Cognitive Development xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Cognitive Development

Do children need reminders on the day–night task, or simply some way to prevent them from responding too quickly?

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ARTICLE INFO

Article history:
Received 10 April 2015
Received in revised form 3 October 2015
Accepted 13 October 2015

Keywords:
Inhibitory control
Working memory
Impulsivity
Executive functions
Self-regulation

ABSTRACT

We previously reported better performance on the day–night task when a ditty was chanted between stimulus presentation and when children could respond (Diamond, Kirkham, & Amso, 2002). Here we investigated competing hypotheses about why the ditty helps. Does it help because it imposes a brief waiting time (the child waits while the ditty is chanted before responding)? Or, does the ditty help because of its content, providing information helpful to performing the task? One-third of the 72 children (age 4) were tested with the ditty previously used which reminds them: "Think about the answer; don't tell me". Another 24 children were tested with a ditty with no task-relevant content: "I hope you have a nice time; I like you". One-third received the standard condition. Performance in both ditty conditions was comparable and better than in the standard condition. That indicates that a factor common to both ditties (that chanting them took time, allowing the prepotent response to subside and the more-considered answer to reach response threshold) likely accounts for their benefit. Whether a ditty reminded children what to do or not did not affect the results. The challenge of the day–night task for preschoolers is not its working memory demands but the need to inhibit a dominant response, making a different response instead.

1. Introduction

Children of 3–5 years err on the day–night stroop-like task, which requires that they say the opposite of what the stimulus cards represent (saying "day" when shown a black card with a moon and stars and saying "night" when shown a white card with a sun (Gerstadt, Hong, & Diamond, 1994; review: Montgomery & Koeltzow, 2010).

Why young children have difficulty with the task has been hotly debated. One hypothesis is that young children are too impulsive to take the time they need to inhibit their prepotent response (Diamond, Kirkham, & Amso, 2002; Gerstadt et al., 1994; McAuley, Christ, & White, 2011; Montgomery & Fosco, 2012; Simpson & Riggs, 2005). Another hypothesis is that young children have difficulty holding the rules for the task in mind with sufficient clarity over the 16 test trials (Munakata, 2013).

Diamond et al. (2002) reasoned that if young children need time to successfully inhibit their prepotent response and compute the correct answer, then giving children more time with the stimulus visible before they can respond should aid their performance. In one condition, after turning over a stimulus card, the tester chanted a little ditty before the child responded. Four-year-olds were correct on almost 90% of the trials (89% correct), whereas in the standard condition four-

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http://dx.doi.org/10.1016/j.cogdev.2015.10.003
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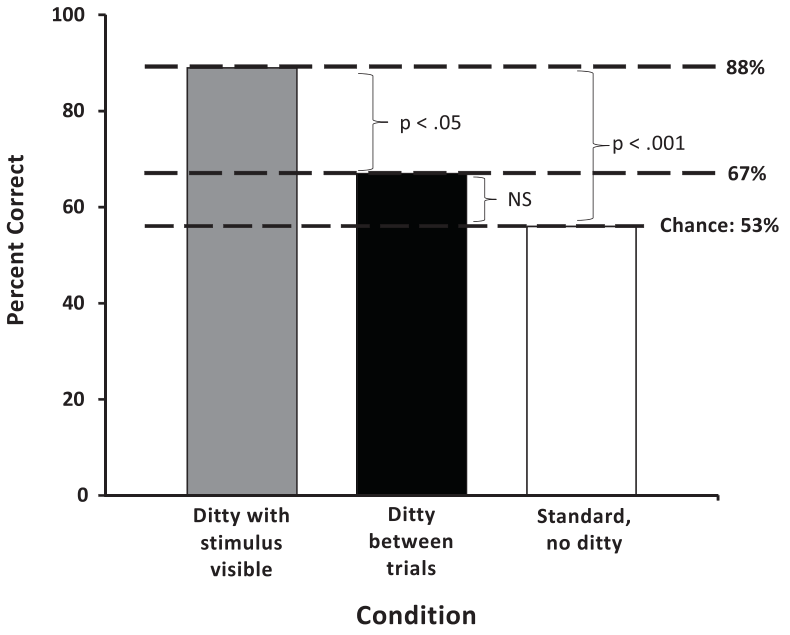

Fig. 1. Results from the ditty and standard conditions of Diamond et al. (2002).

year-olds performed at chance (56% correct). When the same ditty was chanted between trials (before the stimulus was revealed) it did not significantly aid performance. See Fig. 1.

