Goal neglect and working memory capacity in 4- to 6-year-old children.

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Abstract:

Goal neglect is the phenomenon of failing to execute the momentary demands of a task despite understanding and being able to recall the task instructions. Successful goal maintenance is more likely to occur in adults with high working memory capacity (WMC) who can keep rules mentally accessible while performing the task. The current study predicted that goal neglect would also be related to WMC in children. It assessed thirty-seven 4-year-old and twenty-eight 6-year-old children on the goal neglect version of the Dimensional Change Card Sort, and 3 tasks that measure WMC. As predicted, children with higher WMC scores were more likely to maintain goals adequately for task performance. The findings are consistent with a 2-factor model of working memory and its development.

Keywords: psychology | child development | memory | working memory | memory capacity | memory in children | goal-directed behavior

Article:

Goal-directed behavior is complex, as it necessitates a representation of the goal state, formulation of a plan to achieve the goal state, and the ability to hold the goal in mind so that it may guide behavior at the appropriate time. Failure to behave accordingly, despite demonstrating knowledge of the appropriate actions, has been termed "goal neglect" (Duncan, Emslie, Williams, Johnson, & Freer, 1996) and has often been attributed to momentary lapses in working memory in typically developing populations (Kane & Engle, 2003) and associated with fluid intelligence and frontal lobe functioning (Duncan, 1995). Importantly, goal maintenance relies on self-regulatory skills such as persistence and resistance to distractibility, which are known to predict school readiness and academic success (Blair, 2002; McClelland et al., 2007).

We take the view that goal neglect can result in perseverative responding, the tendency to behave incorrectly in a manner that was previously correct. Perseverative responding is seen widely in infancy and early childhood and may result from the inability to maintain the goal representation

sufficiently to override a prepotent response (Marcovitch & Zelazo, 2009). This view is consistent with a number of theories of goal-directed behavior in children, and we will illustrate its potency by examining theories of performance on the Dimensional Change Card Sorting task (DCCS; Zelazo, Frye, & Rapus, 1996; Zelazo, Müller, Frye, & Marcovitch, 2003), a popular measure of executive function in young children. In the DCCS, children are told an explicit rule to match cards according to one dimension (e.g., color). After several trials, the rule is changed so that the children now match cards by the other dimension (e.g., shape). For example, children may be instructed to match blue circles and green squares to a blue square and a green circle. They initially are instructed to sort by color, thus matching blue circles to the blue square and green squares to the green circle. After a number of trials, the rule is switched and they are instructed to sort by shape, thus matching blue circles to the green circle and green squares to the blue square. Although 3-year-olds can sort the cards by each rule independently, they have difficulty following the second rule after sorting by the first. Of importance, despite sorting incorrectly after hearing the second rule, children display knowledge of the rule when asked to point to the correct location (Zelazo et al., 1996), when judging the sorting behavior of a puppet (Jacques, Zelazo, Kirkham, & Semcesen, 1999), and when told to verbalize it (Kirkham, Cruess, & Diamond, 2003; Towse, Redbond, Houston-Price, & Cook, 2000; but see Müller, Zelazo, Lurye, & Liebermann, 2008). Thus, the criterion for goal neglect set forth by Duncan (1995) is met—children know the appropriate response but do not execute it.

Although there are several disparate accounts of perseveration in the DCCS, they all (explicitly or implicitly) share the central feature that children who perseverate are not holding the correct rule in mind. In the revised version of cognitive complexity and control theory, Zelazo et al. (2003) argue that increases in levels of reflection allow for the formation and implementation of higher order rules that are needed to handle the two contradistinctive rules simultaneously. Children who do not formulate, and thus cannot hold in mind, higher order rules have difficulty on the DCCS. In contrast, children who succeed on the task not only know the rules, but they know that they know the rules allowing them to consider the contradistinctive rules in parallel. According to a different account of perseveration, the attentional inertia account (Kirkham et al., 2003), children perseverate by continuing to act on the wrong rule unless they are primed to activate the correct rule by emphasizing the relevant dimension such as through labeling. Thus, success hinges on accessing the appropriate rule as needed. Similarly, in redescription accounts of the DCCS (Kloo & Perner, 2005; Perner & Lang, 2002), young children cannot think about a stimulus as two things simultaneously (i.e., a red thing and a balloon) and therefore it is difficult for them to maintain the new rule in mind, which requires redescribing the stimulus after the rules have been switched. Finally, in accounts that link perseveration to the degree of conflict (Jordan & Morton, 2008; Morton & Munakata, 2002), children's performance can be improved when the degree of conflict is degraded by increasing the salience of the postswitch dimension and the likelihood that the rule is kept in mind. Thus, all the primary accounts of the DCCS

