Use it or lose it: examining preschoolers' difficulty in maintaining and executing a goal

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Abstract:

Individuals with low working memory capacity (e.g. preschoolers) are more prone to goal neglect, or a failure to execute a goal even though it is understood. We examined the role of goal neglect in performance on the Dimensional Change Card Sort by including 'redundant' cards that could be sorted without attending to the rules, as well as the traditional 'conflict' cards that encouraged awareness of the rules. In Experiment 1, 4- and 5-year-old children were administered two card sorts that differed on the proportion of redundant cards presented (20% vs. 80%). Children neglected the goal more often when faced with a preponderance of redundant cards, suggesting that consistent attention to the rules leads to goal maintenance. In Experiment 2, results were replicated even when the post-switch rules were repeated on every trial. Implications for the development of working memory are discussed.

Article:

Introduction

Maintaining a goal is critical for success in a number of domains in everyday life, from navigating your way home after work to choosing a graduate program congruent with your career ambitions. However, we can all recount anecdotes of driving home directly in spite of our desire to pick up milk at the grocery store, arriving at work with the letter that we should have mailed on the way there, or forgetting to invite a friend to a party in the midst of everyday banter. These are all examples of *goal neglect*, which refers to the disregard of task requirements despite understanding and being able to recall them (Duncan, Emslie, Williams, Johnson & Freer, 1996). Goal neglect results from failures of working memory – specifically, limitations of an executive component that is responsible for the intentional and conscious manipulation of information (e.g. central executive, Baddeley, 1996; attentional control, Engle, 2002; Kane & Engle, 2003; supervisory attentional system, Norman & Shallice, 1986). Recent research by Smith (2003) implicates the role of working memory in prospective memory tasks (e.g. goal maintenance), even in situations where the goal state is far enough in the future that it is unlikely to be continuously active in working memory.

Goal maintenance can be achieved by consistently reminding oneself of the goal state so that it can be executed under appropriate environmental conditions (cf. Kane & Engle, 2003). Research on goal maintenance with children may provide a promising window into cognitive competencies associated with the development of the prefrontal cortex, such as executive function (Diamond & Doar, 1989), prospective memory (Ward, Shum, McKinlay, Baker-Tweney & Wallace, 2005), and working memory (Luciana & Nelson, 1998). Few studies have examined the maintenance of goals and/or strategies in preschoolers. Lange and Pierce (1992) reported that 4- and 5-year-olds maintained the usage of a novel strategy when provided with a brief period of metacognitive instruction. In another study, Guajardo and Best (2000) demonstrated that prospective memory performance on both naturalistic and experimental tasks improved between 3 and 5 years of age, perhaps due to enhanced strategy execution or advances in working memory. Under the right conditions, young children can successfully maintain a goal and use it effectively to guide behavior.

However, relative to adults, preschoolers have low working memory capacity and difficulties with attentional control. Kane and Engle (2003) suggested that successful goal maintenance in individuals with low working memory spans may be achieved through consistent activation of the goal state. They administered a modified version of the Stroop task with adults in which the typical 'incongruent' trials (e.g. the word 'RED' written in green) were interspersed with ‘congruent’ trials (e.g. the word ‘RED’ written in red), and neutral trials (e.g. ‘JKM’ written in red).