Munakata (2013) has offered a different interpretation for why the ditty helped. The words of the ditty were, "Think about the answer; don't tell me". Telling children to think about the answer could be considered task-relevant information instructing them to think before answering. Munakata hypothesized that the content of the ditty was responsible for the ditty's beneficial effect. Although chanting the ditty between trials did not significantly improve performance (Diamond et al., 2002), there was a slight trend for performance to be better there than in the standard condition (see Fig. 1) consistent with Munakata's hypothesis.

Here, we put these two competing interpretations (a ditty helps because it allows time for the prepotent response to subside, making it easier to inhibit that response and give the correct response instead – or – a ditty helps because it aids memory by reminding the child of task-relevant information) to the test. We did that by having two conditions with different ditties, one using a ditty without task-relevant information, "I hope you have a nice time; I like you" and one with task-relevant information (the original ditty used previously: "Think about the answer; don't tell me"). If children *only* benefit, or benefit more, from the task-relevant ditty, then the content of the ditty accounts for all, or at least part, of the beneficial effect of chanting the ditty. If both ditties aid performance comparably (the one without task-relevant information and the one with) then it would seem that the entire beneficial effect of a ditty is due simply to it taking time to chant it and children waiting until the chanting is over before responding (i.e., it provides a way to get children to wait a few seconds before responding).

2. Method

2.1. Participants

Seventy-two children (33 girls and 39 boys) were tested. Their mean age was 4.4 years (0.4 years SD; range was 45.0–59.5 months). All children could understand and converse in English, had normal or normal-with-correction hearing and sight. None were taking any medication that affects cognition; none had suffered a concussion or lost consciousness from a fall or blunt trauma to the head. The children came from all over the greater Vancouver area. Most were of East Asian (42%) or European (30%) origin; 10% were of South Asian origin, 5% were Hispanic, and 13% were of mixed or other ethnicity. Most of the children were tested in StrongStart Centres (81%); the rest were tested at our lab (Standard: 21%; Task-relevant-ditty: 21%; Task-irrelevant ditty: 17%). Each child was accompanied by a parent or caregiver who either sat behind the child during testing or watched through the lab's one-way mirror. A subset of sessions (10%) was videotaped with permission from the parent/caregiver.

Of the 72 children, one-third (24 children; 50% female) were tested on the standard condition (no ditty), one-third (42% female) with the old, task-relevant ditty ("Think about the answer; don't tell me"), and one-third (46% female) with the new,

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Table 1
Number of sets of two practice trials that children needed to pass practice.

Practice block	Number of sets needed to pass	Number of children		
		Ditty with relevant content	Ditty without relevant content	Standard condition
Practice without ditty	One	11	9	7
	Two	10	8	6
	Three	3	7	11
Practice with ditty	One	11	7	–
	Two	7	11	–
	Three	6	6	–

task-irrelevant ditty ("I hope you have a nice time; I like you"). In each condition, the mean age of the children tested was 4.4 years (SD = 0.4).

Three children (one girl in the content-relevant ditty condition and two girls in the content-irrelevant ditty condition) were tested but their data were dropped from the analysis because one failed practice, one did not want to play, and one seemed to have a developmental disorder.

2.2. Materials

A total of 16 cards (8 sun, 8 moon) were used for testing. The cards were made of cream-colored cardboard measuring 10 × 10 cm. On the front of half the cards was the picture of a large bright-yellow sun on a white background. On the front of the other cards was a picture of a yellow moon and silver star against a black background. The back of all cards looked identical.

2.3. Procedure

For children in a ditty condition, the ditty was chanted by the experimenter after stimulus presentation, before the child could give a response. For each of the 3 conditions, experimenter (DL or CW), child's gender, and child's age (under 4.5 years or 4.5 years or older) were fully crossed. Thus, for each condition, each experimenter tested half the children (12 boys and 12 girls).