attribute perseveration to a failure in accessing the correct rule, which is a central tenet of goal neglect.

Towse, Lewis, and Knowles (2007) investigated goal neglect and its potential causes in young children by combining elements of the DCCS procedure with those of Duncan's (1995) method of inducing goal neglect in adults. Here, 4-year-old children were presented with the outlines of a blue house (on the left) and a red house (on the right) on a laptop computer, and were explained that food items would appear in the houses, but that they should only focus on one particular house. They were taught the rules of the game: (a) On the first presentation of the food items, an arrow will point to the target house that children should initially attend and name the food items. (b) At some unpredictable time, a new task signal will appear: If it is a blue square, then children should begin to name the items in the blue house, but if it is a red square, they should begin to name the items in the red house. Note that these signals sometimes cued the children to continue with the same house, and sometimes required them to switch houses. Because children were tested on whether they understood the rules prior to the study, failure to switch houses after the presentation of the appropriate cue was considered goal neglect. Interestingly, this type of goal neglect correlated negatively with performance on the DCCS, suggesting that goal maintenance is directly related to task switching.

The DCCS has also been modified to assess goal neglect in 4- and 5-year-olds, who typically perform well on the DCCS (Marcovitch, Boseovski, & Knapp, 2007). In the goal-neglect version of the DCCS (GN–DCCS), children received five preswitch trials where they were instructed to sort according to one dimension (e.g., color). On the postswitch trials, children received 30 trials where they were instructed to sort according to the other dimension (e.g., shape). Two types of stimulus cards were used in the postswitch: conflict cards, which were the standard DCCS cards where one dimension mapped on to one target card while the other dimension mapped onto the other target card, and redundant cards, which were identical to the target cards (see Figure 1). In the mostly conflict condition, 80% of the postswitch trials were conflict cards. In contrast, in the mostly redundant condition, only 20% of the postswitch trials were conflict cards (i.e., the preponderance of cards were redundant). Marcovitch et al. (2007) reasoned that in the context of constantly sorting conflict cards, it would be relatively simple to keep the relevant postswitch rule in mind either because the conflict trials reinforce the sorting rule, or because the presence of repeated conflict reinforces the need to keep the rule in mind. On the other hand, in the context of constantly sorting redundant cards—where theoretically no rule is needed most of the time, as the test card matches one of the targets on both dimensions—it is more challenging to recall the correct rule when finally faced with a conflict card. Thus, Marcovitch et al. predicted that a higher percentage of conflict cards will be sorted correctly in the mostly conflict condition as compared with the mostly redundant condition, which they considered the measure of goal

neglect. This is precisely what was found, regardless of whether the children were reminded of the rule once (Experiment 1) or before every postswitch trial (Experiment 2). The latter provides a striking example of goal neglect given that children were told the correct rule immediately prior to sorting each and every card.

Figure 1 is omitted from this formatted document.

In their Stroop study with adults, Kane and Engle (2003) found that performance in a mostly redundant condition (i.e., with most color words presented in their matching hues) was related to individual differences in working memory capacity (WMC). From Kane and Engle's perspective (see also Engle, 2002; Engle & Kane, 2004), WMC reflects "the interaction of attentional and memorial processes in the working memory system, and . . . this interaction between attention and memory is an elementary determinant of broad cognitive ability" (Engle & Kane, 2004, p. 147). Furthermore, they contend that individual differences in WMC are attributed primarily to differences in the control of actively maintaining goal-relevant information. Thus, individuals with high WMC are more likely to maintain a goal actively in the face of distraction, even across extended periods of time where goal activation is only occasionally (and unpredictably) necessary.

