EOWPVT, Brownell, 2000) was translated into Dutch with minor modifications and omissions when no Dutch translation existed. In this test, a picture is shown on a computer screen and the child is asked to name the picture in one word. Answers were recorded on a score sheet and audio-recorded for later analysis. Item-response analyses (Furr & Bacharach, 2008) showed that the increase in difficulty level of the items is similar to that of the original English version. The split-half (odd/even) sample reliability was .97.

2.3.2. Working memory

Digit Span Backward was used as a working memory test (Wechsler, 2003). Digits that were audio-recorded at a rate of 1 per second and the child asked to repeat the digits in the opposite order. The digit clusters range from 2 to 9 digits, across eight trials. Each trial contains two items with the same number 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 calculated. The split-half (odd/even) sample reliability was .85.

2.3.3. Cognitive flexibility

The Hearts and Flowers task (Diamond et al., 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 stimuli and record responses. Two types of stimuli, a red heart and a red flower, appear either on the right or left side of the screen. Each stimulus was presented for 1500 ms. 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 colored stickers. 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. Each of the first two blocks started with a block of four practice trials. Prior to the third block, no practice trials were presented.

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, 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 (same side and opposite side), and is thus a measure of cognitive flexibility (Diamond et al., 2007). Two consecutive trials can be either nonswitch trials (i.e., both show a heart or both show a flower) or switch trials (i.e., one shows a heart and the other a flower). The number of switch trials varied between and within individuals as a result of the semi-randomized design of the task.

Median reaction time for all items and mean accuracy scores were calculated. Reaction time for only correct items and reaction time for all items were highly correlated ($r = .99$, $p < .01$ in congruent-only, $r = .85$, $p < .01$ in incongruent-only, $r = .95$, $p < .01$ in mixed block at T1; $r = .99$, $p < .01$ in congruent-only, $r = .97$, $p < .01$ in incongruent-only, $r = .97$, $p < .01$ in the 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 analyses. Trials following an error were not excluded from the analyses due to the limited number of trials in the blocks.

2.3.4. 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 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 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.

3. Results

Statistical analyses were performed using SPSS 19 software. Longitudinal changes in mean accuracy and median reaction time of task blocks (congruent-only, incongruent-only, mixed) from T1 to T2 were explored in a 'time (2) × task blocks (3)' repeated measures design. Greenhouse–Geisser corrections were performed when necessary. Differences between T1 and T2 working memory and vocabulary scores were used as covariates in addition to gender and SES.

3.1. Accuracy and speed groups

To explore children's longitudinal gains in accuracy and reaction time, children were grouped into four groups by the quartiles based on accuracy and reaction time scores in the mixed block at T1 ($Q_1 = 0.50$, $median = 0.60$, $Q_3 = 0.81$ for accuracy; $Q_1 = 657.50$, $median = 863.00$, $Q_3 = 1058.00$ for reaction time). There was no significant difference between the groups in accuracy in the congruent-only, $F(3,79) = 2.48$, $p = .07$ and incongruent-only blocks, $F(3,79) = 1.71$, $p = .17$. Children who scored in the third quartile in accuracy (the high-accuracy group: $M = 1035.93$, $SD = 242.48$) were significantly slower than children with scores in the first quartile in accuracy (the low-accuracy group: $M = 775.76$, $SD = 239.68$). There was no significant difference between the groups in speed in the mixed block at T2 $F(3,79) = 0.44$, $p = .73$. The groups were significantly different from each other in accuracy of the switch, $F(3,83) = 88.09$, $p < .01$, and nonswitch trials, $F(3,83) = 71.79$, $p < .01$, indicating that high accuracy children performed better than low accuracy children both on the switch and nonswitch trials of the mixed block. Eighty-one percent of T1 high accuracy children scored higher than the median accuracy score ($median = .70$) and 54.5% of them performed higher than the third quartile ($Q_3 = 0.87$) score of the mixed block at T2. Longitudinal gains of the T1 accuracy group and T1 speed groups were tested by adding these variables as additional between-subjects factors in separate sets of analyses.