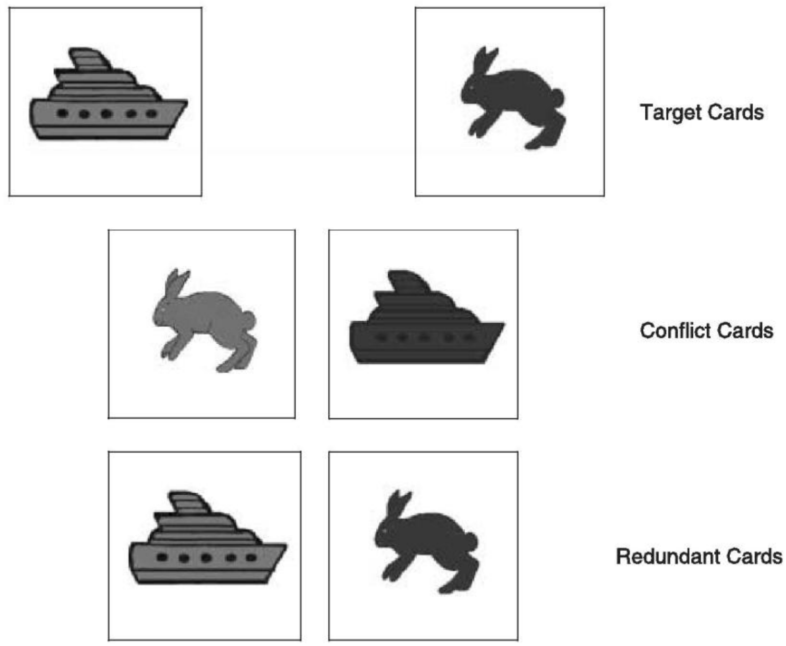

Figure 1 *Sample target, conflict, and redundant cards used in the study.*

As the task is to name the font color while suppressing the natural tendency to read the word, accurate responding on incongruent trials necessitates that the goal be active, whereas accurate responding on congruent trials can be achieved whether or not the goal is active. Kane and Engle found that (a) both high and low span adults were successful when the goal state was constantly active (i.e. all trials were incongruent), and (b) high span individuals outperformed low span individuals when the goal state did not need to be active (i.e. 75% of trials were congruent). These findings are consistent with the suggestion that high working memory capacity is required to maintain the goal when it is not active.

Preschoolers’ low working memory capacity may render them similar to the low span adults in the Kane and Engle (2003) study. Specifically, they may be very successful at maintaining goals when the goal state is consistently active, but very poor at maintaining goals when endogenous control of attention is needed. One experimental task that requires preschoolers to keep goals (i.e. rules) active in memory is the Dimensional Change Card Sort (DCCS; Zelazo, Müller, Frye & Marcovitch, 2003). The DCCS has been widely used by researchers to investigate children’s rule use (Frye, Zelazo & Palfai, 1995), representational inflexibility (Jacques, Zelazo, Kirkham & Semcesen, 1999), representational strength (Munakata & Yerys, 2001), inability to shift attention (Kirkham, Cruess & Diamond, 2003), and impairments in theory of mind (see Zelazo, Burack, Boseovski, Jacques & Frye, 2001). In the standard DCCS, children sort bivalent stimuli by one dimension (e.g. shape, see Figure 1). After several trials, they are then required to sort the stimuli by another dimension (e.g. color). Typically, 3-year-olds succeed in sorting by the initial dimension, but are unable to switch rules and sort by a new dimension. In contrast, older preschoolers (i.e. 4- and 5-year-olds) sort correctly both before and after the rules are switched (Zelazo *et al.*, 2003).

In the present study, we administered a modified version of the DCCS in which *redundant* test cards (i.e. sorted the same regardless of the rules) were interspersed with the standard *conflict* test cards (i.e. sorted differently depending on the rules). We predicted that 4- and 5- year-old children would be more successful when faced with a high proportion of conflict cards because the task environment provides reminders of the relevant rules and keeps the goal state active. Note that in the standard DCCS in which children of this age are typically successful, the test cards consist solely of conflict cards. In contrast, if faced with a high proportion of redundant test cards, children are apt to lose sight of the goal and sort conflict cards incorrectly.

Experiment 1

Method

Participants

Sixteen 4-year-olds (mean age = 4.52 years, SD = 0.24, 11 girls) and 16 5-year-olds (mean age = 5.46 years, SD = 0.14, seven girls) were included in the final sample. All children in the final sample sorted correctly on at least 80% of the pre-switch trials, which is a criterion commonly employed in previous DCCS studies (e.g. Zelazo *et al.*, 2003).

Materials

The laminated cards were 13 cm × 8 cm and depicted either a red boat, a red bunny, a blue boat, a blue bunny, a yellow car, a yellow flower, a green car, or a green flower (see Figure 1). All pictures were approximately 16 cm^2 in area and were centered and aligned vertically on the card. Two grey sorting boxes 28.5 cm × 20 cm × 11 cm were also used. Children sorted the cards by placing them through slits that were cut into the lids of the boxes.

Procedure

All children played two card sorting games. In the 'mostly conflict' card sort, 80% of the post-switch test cards were conflict cards, whereas in the 'mostly redundant' card sort, 80% of the post-switch test cards were redundant cards. The order of the two games was counterbalanced across children, and they were administered identically, except for the ratio of redundant to conflict cards in the post-switch phase. There was a 5 to 10 minute break in between the two games during which the child was engaged in another task. No feedback was given on any of the pre- or post-switch trials.

Each game began with the experimenter affixing the two target cards (e.g. red bunny and blue boat) to the sorting boxes. Then, the pre-switch rules were explained to the child: '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]'. The experimenter then administered five pre-switch trials using only conflict cards and repeating the rules on *every* trial. After the pre-switch trials, the post-switch rules were explained to the child: 'Now, we're going to play a DIFFERENT game called the _____________ (color/shape) game.' The phrasing of the post-switch rules were identical to the pre-switch rules except that the newly relevant dimension was highlighted. On all trials, the test card was labeled by both dimensions (e.g. 'here's a blue bunny, where does it go?').