Following this perspective, Marcovitch et al. (2007) argued that, compared with adults, 4- and 5-year-old children have difficulty in maintaining goals and that this was the predominant factor for their poor performance on the mostly redundant sort. However, Marcovitch et al. were interested in group performance and did not assess WMC in the children. In the current study, we assessed individual differences in WMC in 4- to 6-year-old children to determine whether WMC was related to goal neglect as measured by the mostly redundant sort. We assessed WMC via three working memory span tasks that all require keeping in mind a series of items while intermittently performing an unrelated, secondary task (e.g., Case, Kurland, & Goldberg, 1982). Given the importance of maintaining representations over time and in the face of distraction on these tasks, we hypothesized that if the mostly redundant card sort indeed relied on these skills then performance should be predicted by individual differences in WMC. Alternatively, it is entirely possible, and consistent with Marcovitch et al.'s (2007) earlier findings, that young children as a whole may not yet have the necessary capacity to maintain goals across periods of inactivity. In other words, even if children's WMC is high relative to their peers, the absolute level of WMC may still not be sufficient to succeed on the mostly redundant sort.

Establishing that individual differences in WMC impact performance on the mostly redundant sort is theoretically and practically important, for several reasons:

1 It would provide a unified explanation for goal neglect from early childhood to adulthood. We hypothesize that goal neglect is a byproduct of the inability to maintain a representation over time and distraction, a skill measured directly by working memory span tasks.

2 A positive relation would imply that improvements in WMC—perhaps via special training—would also improve goal maintenance (e.g., Klingberg et al., 2005). This may be extremely useful for improving goal-directed behavior in typical populations in educational settings, as well as atypical populations in directed training sessions.

We further hypothesize that WMC should be related to performance on the mostly conflict sort for the younger but not the older children. This is because goal maintenance is still required to pass the mostly conflict sort, but the constant usage of the rule makes it easier to keep in mind and partially scaffold performance for the younger children with lower WMC. Older children will generally not require the additional scaffolding to succeed on the mostly conflict sort, and thus no relation between WMC and performance is expected.

Finally, we wanted to assess to what degree WMC predicts performance on each card sort above and beyond the other card sort. On one hand, we expect a meaningful amount of variance common to both card sorts to be accounted for by WMC, as both card sorts have many procedural similarities, and both require goal maintenance albeit to different degrees. However, consistent with the two-factor theory of executive control postulated by Engle and Kane (2004; for a related view, see Braver, Gray, & Burgess, 2007), we also predict that WMC may account for unique variability in the performance of each card sort. According to Engle and Kane, one factor of executive control is "the maintenance of the task goals in active memory" (p. 186), potentially assessed in the current study by performance on the mostly redundant card sort. Engle and Kane argue that goal maintenance is resource-demanding, and thus better executed by individuals with high WMC. The other factor of control is "the resolution of response competition or conflict, particularly when prepotent or habitual behaviors conflict with behaviors appropriate to the current task goal" (p. 186), potentially assessed in the current study by performance on the mostly conflict sort. If each card sort is a measure as a distinct factor of WMC, then variability in performance for each sort should be accounted for uniquely by our measures of working memory.

Method

Participants

We recruited children in a midsized Southeastern city from local day care centers and from a database of parents who had previously expressed interest in participating in research studies. There was no payment for participation, although the children received a gift after the study. The treatment of participants was in accordance with the ethical standards of the American Psychological Association and the study was approved by the local Institutional Review Board. The final sample consisted of thirty-seven 4-year-olds (M = 4.71 years, range = 4.02–5.45, 16 girls) and twenty-eight 6-year-olds (M = 6.22 years, range = 5.55–6.98, 15 girls). Thirteen additional children (ten 4-year-olds and three 6-year-olds) were tested but their data were not included because they did not perform to criterion on the preswitch sorts (see the following). The sample was racially diverse (69% self-reported as White, 18% Black, 3% biracial, 3% Asian, and 8% preferred not to respond) with varying levels of socioeconomic status (51% reported household earnings over $60,000, 26% under $60,000, and 23% refused to respond).