3.2. Descriptive statistics

Descriptive statistics for the main variables at T1 and T2 are reported in Table 1. SES, vocabulary and the scores of the mixed block of the Hearts and Flowers task (at both time points) were normally distributed. The distributions of the scores of the congruent-only and incongruent-only blocks of the Hearts and Flowers task and working memory (at both time points) were skewed. Bivariate correlations between child's age, SES, working memory, vocabulary, and cognitive flexibility 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 Hearts and Flowers task at both time points. Working memory was positively associated with reaction time in the mixed block at T1. In addition, SES and vocabulary performance measured at T1 were positively correlated with accuracy in the mixed block measured at T2. Vocabulary scores at T1 and T2 were highly correlated. Working memory scores at T1 and T2 were not significantly associated, possibly due to the skewed distribution in both variables. Whereas speed showed significant stability from T1 to T2 in all blocks, the stability of the accuracy score was significant only in the mixed block. On the other hand, accuracy scores in the single-task demonstrated no stability from T1 to T2. Boys were significantly faster than girls in the mixed block at T1, $t(85) = -2.06$, $p < .05$, and in the congruent-only, $t(85) = -2.77$, $p < .01$, and incongruent-only blocks at T2, $t(85) = -2.09$, $p < .05$.

Table 1
Descriptive statistics for child's age and test scores before and after transition to formal education.

	T1 *M* (*SD*)	T2 *M* (*SD*)
Child age (months)	72.44 (3.65)	82.96 (3.33)
Working memory	3.59 (1.99)	4.64 (1.61)
Vocabulary	46.72 (12.11)	57.09 (11.96)
SES (standardized)	0.00 (0.80)	–
HF Congruent-only Acc	0.94 (0.08)	0.97 (0.06)
HF Incongruent-only Acc	0.88 (0.18)	0.86 (0.22)
HF Mixed Acc	0.65 (0.18)	0.70 (0.19)
The high-accuracy group	0.89 (0.06)	0.84 (0.17)
The average-to-high accuracy	0.71(0.07)	0.72 (0.17)
The low-to-average accuracy	0.55 (0.03)	0.6 (0.16)
The low-accuracy group	0.44 (0.07)	0.63 (0.18)
HF Congruent-only RT	559.72 (203.58)	450.71 (133.97)
HF Incongruent-only RT	725.9 (257.70)	596.56 (180.85)
HF Mixed RT	866.91 (242.48)	788.95 (223.60)
The high-accuracy group	1035.93 (169.17)	835.36 (182.17)
The average-to-high accuracy	945.47 (226.61)	771.63 (237.71)
The low-to-average accuracy	699.4 (177.24)	768.82 (241.47)
The low-accuracy group	775.76 (239.67)	778.65 (237.73)

Note: HF = Hearts and Flowers; Acc = Accuracy (mean); RT = Reaction time (median). RT in ms.

3.3. *Longitudinal changes in accuracy and reaction time*

Controlling for the potential influences of gender, SES, the longitudinal differences in working memory and vocabulary, the first set of within-subjects repeated-measures ANCOVAs revealed significant main effects of time, $F(1,82) = 4.70$, $p < .05$, $\eta_p^2 = .05$, and task condition, $F(1.82,148.83) = 56.48$, $p < .01$, $\eta_p^2 = .41$, and a no significant interaction between time and task condition, $F(1.54,125.93) = 0.74$, $p = .48$ on mean accuracy. Similar repeated-measures analyses demonstrated significant main effects of time, $F(1,82) = 14.28$, $p < .01$, $\eta_p^2 = .28$ and task condition, $F(1.80,150.72) = 59.79$, $p < .01$, $\eta_p^2 = .42$ on median reaction time. However, the interaction between time and task condition was nonsignificant, $F(1.79,146.91) = 2.74$, $p = .07$. There were no significant interactions between time and any of the covariates.

Children performed better and faster from T1 to T2. In addition, their accuracy and speed decreased from the congruent-only block to the incongruent-only block [accuracy: $F(1,82) = 14.83$, $p < .01$, $\eta_p^2 = .15$; reaction time: $F(1,82) = 47.15$, $p < .01$, $\eta_p^2 = .37$], from the incongruent-only block to the mixed block [accuracy: $F(1,82) = 38.03$, $p < .01$, $\eta_p^2 = .32$; reaction time: $F(1,82) = 23.55$, $p < .01$, $\eta_p^2 = .22$].

From T1 to T2, children showed a significant increase in accuracy in the mixed block $F(1,82) = 5.66$, $p < .05$, $\eta_p^2 = .07$, but not in congruent-only or incongruent-only blocks. In addition, they showed a significant decrease in reaction time in the congruent-only, $F(1,82) = 13.40$, $p < .01$, $\eta_p^2 = .14$, and incongruent-only blocks, $F(1,82) = 16.59$, $p < .01$, $\eta_p^2 = .17$, but not in the mixed block (Fig. 1). The gain in the mixed block performance, which requires flexible responding to conflicting demands, was in accuracy, but not in reaction time.