In the 'mostly conflict' sort, the first six post-switch trials consisted of conflict cards. Of the remaining 24 post-switch trials, 18 conflict cards and six redundant cards were administered in a quasi-random order such that two redundant cards could not be administered consecutively. In the 'mostly redundant' sort, this contingency was reversed. For both card sorting games, the post-switch rules were not repeated after their initial introduction at the beginning of the post-switch phase.

Results

As expected, children in the post-switch phase were very successful in sorting the redundant cards (98% correct). The dependent variable of interest was children's performance on the conflict cards (see Figure 2, Experiment 1). A 2 × 2 (Age, between subjects × Condition, within subjects) mixed ANOVA on the proportion of conflict cards sorted correctly revealed a marginal effect of age, $F(1, 30) = 3.41$, $p = .07$, $\eta^2_p = 0.10$, and a main effect of condition, $F(1, 30) = 8.88$, $p = .01$, $\eta^2_p = 0.23$, such that children sorted fewer conflict cards correctly in the 'mostly redundant' condition. The interaction between age and condition was not significant, $F(1, 30) < 1$, $\eta^2_p = 0.01$.

Discussion

The present study demonstrates that goal maintenance in young children can easily be disrupted. We postulate that to sort successfully on the DCCS, children must consistently keep the rules in mind, even when sorting the redundant cards. Children's poor performance in the 'mostly redundant' condition reflects limitations in the executive component of working memory, specifically the ability to consistently attend to the rules when it is not necessary to do so.

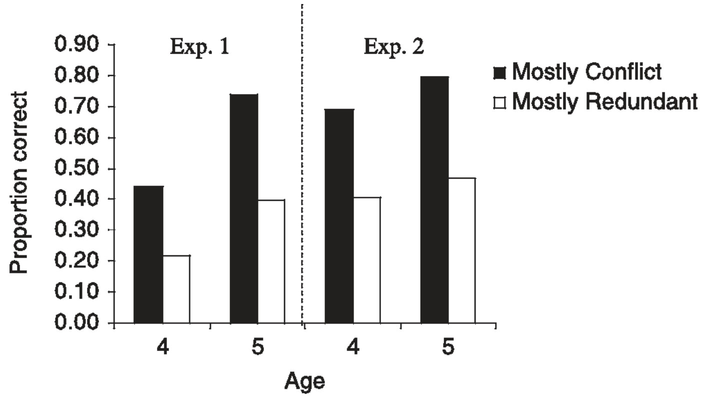

Figure 2 *Proportion of conflict cards sorted correctly by age and condition.*

Interestingly, a fairly large number of 4-year-olds (56%) sorted conflict cards incorrectly in both the 'mostly conflict' and 'mostly redundant' conditions. A major difference between the current study and the standard DCCS is that children only heard the post-switch rules *once* in this experiment. Thus, it is possible that children's poor performance in the 'mostly redundant' condition may be due to simply forgetting the rules. This is an especially important consideration given that goal neglect can only occur if the participant knows the appropriate way to act. Indeed, Kane and Engle (2003, Experiment 2) demonstrated that adults with low working memory capacity struggled on 'mostly redundant' versions of the Stroop task even when they were given feedback on every trial. In Experiment 2, children were reminded of the post-switch rules immediately before *every* trial. This manipulation renders it unlikely that children's failure to sort correctly can be attributed to simply forgetting the rules.

Experiment 2

Method

Participants

Sixteen 4-year-olds (mean age = 4.31 years, SD = 0.21, 10 girls) and 16 5-year-olds (mean age = 5.30 years, SD = 0.29, five girls) were included in the final sample (i.e. sorted correctly on at least 80% of the pre-switch trials). None of the children had previously participated in Experiment 1.

Materials

The materials were the same as in Experiment 1.

Procedure

The procedure was identical to Experiment 1 except that the post-switch rules were repeated by the experimenter before every post-switch trial.