Materials

For the GN–DCCS, laminated cards (13 cm × 8 cm) depicted either a yellow car, a yellow flower, a green car, a green flower, a red boat, a red bunny, a blue boat, or a blue bunny (all pictures were approximately 16 cm × 16 cm). Participants sorted the cards into two gray sorting boxes (28.5 cm × 20 cm × 11 cm) with slits that had been cut into the lids.

In the Visual Counting Span task of WMC, two types of stickers were affixed to paper cards (21 cm × 20 cm): hearts and American flags, stars and rainbows, or bees and frogs. The number of stickers of each type per card ranged from one to eight. In the Visual Backward Word Span task, paper cards (14 cm × 14 cm) depicted a picture of a common object or animal (approximately 5 cm × 4 cm). Finally, in the Auditory Backward Digit Span task, we presented stimuli using a stuffed pink and white rabbit toy named "Fluffy."

Design and Procedure

In the experimental session, all children completed the three WMC tasks (Visual Counting Span, Visual Backward Word Span, and Auditory Backward Digit Span) and the two card sorting tasks (mostly redundant, mostly conflict). The order of the tasks was counterbalanced with the constraint that the first, third, and fifth tasks were WMC tasks whereas the second and fourth tasks were card sorting tasks.

Goal-Neglect DCCS

All children participated in two games: one mostly redundant card sort and one mostly conflict card sort (Marcovitch et al., 2007). Children sorted red and blue bunnies and boats in one game and yellow and green cars and flowers in the other. At the beginning of each game, the experimenter affixed the target cards—which differed by both color and shape (e.g., red boat and blue bunny; see Figure 1)—to the sorting boxes. In the five preswitch trials, children were instructed to sort test cards according to one dimension (e.g., color) that was counterbalanced across task order: "In the _____ (shape/color) game, _____ (bunnies/red ones) go here [pointing to the box with the red bunny] and _____ (boats/blue ones) go here [pointing to the box with the blue boat]." Note that for preswitch trials, all test cards were conflict cards (i.e., the same color as one target, but the same shape as the other target) and the instructions were repeated before every trial. As it is critical for the logic of the task that children pass the preswitch phase, only children who sorted correctly on at least 8 of 10 preswitch trials across both tasks were included in the final sample (see Marcovitch et al., 2007).

On the postswitch trials, the instructions were changed so that children were now required to sort by the other dimension (e.g., shape). Children then received 30 postswitch trials such that the rule was repeated before every fifth trial, regardless of whether it was a redundant or conflict trial. When playing the mostly conflict game, the first 6 trials, and 18 of the remaining 24 trials involved conflict cards (i.e., 80% of all postswitch trials used conflict cards). The remaining 6 trials used redundant cards which matched one of the targets exactly. When playing the mostly redundant game, the contingency was reversed (i.e., 80% of all postswitch trials used redundant cards). In both sorts, the placement of the conflict and redundant cards were randomized for each participant.

Working Memory Tasks

Visual Counting Span (Case et al., 1982).   In this task, children were shown cards, one at a time, which displayed pictures of two objects (e.g., frogs and balloons). They were instructed to count one of the objects (e.g., balloons) and remember the number before turning the card face down, after which they were required to recall the numbers in the correct order. Children received three sets each of 2 cards, 3 cards, 4 cards, and 5 cards, in that order.

Visual Backward Word Span (Carlson, Moses, & Breton, 2002).   In this task, children were shown cards, one at a time, each of which displayed a single picture familiar to young children (e.g., car, tree, and shoe). The children were asked to identify each picture aloud before turning the card over and then to recall the items in reverse order. Children received three sets each of 2 cards, 3 cards, 4 cards, and 5 cards, in that order.