3.4. *Longitudinal patterns of the accuracy groups in the mixed block*

The second set of within-subjects repeated measures ANCOVAs, with time as within-subjects factor and T1 accuracy groups (four groups by quartiles) as between-subjects factor, gender, SES, the longitudinal differences in working memory and vocabulary as the covariates on accuracy and reaction time as the dependent variables, revealed significant interactions between time and T1 accuracy groups on accuracy, $F(3,79) = 7.60$, $p < .01$, $\eta_p^2 = .22$, and on reaction time, $F(3,79) = 5.02$, $p < .01$, $\eta_p^2 = .16$.

Longitudinal performance of groups in the mixed block (Fig. 2) showed that the only group that improved accuracy was the one consisting of children scoring in the first quartile ($Q_1 = 0.50$) at T1 (T1 low-accuracy children); $F(1,18) = 20.88$, $p < .01$, $\eta_p^2 = .54$. The other three groups did not show a significant gain in accuracy from T1 to T2. Despite the accuracy gain of the T1 low-accuracy children over time, they were still significantly less accurate ($M = 0.63$, $SD = 0.18$) than T1 high- accuracy children ($M = 0.84$, $SD = 0.19$) in the mixed block at T2, $F(3,83) = 8.69$, $p < .01$. However, they could catch up to the 'low-to-average accuracy' (children who scored between the Q_1 and the median) and 'average-to-high accuracy' (children who scored between the median and the Q_3) groups. The only group that gained in speed over time was the one consisting of children who performed average-to-high in the mixed block at T1 (children with accuracy scores in the third quartile); $F(1,17) = 4.98$, $p < .05$, $\eta_p^2 = .23$. Although nonsignificant, it is important to note that the effect size for the speed gain of the high-accuracy group was close to the effect size for the speed gain of the average-to-high accuracy group (Table 3).

The repeated measures ANCOVA, with time as within-subjects factor, and T1 speed groups (four groups by quartiles) as between-subjects factor, gender, SES, the longitudinal differences in working memory and vocabulary as the covariates on reaction time as the dependent variable, revealed a significant interaction between time and T1 speed groups, $F(3,79) = 20.09$, $p < .01$, $\eta_p^2 = .43$. The interaction for accuracy was not significant. Inspection of the longitudinal performance of the groups in

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. Child's age (months)	1																	
2. Family SES (standardized)	−.14	1																
3. T1 WM	.12	.15	1															
4. T1 Vocabulary	.31**	.27*	.22*	1														
5. T1 HF Congruent-only Acc	.03	.18	.25*	.18	1													
6. T1 HF Incongruent-only Acc	.12	.04	.07	.06	.32**	1												
7. T1 HF Mixed Acc	.09	.16	.16	.16	.31**	.19	1											
8. T1 HF Congruent-only RT	−.06	−.11	−.09	−.18	.10	.12	−.10	1										
9. T1 HF Incongruent-only RT	−.16	−.05	−.17	−.18	.20	.19	−.03	.54**	1									
10. T1HF Mixed RT	.09	.15	.28**	.20	.36**	.37**	.47**	.15	.29**	1								
11. T2 WM	.07	.14	.20	.20	.07	.08	.09	−.13	−.08	.17	1							
12. T2 Vocabulary	.15	.31**	.24*	.70**	.15	.08	.08	−.12	−.13	.18	.20	1						
13. T2 HF Congruent-only Acc	.02	−.03	−.04	−.13	−.02	.16	.08	.09	.11	−.00	−.09	−.17	1					
14. T2 HF Incongruent-only Acc	−.05	.15	.05	.13	.15	−.02	.17	−.28**	−.11	.03	.14	.18	−.05	1				
15. T2 HF Mixed Acc	−.02	.25*	.15	.23*	.16	.16	.44**	−.03	.02	.30**	−.05	.22*	.20	.19	1			
16. T2 HF Congruent-only RT	−.19	.05	−.07	−.18	.03	.09	.02	.34**	.40**	.16	−.05	−.10	.14	−.04	.17	1		
17. T2 HF Incongruent-only RT	−.18	.02	−.13	−.16	−.06	.10	.02	.38**	.48**	.16	−.00	−.13	.15	.04	.21	.70**	1	
18. T2 HF Mixed RT	−.02	.03	−.01	.03	−.07	.07	.06	.24*	.28**	.22*	−.20	−.03	.26*	−.15	.58**	.47**	.54**	1

Note: HF = Hearts and Flowers; WM = working memory; T1 = Kindergarten; T2 = first grade; Acc = Accuracy (mean), RT = reaction time (median). RT in ms.

* $p < .05$.

