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The executive demands of strategic reasoning are modified by the way in which children are prompted to think about the task: Evidence from 3- to 4-year-olds

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Abstract

We investigated a test of strategic reasoning (the Windows task) that in different studies has yielded contrasting pictures of young children's executive abilities [Russell, J., Mauthner, N., Sharpe, S., & Tidswell, T. (1991). The "windows task" as a measure of strategic deception in preschoolers and autistic subjects. *British Journal of Developmental Psychology*, *9*, 331–349; Samuels, M. C., Brooks, P. J., & Frye, D. (1996). Strategic game playing through the windows task. *British Journal of Developmental Psychology*, *14*, 159–172]. An experiment with 52 three- to four-year-olds showed robust effects of different wordings for the prompts used to ask children to respond, and found that a single exposure to the facilitating wording led to improved performance on subsequent trials where the standard wording was used. This suggests that the effect of the wording was to help children infer an appropriate basis for responding, and not to reduce the trial-by-trial working memory or inhibitory demands of the task.

Keywords: Executive function; Theory of mind; Metacognition; Inhibition; Strategic reasoning

Executive functions (EFs) are a highly complex, interdependent group of abilities that are involved in governing an individual's goal-directed behaviour. Many higher-level processes are thought to be underpinned by EFs (such as theory of mind tests: e.g., Freeman & Lacohee, 1995; Moses, 2001) and clarifying the nature of executive demands on developmental tasks and charting the development of children's executive control is an important goal. One task that has often been used to try and understand the relationship between executive control and conceptual development is the Windows task (Russell, Mauthner, Sharpe, & Tidswell, 1991), although widely

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differing levels of performance have been reported. This paper aims to investigate and explain these differences to give a clearer picture of young children's abilities.

In the Windows task, children are presented with two boxes and a simple rule: they must point to a box for someone else to open, and they will open the other box themselves. The child can see a treat in one box, and can see that the other box is empty. Thus, in order to obtain the treat, the child must point to the empty box. Although preschool children are able to report the rule, and correctly report who is to receive each box after they have pointed, these children commonly point to the box containing the sweet that they wish to obtain, and thereby lose the treat. Moreover, many children persist with this incorrect strategy over 15 or 20 repeated trials. This has led to the suggestion that children's difficulty is with executive control, and in particular with the dual requirement that they hold in mind the task rules while inhibiting a prepotent response of pointing directly at the treat (Hala & Russell, 2001).

The idea that at least part of children's difficulty is with mustering sufficient control over their actions to point away from the treat seems consistent with the observation of better performance when children respond by rotating an arrow, or by moving a cardboard marker or picture (Carlson, Moses, & Hix, 1998; Hala & Russell, 2001). Carlson et al. (1998) argue that these manipulations reduce the inhibitory demands of the task by disrupting children's automatic or "habitual" response of pointing "informatively and veridically" (but incorrectly) to the box containing the treat. However, other evidence suggests that limited control over manual pointing is not the only source of children's difficulties. For example, simply changing the way in which children are prompted to respond may have a significant effect on performance, even when they are still required to point manually. Simpson, Riggs, and Simon (2004) found that most children pointed correctly when prompted with the words "point to the empty box", whereas many children performed poorly when prompted with a more standard wording: "point to a box for the dog [opponent] to open". This finding clearly shows that children are able to point away from the treat in some circumstances. However, it is unclear exactly why being told to "point to the empty box" helps children, because this prompt has two potentially important effects. First, as Simpson et al. (2004) note, children no longer need to infer the correct response strategy because this is simply given in the prompt. Second, the prompt means that children no longer need to remember the task rules (that the experimenter will keep the contents of the box indicated by the child), because it directly specifies a single location ("the empty box") as the target for children's action. If it is the *combined* demands on memory and inhibitory that are so difficult for children (e.g., Hala & Russell, 2001), then it may be the reduction in memory demands and not the absence of an inferential demand that explains the effect of prompting children to "point to the empty box".