Auditory Backward Digit Span (Carlson et al., 2002). Children were shown and told about Fluffy, the silly bunny puppet who says things backward. After speaking a list of numbers, the experimenter asked, "Fluffy says things backwards, so what would he say?" Children heard three sets each of 2 numbers, 3 numbers, and 4 numbers, in that order.

Results

For all analyses, α is set to .05 for statistical significance and .10 for marginal significance.

Goal-Neglect DCCS

The proportion of conflict cards sorted correctly in each sort is displayed in Figure 2. A 2×2 (AGE GROUP $\times$ SORT TYPE) mixed analysis of variance (ANOVA) with SORT TYPE as the repeated measure revealed an effect of SORT TYPE, $F(1, 63) = 7.1$, $p < .01$, $MSE = 0.051$, $\eta p^2 = .10$, such that children sorted more conflict cards correctly in the mostly conflict condition. This replicated the previous finding of goal neglect (Marcovitch et al., 2007). The ANOVA did not reveal an effect of AGE GROUP, $F(1, 63) = 2.0$, $p > .10$, $MSE = 0.11$, $\eta p^2 = .03$, nor an interaction between AGE GROUP and SORT TYPE, $F < 1$, $MSE = 0.051$, $\eta p^2 = .00019$.
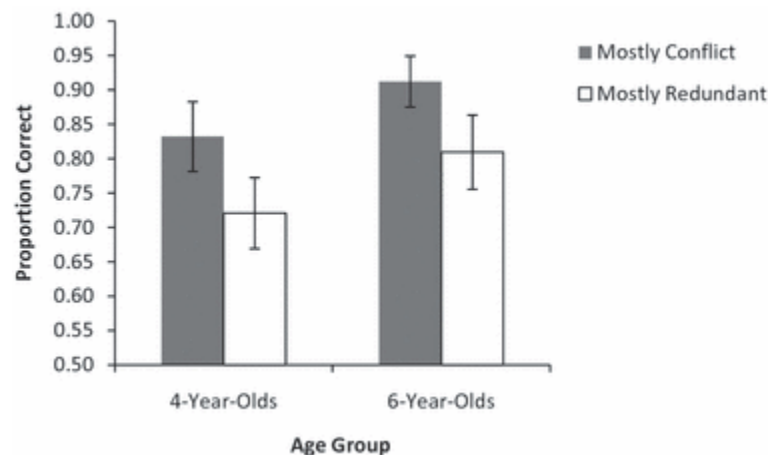

Figure 2.   Proportion of conflict cards sorted correctly by age and condition.

We also analyzed whether the presentation order of the card sort (ORDER) had an effect on performance, and whether it interacted with AGE GROUP and SORT TYPE. We did find an effect of ORDER, $F(1, 61) = 8.2$, $p < .01$, $MSE = 0.097$, $\eta p^2 = .12$, such that children who received the mostly redundant card sort first performed better on both card sorts. Notably, there

was no interaction between ORDER and AGE GROUP, $F(1, 61) = 1.9$, $p > .10$, $MSE = 0.097$, $\eta p^2 = .03$, nor between ORDER and SORT TYPE, $F < 1$, $MSE = 0.052$, $\eta p^2 = .00$, which demonstrates that the effect of goal neglect holds regardless of the order of presentation.

Working Memory Tasks

For all working memory tasks, each set of items were scored for the proportion of remembered items irrespective of serial order. For example, if the correct response was 2, 3, 6 and the child's response was 2, 6, 4, then that set would be assigned a score of .67 (two correct items out of a possible three items). Then, the average proportion across every set of items was calculated (see Friedman & Miyake, 2005, for advantages using this scoring system).

Means and Correlations Across Tasks

Table 1 displays the means (and standard errors) for all three working memory tasks. As expected, 6-year-olds outperformed 4-year-olds on the Visual Counting Span, $t(63) = 2.7$, $p < .01$, $MSE = 0.028$, $\eta^2 = .10$; the Visual Backward Word Span, $t(63) = 2.9$, $p < .01$, $MSE = 0.023$, $\eta^2 = .11$; and the Auditory Backward Digit Span, $t(63) = 3.5$, $p < .01$, $MSE = 0.048$, $\eta^2 = .16$. Table 2 displays the correlation matrix of all the study variables. To best measure WMC as an individual-differences construct, we created a composite WMC score by standardizing each working memory measure across both age groups and summing them together. Our logic was that because no task is a pure measure of its intended construct, the influence of task-specific variance that is independent of WMC can be minimized, and the influence of WMC-related variance maximized, by averaging across multiple WMC tasks that each make different non-WMC-related demands (see, e.g., Conway et al., 2005; Kane et al., 2004).