** $p < .01$.

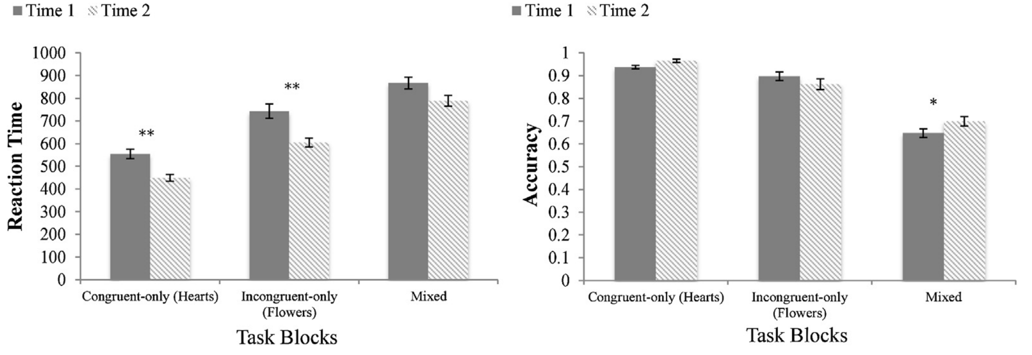

Fig. 1. Gains in the task blocks of the Hearts and Flowers (*p < .05, **p < .01).

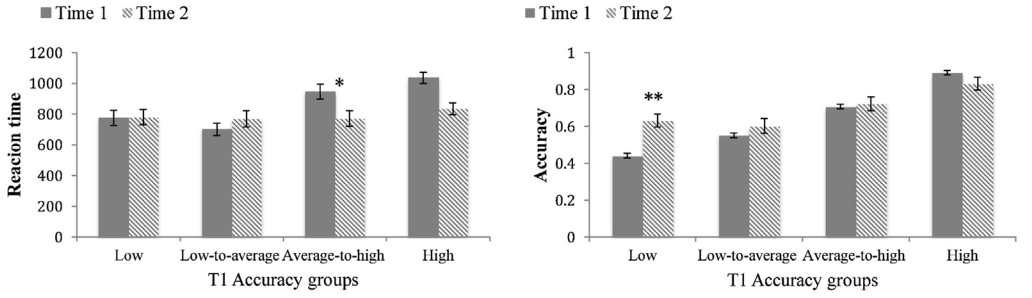

Fig. 2. Gains of the T1 subgroups in the mixed block of the Hearts and Flowers (*p < .05, **p < .01).

Table 3
Effect sizes (partial eta^2) for the gains in accuracy and reaction time of the subgroups based on the quartiles.

	T1 accuracy groups			
Gain	Low	Low-to-average	Average-to-high	High
Accuracy	0.54[**]	0.05	0.03	0.00
Reaction time	0.05	−0.10	0.23[*]	0.18
	T1 speed groups			
Gain	Initially slowest			Initially fastest
Accuracy[a]	0.01	0.06	0.07	0.34[**]
Reaction time	0.53[**]	0.08	0.07	−0.13

[a] The interaction between time × ‘T1 speed groups’ was not significant for accuracy.
[*] $p < .05$.
[**] $p < .01$.

the mixed block revealed that children who were initially slowest in responding increased their speed over time without any gain or loss in accuracy, $F(1,16) = 18.23$, $p < .01$, $\eta_p^2 = .53$. The other three groups did not show significant change in speed.

4. Discussion

The findings showed that 5–6-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 first grade, whereas those in the low-accuracy group, consisting of children scoring in the first quartile, improved their performance substantially. The reaction time patterns revealed that children in the high-accuracy groups, consisting of children scoring higher than the median score in accuracy in kindergarten, became faster whereas reaction time in the low-accuracy groups did not change. In addition, children who were initially fastest in responding decreased their speed from kindergarten to first grade.

A close look at speed and accuracy scores of the mixed block in a cognitive flexibility task provided insight into how children handle an ambiguous situation with continuously changing, conflicting and time-limited demands. 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, SES and 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 contrast, improvement in the incongruent-only block, in which children's inhibitory control is assessed, occurred in speed, but not accuracy.

It has been suggested that the major accuracy gains in tasks requiring complex response inhibition (i.e., inhibiting a prepotent response while holding a new rule) occur between the ages 3 and 5 (Garon, Bryson, & Smith, 2008). Given their high level of accuracy in the incongruent-only block in kindergarten, children at this age appear able to inhibit the previously learned rule and respond correctly according to a new rule. The transition to formal schooling may help them to speed up this response inhibition.