Evidence that might de-confound these explanations comes from a study by Samuels, Brooks, and Frye (1996) who observed near-ceiling performance among 3-year-old children in five variants of the Windows task that used different prompts from those used in standard tasks e.g., "Point to a box for E1 [Experimenter 1] so that you get the sticker"; "Point to a box to tell E1 where to look so E1 does not get the sticker"; "Point to a box for E1 so that E1 does not get the sticker"; "Give a box to E1 so that you get the sticker"; "Give a box to E1 so that E1 does not get the sticker". Unlike telling children to "point to the empty box" these prompts do not specify a single action for the child to perform. To arrive at the correct response the child must interpret the prompt in terms of the task rules (that the experimenter will keep the contents of the box indicated by the child). Thus, unlike the prompt used by Simpson et al. (2004) those used by Samuels et al. (1996) do not obviate the need for the child to remember the task rules. For the same reason, these prompts do not eliminate the inferential demands of the task either. However, it seems plausible that the inferential demands may be reduced, because whereas the "standard" prompt used in many studies simply tells children to “point to a box for the experimenter to open” (Hala & Russell, 2001), the prompts used by Samuels et al. (1996) make clear reference to the causal relationship between children’s pointing behaviour and who does or does not receive the sticker. In doing so they may have helped children use the task rules to work out the correct response.

In sum, the findings of Samuels et al. (1996) may support Simpson et al.’s contention that children’s difficulty with the Windows task is primarily with inferring a correct response strategy. However, this support is weakened by the fact that Samuels et al. (1996) did not include a “standard” prompt for comparison with their five variants, so it is unclear whether their results can be attributed to the nature of their prompts, or to an unusually able sample of preschoolers. Our first objective in the current study was to compare “standard” and “Samuels” prompts directly in a single sample. Our second objective was to test whether the effect of the “Samuels” prompts was to help children infer the correct response on a trial-by-trial basis, or whether they effected an enduring change on children’s understanding of the task. To do so we compared the performance of children in three conditions: one where they received the “standard” prompt on all test trials; one where they received a “Samuels” prompt on all test trials; and one where they received a “Samuels” prompt on the first test trial, and “standard” prompts on all subsequent trials.

1. Method

1.1. Participants

Fifty-two children at nursery school in Birmingham, UK, were tested. Three children were excluded as they withdrew before completing a full set of test trials, so 49 children (24 male) provided data for the study (mean age 3:11 years, range 3:6 to 4:5 years). There were 16 children in the standard and Samuels condition, and 17 in the transfer condition. Children were assigned randomly to one of the three experimental conditions. A one-way analysis of variance (ANOVA) showed that the ages of the three groups were not significantly different ($F(2,46) = 1.062$, $p = 0.35$).

1.2. Materials

Two boxes (one red, one blue) measuring 9 cm × 9 cm × 12 cm were used for the training phase. For the testing phase, we used two similar boxes with windows cut in the side of them.

1.3. Procedure

Participants were tested by a male experimenter in a quiet room adjacent to the main classroom. The child and the experimenter sat facing each other across a table. The children were told that they were going to play a game with the experimenter to try and win stickers. All children underwent a training phase using opaque boxes to ensure that they understood the rules of the game and that they were able to execute the responses necessary to participate on the task.

1.3.1. Training phase

Children were shown the (non-windowed) boxes and were told that the experimenter was going to put a sticker in one of the boxes. They were told that they could choose which box the experimenter would look in. It was explained that if the experimenter found the sticker he would keep it, but that if the experimenter did not find the sticker, the child would keep it. The child was then asked to cover their eyes while the sticker was hidden. They then opened their eyes and were asked to point to the box they wanted the experimenter to open. The experimenter opened the box indicated; if he found the sticker, he kept it; if he failed to find the sticker, the second box was opened and the child got to keep it. This was repeated for five trials. On the sixth trial, after the indicated box had been opened, the child was asked "So who gets the sticker this time?" to ensure that the child understood the rules governing who got to keep the sticker. This questioning was repeated until the child had given three consecutive correct responses. All children managed this within 10 trials.