Table 1. *Means (and Standard Errors) on Working Memory Tasks*

Task	Age group	
	4-year-olds	**6-year-olds**
Visual Counting Span	.59 (.03)	.71 (.03)
Visual Backward Word Span	.63 (.03)	.74 (.02)
Auditory Backward Digit Span	.64 (.04)	.83 (.02)

Table 2. *Correlation Matrix of Study Variables*

	Card sorts		Working Memory Span tasks		
	Mostly redundant	**Mostly conflict**	**Visual Counting**	**Visual Word**	**Auditory Digit**
Age	.28*	.16	.41**	.41**	.55**
Mostly redundant		.39**	.24†	.25*	.31*
Mostly conflict			.38**	.23†	.31*
Visual Counting				.59**	.35**
Visual Word					.47**

$^{\dagger}p < .10.$ *$p < .05.$ **$p < .01.$

WMC as a Predictor of the GN–DCCS

Separate regression analyses were conducted on the proportion of correctly sorted conflict cards in the mostly redundant sort (PROP REDUNDANT), our measure of goal maintenance, and the proportion of correctly sorted conflict cards in the mostly conflict sort (PROP CONFLICT), our measure of response competition. In these analyses, the predictor variables were age (AGE, standardized), the WMC composite (standardized), and the interaction between the two predictor variables (AGE × WMC). Given the multicollinearity between AGE and WMC ($r = .57$, $p < .01$), we opted to enter WMC, the variable of primary importance, into the model as our first step. Then, we entered AGE as our second step and AGE × WMC as our last step.

The regression analysis on PROP REDUNDANT revealed a good overall fit, $F(3, 61) = 2.9$, $p < .05$, $R^2 = .13$, and a significant effect of WMC, $B = .11$, $t(61) = 2.8$, $p < .01$, $\Delta R^2 = .11$. Neither AGE ($\Delta R^2 = .01$) nor AGE × WMC ($\Delta R^2 = .002$) added significantly to the model. Similarly, the regression analysis on PROP CONFLICT revealed a good overall fit, $F(3, 61) = 3.8$, $p < .05$, $R^2 = .16$, and a significant effect of WMC, $B = .10$, $t(61) = 2.1$, $p < .05$, $\Delta R^2 = .15$. Once again, neither AGE ($\Delta R^2 = .005$) nor AGE × WMC ($\Delta R^2 = .004$) added significantly to the model. Thus, our predictions were confirmed that WMC is a significant predictor of performance on both the mostly redundant and mostly conflict card sorts.

It is also possible that the multicollinearity of the predictors suppressed age differences in our analyses. To determine whether there were differences between age groups, we conducted additional regression analyses for each age group with WMC as the predictor variable. For the mostly redundant card sort, the regression analysis with the 4-year-olds revealed a marginally significant effect of WMC, $B = .03, t(35) = 1.7, p < .10, R^2 = .08$, but a significant effect of WMC with the 6-year-olds, $B = .07, t(26) = 2.1, p < .05, R^2 = .14$, confirming that WMC predicts performance across both ages. In contrast and as expected, the regression analysis for the mostly conflict card sort revealed a significant effect of WMC for the 4-year-olds, $B = .05, t(35) = 2.8, p < .01, R^2 = .18$, but not the 6-year-olds, $B = .01, t < 1, R^2 = .01$.

Finally, we sought to determine whether WMC predicted variance for each sort above and beyond the other sort. To accomplish this, we included PROP CONFLICT in the first step of the regression on the mostly redundant sort, and likewise included PROP REDUNDANT in the first step of the regression on the mostly conflict sort. For these analyses we once again entered AGE as a predictor (i.e., we analyzed the entire sample together).