In the literature, 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 present results revealed that speed showed significant stability from kindergarten to first grade in all blocks of the cognitive flexibility task whereas the stability of the accuracy score was significant only in the mixed block. It is likely that speed of responding may reflect a persistent trait whereas performance accuracy may be more state-dependent. Although further longitudinal research is needed, our findings support the idea that different score types show different results and hence lead to different conclusions (Davidson et al., 2006).

Some have argued that it is not clear whether accuracy and response speed reflect the same processes of cognitive flexibility (Cragg & Chevalier, 2012). To our knowledge, no study explains the nature of the processes that accuracy and speed may tap into. However, there is some evidence that the relation between accuracy and speed of flexible responding may change depending on the executive function task and participants' age (Best, Miller, & Naglieri, 2011). Our findings revealed that accuracy and speed are not related in single-task blocks (Congruent-only and Incongruent-only blocks) whereas they are positively associated in the mixed block, which is in line with the idea of a speed-accuracy tradeoff. This association between accuracy and speed became stronger in this block at T2, indicating that children might have improved their monitoring skills, which led them to respond in a more cautious way in this unpredictably changing, therefore challenging situation.

To further understand how accuracy and speed of flexible responding unfold longitudinally, we divided children into four groups based on their accuracy scores in the mixed block in kindergarten (T1). As expected, T1 high-accuracy children (third quartile) were significantly slower than T1 low-accuracy children (first quartile) in the mixed block. However, the speed difference between the groups disappeared at T2. The more accurate children increased speed whereas the less accurate children did not. In contrast, the accuracy gap between groups remained significant at T2 despite the significant gain in accuracy of the T1 low-accuracy group. Given that the mean accuracy of the T1 low performing groups (i.e., the groups that scored lower than the median accuracy) in the first two blocks (Congruent-only, and Incongruent-only) was very high, and not significantly different from the T1 high performing groups (i.e., the groups that scored higher than the median accuracy in kindergarten), these children understood the two main rules of the task (pressing on same side with heart and opposite side with flower). However, they had difficulties in switching between responses flexibly in a condition where the rules unpredictably change, leading to incorrect and fast responses in the mixed block, which can be considered as an indicator of inflexible thinking. The T1 high-accuracy group showed no significant change in accuracy from T1 to T2 although there was room for improvement. On the other hand, the T1 low-accuracy group was still less accurate than the T1 high-accuracy group at T2 despite their gain in accuracy.

These findings indicate that children in the two accuracy groups showed longitudinally different response patterns to ambiguity and conflict in the mixed block. There is some evidence that exposure to learning resources during the preschool years shapes the development of executive control function and greater access to these resources facilitates the growth of executive functions (Clark et al., 2013). The transition to formal education is also characterized by changes in context and content of learning as well as expectations regarding 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 et al., 2010). It is likely that formal schooling provides organized built-in opportunities (e.g., adding and subtracting within one set of math problems, or alternating capital letters and small letters in writing) for children to learn to be more attentive to rules and changes in rules.

We tentatively conclude that this period may have helped less accurate children in T1 to improve their selective attention to changing demands of the environment. In contrast, more accurate children in T1 appear to have gained in processing speed, indicating that they responded to the changing environment as correctly as they had previously done but they did it faster, possibly due to an additional year's worth of practice both in daily life and in the school setting. Recent literature points to the possibility that temperamental (Friedman, Miyake, Robinson, & Hewitt, 2011) or motivational (Dreisbach & Goschke, 2004; Marien, Aarts, & Custer, 2012) dimensions are crucial factors. Thus, future researchers should examine whether individual differences in these factors may explain further the differing longitudinal response patterns to the changing environment.

Our sample consisted of low SES Turkish minority children who were born in the Netherlands and most of whom had at least one parent also born in the Netherlands. Therefore they differ from majority children regarding ethnicity as well as family economic status, which may affect generalizability of the findings. On the other hand, children's minority status may have specific implications for the interpretation of our results. On average, ethnic minority children (even of the third generation) perform less well in some areas (Kao & Tienda, 1995; Leventhal, Xue, & Brooks-Gunn, 2006), are more likely to drop out of school (Rumberger, 1995), and tend to be from lower SES backgrounds, compared to 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 well on cognitive flexibility at kindergarten age. This finding can be seen as supportive of policies regarding early school entry for low-SES and ethnic minority children (Dominguez, Vitiello, Fuccillo, Greenfield, & Bulotsky-Shearer, 2011; Raver et al., 2011; Welsh, Nix, Blair, Bierman, & Nelson, 2010). Nevertheless, developmental processes are not necessarily 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 only group-specific patterns.