Results

Children in the post-switch phase were very successful in sorting the redundant cards (98% correct). The dependent variable of interest was children's performance on the conflict cards in the post-switch phase (see Figure 2, Experiment 2). A 2 × 2 (Age, between subjects × Condition, within subjects) mixed ANOVA on the proportion of conflict cards sorted correctly revealed a main effect of condition, $F(1, 30) = 11.96$, $p = .002$, $\eta^2_p = 0.29$, such that children sorted fewer conflict cards correctly in the 'mostly redundant' condition. Neither the age effect, $F(1, 30) < 1$, $\eta^2_p = 0.02$, nor the interaction between age and condition, $F(1, 30) < 1$, $\eta^2_p = 0.00$, was significant.

We also assessed the impact of repeating the rules before every post-switch trial. Planned contrasts that compared performance across the two experiments revealed that 4-year-olds sorted more conflict cards correctly when the rules were repeated after every trial, $F(1, 60) = 3.27$, $p = .08$, whereas 5-year-olds did not, $F(1, 60) < 1$.

Discussion

Despite being told the rules immediately before every trial, children had difficulty sorting the conflict cards in the ‘mostly redundant’ condition, replicating the findings from Experiment 1. This is consistent with the main tenet of goal neglect; children fail to use the rules despite knowing and being aware of them.

One can argue that children’s relatively poor performance in the ‘mostly redundant’ condition is a consequence of children ignoring the rules because of the simplicity of sorting redundant cards on the majority of trials. Given that 4-year-olds sorted more accurately when they were told the rules on every trial, it seems likely that they were indeed processing the repeated rule. However, the possibility that children ignored the rules on some, but not all, of the trials cannot be ruled out, and this may have contributed to the relatively poor performance in the ‘mostly redundant’ condition.

General discussion

The present studies clearly demonstrate that consistent activation of the goal state is critical for goal maintenance in preschoolers. We were able to disrupt attention towards the goal simply by having children sort a high percentage of redundant cards on the DCCS. These redundant cards could be sorted correctly without reference to the particular goal and as a result, likely reduced children’s effort to focus attention on the task.

Children’s difficulty in the present studies highlights the importance of attending to relevant features of the task. In one study, Kirkham *et al.* (2003) improved 3- year-old children’s performance on the DCCS by having them label the relevant sorting dimension before each trial, presumably because labeling allowed the children to focus their attention on the goal. The current findings show that performance can also be hindered by disengaging children’s attention from the goal which in turn reduces the likelihood that the goal is activated consistently. These findings are also broadly consistent with the neural network model proposed by Morton and Munakata (2002). In their account, perseveration occurs when active memory is not strong enough to overcome previously established latent biases. Because of its simplicity, sorting a high proportion of redundant stimuli may cause a reduction in the strength of active memory, which in turn reduces the likelihood of maintaining the goal state.

The present findings pose a challenge to developmental theories of executive function, as no extant theory highlights the importance of goal maintenance through consistent activation of the goal state. For example, Zelazo and Müller (2002) postulated that tasks that elicit failures of executive function can be ordered by their level of complexity. In the context of the current task, it is difficult to explain why differences in the ratio of redundant to conflict cards affect the complexity of the task. Current developmental theories of executive function (and similarly, the executive component of working memory) need to account for the importance of goal execution. In addition, research is needed to illuminate whether goal maintenance is facilitated by the execution of the act *per se*, or whether executing an act encourages reflection on the representation of the rules (cf. Marcovitch & Zelazo, 2006).

One alternative possibility is that correct sorting of the redundant cards may inadvertently reward previously correct behavior (i.e. the pre-switch rules). From this perspective, it is not goal neglect that causes children to sort perseveratively in the ‘mostly redundant’ condition, but rather the difficulty in inhibiting the highly rewarded pre-switch rules. Although this interpretation cannot be ruled out in the current experiments, Zelazo, Frye and Rapus (1996, Experiment 2) have demonstrated that children’s error rates on the post-switch trials do not change as a function of the number of pre-switch trials; indeed, they show perseverative behavior even after one trial. Thus, if we accept the argument that the redundant stimuli serve as additional reinforcement for the pre-switch rules, it is unlikely that the additional reinforcement would elicit such a large difference in perseverative behavior across conditions.

We speculate that the children who were successful in the 'mostly redundant' condition were capable of successfully activating the goal state even though it was not necessary, and this may be indicative of maturation of the prefrontal cortex, as suggested by Duncan *et al.* (1996). Indeed, there was considerable variability in the sample of 5-year-olds tested – across both studies, 23% of 5-year olds sorted correctly in the 'mostly redundant' condition, which implies that these children may have advanced working memory capacity compared to their peers. Consistent with Kane and Engle's (2003) demonstration of a strong relation between working memory capacity and adults' performance on the modified Stroop task, the current modified DCCS could be used to measure controlled attention, and more generally, working memory capacity in young children.

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