The regression analysis for the mostly redundant card sort revealed that PROP CONFLICT was a significant predictor of performance, $\Delta R^2 = .15, p < .01$, and that WMC accounted for a marginally significant amount of additional variability, $\Delta R^2 = .04, p < .10$. Similarly, the regression analysis for the mostly conflict card sort revealed that PROP REDUNDANT was a significant predictor of performance, $\Delta R^2 = .15, p < .01$, and that WMC accounted for a significant amount of additional variability, $\Delta R^2 = .07, p < .05$. In neither case did AGE nor AGE × WMC contribute significantly to the model.

Discussion

WMC has been associated with a wide range of cognitive skills that involve shifts of attention and executive control (Engle & Kane, 2004; Gathercole et al., 2008). The current study was designed to assess whether WMC was predictive of the ability to maintain a novel goal in young children. The results demonstrated that both 4- and 6-year-old children with higher WMC were more successful in goal maintenance, as measured by performance on the mostly redundant sort. This finding is consistent with Kane and Engle's (2003) report that WMC was related to goal maintenance in adults and extends previous research by demonstrating the relation between working memory and goal maintenance in young children. The current findings refute the idea that young children in general simply do not have the capacity to maintain a representation over a period of inactivity, and thus emphasize the importance of individual differences in WMC on the execution of goal-directed behavior.

WMC also predicted performance on the mostly conflict sort for 4-year-olds but not for 6-year-olds. We interpret 4-year-olds' higher performance on the mostly conflict sort compared with the mostly redundant sort as evidence that they benefit from the constant execution of the rule.

However, because they still have some difficulty maintaining the rule, there are individual differences based on WMC. In contrast, 6-year-olds generally possess a higher WMC (relative to 4-year-olds) that is sufficient to take full advantage of the scaffolding afforded by the mostly conflict task, and so WMC-related individual differences were absent. In addition, the success of 6-year-olds (relative to 4-year-olds) on the mostly conflict sort must be independent of WMC and suggests that other age-related processes might be contributing to success. One candidate is the ability to switch flexibly from one response set to another (i.e., set shifting; Cragg & Chevalier, in press; Garon, Bryson, & Smith, 2008; Miyake et al., 2000), a process that is not tested directly in our measure of WMC but is clearly needed to succeed on the mostly conflict sort. Indeed, vast improvements in set shifting have been reported in young children, especially between 3 and 6 years of age (e.g., Chevalier & Blaye, 2008; Deak, 2000; Zelazo et al., 2003).

We argue that the two card sorts are tapping into related but separable abilities. This is because: (a) WMC predicts common variance for both card sorts along with unique variance for each card sort, (b) the modest correlation between performance on these two sorts ($r = 0.39$, $p < .01$) suggests that these factors are interrelated but separable, and (c) there are different patterns of performance for 4- and 6-year-olds on the card sorting tasks. As argued earlier, this is consistent with Engle and Kane's (2004) two-factor theory of working memory and extends the theory to early childhood. Importantly, we now have some empirical evidence that each factor can be measured by its own card sort. Clearly, additional research needs to be conducted that speaks to the extent that each card sort assesses each factor, and the importance of assessing the development of each factor independently.

The findings from the current study have direct implications for implementing ways to improve goal-directed behavior. From our perspective, goal maintenance can be enhanced in children who undergo specific training in working memory. This idea is supported by recent research from Diamond, Barnett, Thomas, and Munro (2007) who have used the Tools curriculum to train low income preschool children on a variety of executive function tasks in an effort to improve executive control, the central component of working memory as conceptualized by Engle and Kane (2004; see also Baddeley, 2007). Vast improvements were seen on several measures, including the Dots task, which interleaves congruent and incongruent trials in a similar manner to the GN–DCCS.

In sum, individual differences in working memory predict goal neglect even in young children. These results highlight the utility of this paradigm to set the groundwork for future studies designed to investigate the specific mechanisms involved in the development of working memory.

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