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). Furthermore, formal education that provides a cognitively stimulating (and structured, i.e., rules) learning context may have helped children who performed less well in kindergarten to improve cognitive flexibility.

We thus suggest that transition to school is an important assessment point for children's strengths and skills for improvement, given our findings indicate that cognitive flexibility might be malleable to changing environmental conditions during this period. Given the evidence that this flexibility 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 high and low performing groups can be narrowed further by deliberate effort, such as daily EF practices at school (Diamond et al., 2007).

It is important to note several 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 written contact. This low response rate has previously been reported for ethnic minorities in the Netherlands, especially families with low SES (Feskens, Hox, Lensvelt-Mulders, and Schmeets, 2007). Second, a mixed sample of ethnic majority and minority children would enable us to examine flexibility performance of ethnic minority children relative to majority children during the school transition. However, it is a methodological challenge to recruit ethnic majority children who are comparable to minority children in terms of family backgrounds, due to disparity in SES 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. Thus, future studies should include a battery of measures.

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

Acknowledgements

Financial support from NORFACE (New Opportunities for Research Funding Agency Co-operation in Europe) research program on Migration in Europe—Social, Economic, Cultural and Policy Dynamics (Grant # NORFACE-292) is acknowledged. We thank all parents, children, teachers and school principals who participated in our study as well as all students who assisted in various phases of the 'Social Integration of Migrant Children: Uncovering factors promoting Resilience' (SIMCUR) project.

References

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development*, *81*(6), 1641–1660. http://dx.doi.org/10.1111/j.1467-8624.2010.01499.x

Best, J. R., Miller, P. H., & Naglieri, J. A. (2011). Relations between executive function and academic achievement from ages 5 to 17 in a large, representative national sample. *Learning and Individual Differences*, *21*(4), 327–336.

Bhattacharya, G. (2000). The school adjustment of South Asian immigrant children in the United States. *Adolescence*, *35*(137), 77–85.

Blackwell, K. A., Cepeda, N. J., & Munakata, Y. (2009). When simple things are meaningful: Working memory strength predicts children's cognitive flexibility. *Journal of Experimental Child Psychology*, *103*(2), 241–249. http://dx.doi.org/10.1016/j.jecp.2009.01.002

Bogacz, R., Wagenmakers, E. J., Forstmann, B. U., & Nieuwenhuis, S. (2010). The neural basis of the speed-accuracy tradeoff. *Trends in Neurosciences*, *33*(1), 10–16. http://dx.doi.org/10.1016/j.tins.2009.09.002

Brownell, R. (2000). *Expressive one-word picture vocabulary test manual*. Novato, CA: Academic Therapy Publications.

Cepeda, N. J., & Munakata, Y. (2007). Why do children perseverate when they seem to know better: Graded working memory, or directed inhibition? *Psychonomic Bulletin & Review*, *14*(6), 1058–1065. http://dx.doi.org/10.3758/Bf03193091

Chevalier, N., Sheffield, T. D., Nelson, J. M., Clark, C. A., Wiebe, S. A., & Espy, K. A. (2012). Underpinnings of the costs of flexibility in preschool children: the roles of inhibition and working memory. *Developmental neuropsychology*, *37*(2), 99–118. http://dx.doi.org/10.1080/87565641.2011.632458

Clark, C. A., Sheffield, T. D., Chevalier, N., Nelson, J. M., Wiebe, S. A., & Espy, K. A. (2013). Charting early trajectories of executive control with the shape school. *Developmental psychology*, *49*(8), 1481. http://dx.doi.org/10.1037/a0030578

Cragg, L., & Chevalier, N. (2012). The processes underlying flexibility in childhood. *Quarterly Journal of Experimental Psychology*, *65*(2), 209–232. http://dx.doi.org/10.1080/17470210903204618

Crone, E. A., Bunge, S. A., Van der Molen, M. W., & Ridderinkhof, K. R. (2006). Switching between tasks and responses: A developmental study. *Developmental Science*, *9*(3), 278–287. http://dx.doi.org/10.1111/j.1467-7687.2006.00490.x

Crosnoe, R. (2005). Double disadvantage or signs of resilience? The elementary school contexts of children from Mexican immigrant families. *American Educational Research Journal*, *42*(2), 269–303. http://dx.doi.org/10.3102/00028312042002269

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037–2078. http://dx.doi.org/10.1016/j.neuropsychologia.2006.02.006