1.3.2. Testing phase – standard condition

The training boxes were replaced with windowed boxes, and the windows were pointed out to the child. A sticker was placed in one of the boxes and the child was asked to indicate a box for the experimenter to open, using the wording "Point to a box for me to open". This continued for 15 trials. After each trial the experimenter announced "[I/You] keep the sticker this time", as appropriate.

1.3.3. Testing phase – Samuels condition

As the standard condition, except that the experimenter used a prompt based on Samuels et al. (1996): "Point to a box for me so that I don't get the sticker". This was repeated on each trial.

1.3.4. Testing phase – transfer condition

On the first testing trial the experimenter used the Samuels prompt of "Point to a box for me so that I don't get the sticker". On the second and all subsequent trials, the standard condition wording of "Point to a box for me to open" was used.

2. Results

Overall, children in the standard condition performed less well than children in the other two conditions. To enable us to look at the effect of feedback on performance in the current study, we divided the 15 trials into five time intervals of three trials each. Fig. 1 shows the percentage of children in each group who indicated the correct box on each time interval. Scores out of 3 were entered into an analysis of variance with time as a within-subject factor and condition

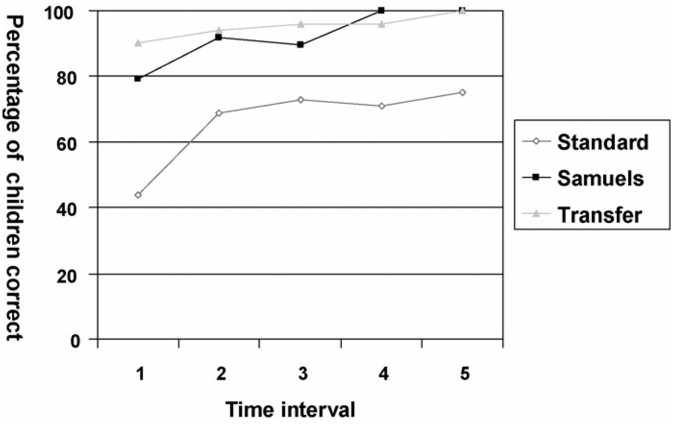

Fig. 1. The percentage of children in each condition responding correctly in each time interval.

as a between-subject factor. There were significant effects for both condition ($F(2,46) = 6.64$, $p < 0.01$) and time ($F(4,184) = 10.13$, $p < 0.001$). There was no interaction between condition and time ($F(8,184) = 1.57$, $p = 0.135$). Bonferroni post-hoc tests showed that performance in the transfer condition was significantly better than standard condition performance ($p < 0.01$), and that performance in the Samuels condition was also significantly better than performance in the standard condition ($p = 0.01$). There was no statistical difference between the transfer and Samuels conditions ($p = 0.891$).

In the standard condition, only 6 out of 16 children managed to indicate the empty box on the first trial, compared with 11/16 in the Samuels condition and 14/17 in the transfer condition. Since the first trial of the Samuels and transfer conditions used the same prompt, we combined these data. Children gave significantly more correct answers when given the Samuels prompt than when given the standard prompt ($x^2(1,49) = 6.79$, $p = .009$). The lack of an interaction between epoch and condition suggests no difference between conditions in the level of improvement over time.

3. Discussion

The current study investigated the surprising discrepancy between preschool children's poor performance in "standard" versions of the Windows task (e.g., Hala & Russell, 2001), and good performance in a study by Samuels et al. (1996) over five task variants, each using different instructions to prompt children's responses. We found that this effect is robust within a single sample of children tested on tasks that differed only in whether a "standard" or "Samuels" wording was used. Both "standard" and "Samuels" conditions seemed to require children to meet the same executive demands of holding the task rules in memory, and resisting a tendency to point impulsively towards the treat that they wished to obtain. Children's good performance in the Samuels condition suggests that children can meet both of these executive demands. This suggests that we should seek some alternative explanation for children's difficulties on standard versions of the Windows task.