Deak, G. O., & Narasimham, G. (2003). Is preservation caused by inhibition failure? – Evidence from preschool children's inferences about word meanings. *Journal of Experimental Child Psychology*, *86*(3), 194–222. http://dx.doi.org/10.1016/j.jecp.2003.08.001
Diamond, A. (2006). The early development of executive functions. In E. Bialystok, & F. I. M. Craik (Eds.), *Lifespan cognition mechanisms of change* (pp. 70–95). Oxford, UK: Oxford University Press.
Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). The early years: Preschool program improves cognitive control. *Science*, *318*(5855), 1387–1388. http://dx.doi.org/10.1126/science.1151148
Diamond, A., & Kirkham, N. (2005). Not quite as grown-up as we like to think – Parallels between cognition in childhood and adulthood. *Psychological Science*, *16*(4), 291–297. http://dx.doi.org/10.1111/j.0956-7976.2005.01530.x
Dominguez, X., Vitiello, V. E., Fuccillo, J. M., Greenfield, D. B., & Bulotsky-Shearer, R. J. (2011). The role of context in preschool learning: A multilevel examination of the contribution of context-specific problem behaviors and classroom process quality to low-income children's approaches to learning. *Journal of School Psychology*, *49*(2), 175–195. http://dx.doi.org/10.1016/j.jsp.2010.11.002
Dreisbach, G., & Goschke, T. (2004). How positive affect modulates cognitive control: reduced perseveration at the cost of increased distractibility. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*(2), 343. http://dx.doi.org/10.1037/0278-7393.30.2.343
Feskens, R. C. W., Hox, J. J., Lensvelt-Mulders, G. J. L. M., & Schmeets, J. J. G. (2007). Nonresponse among ethnic minorities: A multivariate analysis. *Journal of Official Statistics*, *23*(3), 387–408.
Friedman, N. P., Miyake, A., Robinson, J. L., & Hewitt, J. K. (2011). Developmental trajectories in toddlers' self-restraint predict individual differences in executive functions 14 years later: a behavioral genetic analysis. *Developmental psychology*, *47*(5), 1410. http://dx.doi.org/10.1037/a0023750
Furr, R. M., & Bacharach, V. R. (2008). *Psychometrics: An introduction*. Thousand Oaks, CA: Sage Publications, Inc.
Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: a review using an integrative framework. *Psychological bulletin*, *134*(1), 31. http://dx.doi.org/10.1037/0033-2909.134.1.31
Hommel, B., Kray, J., & Lindenberger, U. (2011). Feature integration across the lifespan: Stickier stimulus-response bindings in children and older adults. *Frontiers in Psychology*, *2*, 268–275. http://dx.doi.org/10.3389/fpsyg.2011.00268
Hughes, C., & Ensor, R. (2005). Executive function and theory of mind in 2 year olds: A family affair? *Developmental Neuropsychology*, *28*(2), 645–668. http://dx.doi.org/10.1207/s15326942dn2802_5
Hughes, C., Ensor, R., Wilson, A., & Graham, A. (2010). Tracking executive function across the transition to school: A latent variable approach. *Developmental Neuropsychology*, *35*(1), 20–36. http://dx.doi.org/10.1080/87565640903325691
Huizinga, M., Burack, J. A., & Van der Molen, M. W. (2010). Age-related change in shifting attention between global and local levels of hierarchical stimuli. *Journal of Cognition and Development*, *11*(4), 408–436. http://dx.doi.org/10.1080/15248371003700031
Ivanoff, J., Branning, P., & Marois, R. (2008). fMRI Evidence for a dual process account of the speed-accuracy tradeoff in decision-making. *PLoS ONE*, *3*(7) http://dx.doi.org/10.1371/Journal.Pone.0002635. Artn E2635
Jacques, S., & Zelazo, P. D. (2005). On the possible roots of cognitive flexibility. In B. Homer, & C. Tamis-Lemonda (Eds.), *The development of social understanding and communication* (pp. 53–81). Mahwah, NJ: Erlbaum.
Kao, G., & Tienda, M. (1995). Optimism and achievement – The educational performance of immigrant youth. *Social Science Quarterly*, *76*(1), 1–19.
Karbach, J., & Kray, J. (2007). Developmental changes in switching between mental task sets: The influence of verbal labeling in childhood. *Journal of Cognition and Development*, *8*(2), 205–236. http://dx.doi.org/10.1080/15248370701202430
Leventhal, T., Xue, Y. G., & Brooks-Gunn, J. (2006). Immigrant differences in school-age children's verbal trajectories: A look at four racial/ethnic groups. *Child Development*, *77*(5), 1359–1374. http://dx.doi.org/10.1111/j.1467-8624.2006.00940.x
Magnuson, K., Lahaie, C., & Waldfogel, J. (2006). Preschool and school readiness of children of immigrants. *Social Science Quarterly*, *87*(5), 1241–1262. http://dx.doi.org/10.1111/j.1540-6237.2006.00426.x
Marien, H., Aarts, H., & Custers, R. (2012). Being flexible or rigid in goal-directed behavior: When positive affect implicitly motivates the pursuit of goals or means. *Journal of Experimental Social Psychology*, *48*(1), 277–283. http://dx.doi.org/10.1016/j.jesp.2011.08.013
Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex frontal lobe tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. http://dx.doi.org/10.1006/cogp.1999.0734
Noble, K. G., Norman, M. F., & Farah, M. J. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science*, *8*(1), 74–87.
Pachella, R. G. (1974). The interpretation of reaction time in information processing research. In B. Kantowitz (Ed.), *Human information processing: Tutorial in performance and recognition* (pp. 41–82). Potomac, MD: Erlbaum Associates.
Raver, C. C., Jones, S. M., Li-Grining, C., Zhai, F. H., Bub, K., & Pressler, E. (2011). CSRP's Impact on low-income preschoolers' preacademic skills: Self-regulation as a mediating mechanism. *Child Development*, *82*(1), 362–378. http://dx.doi.org/10.1111/j.1467-8624.2010.01561.x
Riggs, N. R., Blair, C. B., & Greenberg, M. T. (2003). Concurrent and 2-year longitudinal relations between executive function and the behavior of 1st and 2nd grade children. *Child Neuropsychology*, *9*(4), 267–276. http://dx.doi.org/10.1076/chin.9.4.267.23513
Roebers, C. M., Rothlisberger, M., Cimeli, P., Michel, E., & Neuenschwander, R. (2011). School enrolment and executive functioning: A longitudinal perspective on developmental changes, the influence of learning context, and the prediction of pre-academic skills. *European Journal of Developmental Psychology*, *8*(5), 526–540. http://dx.doi.org/10.1080/17405629.2011.571841
Rowe, D. C., Vazsonyi, A. T., & Flannery, D. J. (1994). No more than skin deep – Ethnic and racial similarity in developmental process. *Psychological Review*, *101*(3), 396–413. http://dx.doi.org/10.1037//0033-295x.101.3.396
Rumberger, R. W. (1995). Dropping out of middle school: A multilevel analysis of students and schools. *American Educational Research Journal*, *32*(3), 583–625. http://dx.doi.org/10.3102/00028312032003583

Salthouse, T. A. (2010). Is flanker-based inhibition related to age? Identifying specific influences of individual differences on neurocognitive variables. *Brain and Cognition*, *73*(1), 51–61. http://dx.doi.org/10.1016/j.bandc.2010.02.003

Sarsour, K., Sheridan, M., Jutte, D., Nuru-Jeter, A., Hinshaw, S., & Boyce, W. T. (2011). Family socioeconomic status and child executive functions: The roles of language, home environment, and single parenthood. *Journal of the International Neuropsychological Society*, *17*(1), 120–132. http://dx.doi.org/10.1017/S1355617710001335

Schneider, W., Eschman, A., & Zuccolotto, A. (2007). *E-Prime: User's guide, version 2.0. Psychology software tools.*

Suárez-Orozco, C., & Suárez-Orozco, M. M. (2001). *Children of immigration*. Cambridge, MA: Harvard University Press.

UNESCO Institute for Statistics. (2011). *International Standard Classification of Education: ISCED 2011*. Montreal: UNESCO Institute for Statistics.

Vitiello, V. E., Greenfield, D. B., Munis, P., & George, J. (2011). Cognitive flexibility, approaches to learning, and academic school readiness in Head Start preschool children. *Early Education and Development*, *22*(3), 388–410. http://dx.doi.org/10.1080/10409289.2011.538366, pii:938291188

Wechsler, D. (2003). *Wechsler Intelligence Scale for Children* (4th ed.). San Antonio, TX: Harcourt Assessment, Inc.

Welsh, J. A., Nix, R. L., Blair, C., Bierman, K. L., & Nelson, K. E. (2010). The development of cognitive skills and gains in academic school readiness for children from low-income families. *Journal of Educational Psychology*, *102*(1), 43–53. http://dx.doi.org/10.1037/A0016738

Wiebe, S. A., Espy, K. A., & Charak, D. (2008). Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. *Developmental Psychology*, *44*(2), 575–587. http://dx.doi.org/10.1037/0012-1649.44.2.575

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. http://dx.doi.org/10.1016/j.lindif.2012.10.004