Several other findings in the current study help constrain the form that a new explanation should take. First, the difference in children's performance in standard and Samuels conditions was apparent from the very first trial, indicating that the prompt wordings had an immediate effect on children's approach to the task. Second, there was no difference in the rate of children's improvement in standard and Samuels conditions, indicating that the Samuels prompt only assists children's initial understanding of the task, rather than helping them learn from the experience of winning or losing as the game progresses. Third, the transfer condition showed that a single exposure to the Samuels prompt on the first test trial was enough to effect an improvement in children's performance that lasted over fourteen subsequent trials where children were prompted with the standard wording. We consider two alternative explanations for this pattern of performance.

One consideration is whether children's difficulty on the standard task arises for pragmatic reasons, rather than because children cannot meet the task's executive demands. Young children might feel nervous about taking a sticker away from an adult. Alternatively, because pointing to an empty box may seem to them an odd request, children may simply interpret the standard prompt "point to a box for the experimenter to open" as "point to a box *with a sticker* for the experimenter to open". Because the Samuels wording asks children to "Point to a box so that I [the experimenter] don't get a sticker", the strangeness of the request or their reluctance to deprive an adult of a reward may be alleviated, allowing children to respond more successfully. Moreover, it seems plausible that this pragmatic benefit might be apparent from the very first trial, and that once children understood that they were allowed to deprive the adult of the reward they might continue to do so regardless of whether the words used to prompt their response reverted to the "standard" form. However, the existing literature suggests that children's difficulty is unlikely to be explained by their pragmatic interpretation of the test situation and the standard prompt wording. Two studies directly tackle this question, and show that children's performance is unaffected by reducing the social awkwardness associated with depriving an adult of a reward (Hala & Russell, 2001) or by removing the adult altogether (Russell, Jarrold, & Potel, 1994). Other studies show that, even without attempting to reduce the social awkwardness of playing against an adult, and without altering the standard prompt wording, children's performance can be significantly improved if they respond by placing a marker or pointing with a rotating arrow (Hala & Russell, 2001). Thus, altering the pragmatics seems neither sufficient nor necessary for helping children's performance.

A second possibility is that children's main problem is with the inferential demands of working out the correct response strategy on the Windows task (Simpson et al., 2004), and that these demands are reduced by the Samuels wording. As noted in the introduction, it does indeed seem plausible that the Samuels prompt helps children understand the task by referring to the causal relationship between their pointing behaviour and who does or does not receive the treat. The current findings suggest that exposure to one instance of the Samuels wording enables children to form an enduring basis for correct responses. This pattern is clearly consistent with the idea that children have been helped to infer a correct response strategy (perhaps along the lines of "Point to a box to give away"). Inferring an appropriate response strategy may help children to reconceptualise the task in a way that avoids inhibitory demands altogether. If children select a box on the basis of what to give away, the desirable box may no longer be a competitor for selection. The current findings lend support to the contention that children's primary difficulty is with the inferential demands of the Windows task, rather than with memory for the task rules, inhibition of prepotent responses, or with pragmatic understanding (Simpson et al., 2004).

However, this analysis also leaves an important unanswered question about why children find it easier to pass the standard Windows task when they respond by placing a marker or by rotating an arrow, rather than by pointing with their hand. One possibility is that such manipulations help children who have already inferred the correct response strategy to act in accord with that strategy and avoid pointing incorrectly to the treat that they wish to obtain (e.g., Carlson et al., 1998). Another possibility is that pointing with an arrow or placing a marker actually helps children work out the correct response strategy by providing the "symbolic distance" necessary for thinking flexibly about the task (e.g., Hala & Russell, 2001). These alternatives might be distinguished empirically by examining whether response mode manipulations provide an enduring basis for successful performance, or whether children who performed well when pointing with an arrow performed less well when required to point manually. If it turned out that response mode manipulations provided an enduring basis for successful performance, this would motivate the development of a more precise account of the role of mental representation and inference in performance on the Windows task, and other aspects of flexible behaviour in 3- to 4-year-old children.

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