In all conditions, the experimenter sat directly opposite the child at a child-sized table measuring 76 × 76 × 55 cm. The experimenter sat on a stool measuring 20 × 39 × 23 cm and the child sat in a child-sized chair measuring 36 × 30 × 36 cm. During practice and testing, cards were presented to the child one at a time in a smooth, fluid manner. The deck of stimulus cards was held face down in the experimenter's hand, ensuring that the child did not see the stimulus until the experimenter turned the card over.

2.3.1. Practice before testing

Introduction to the task began with the experimenter presenting the white, sun card, instructing the child to say "night" when shown that card. When the child said "night", the experimenter praised the child. Next the experimenter showed the child the black, moon card and instructed the child to say "day" whenever shown that card. Again, the experimenter showed pleasure when the child produced the correct response. The child was then shown the white, sun card again and asked what to say and then the black, moon card and asked what the correct response to that was. Each time the child was correct on those practice trials, the experimenter cheered.

If the child gave an incorrect answer or no answer on either of those two practice trials, the experimenter re-stated the rules starting with the fragile rule (i.e., the rule the child had gotten wrong) and gave the child another two practice trials, starting with the rule the child had gotten wrong. If the child erred on either practice trial again, the rules were again re-explained and a third set of two practice trials was administered. Each child was given a maximum of 3 practice sets. All children needed to pass two consecutive practice trials to proceed to testing, and all but one child out of 75 did.

When a child was correct on two consecutive practice trials, the child proceeded to testing on the standard condition or to practice with the appropriate ditty if in one of the ditty conditions. For the ditty conditions, the experimenter told the child that s/he would show the same cards, but this time, before the child answered, the experimenter would chant a very short, silly song ("We're going to try some more cards, but now, before you tell me the answer, I'm going to sing a little song that goes like this: [Experimenter chants ditty]"). The child received one practice trial with each card and was again cheered when correct. All children were again given up to three chances to pass practice with both cards. The number of trials children needed to pass practice with and without a ditty is presented in Table 1.

2.3.2. Testing

Once children passed practice, testing commenced. Children in all conditions received 16 test trials. The cards were presented in the pseudorandom order of sun (s; Trial 1), moon (m; Trial 2), m, s, s, m, s, m, m, s, s, m, s, m, m, s. On all trials the correct response was the opposite of what the image on the card represented. No feedback was given during testing, nor

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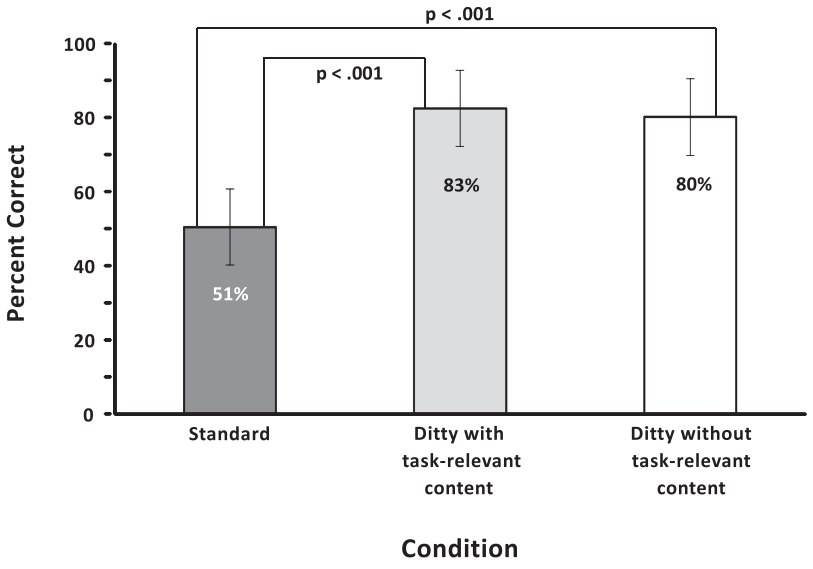

Fig. 2. Percentage of correct responses by condition.

were the rules ever re-stated. The child's first response to a card was recorded as his or her answer on that trial, though the tester noted whenever a child immediately corrected himself. The number of correct responses was totaled and converted to a percentage.

3. Results

There was no significant effect of tester or gender, so neither variable is included in the analyses presented below. As expected, older children performed better than younger children. A two-way analysis of variance (ANOVA) with condition and age as the independent variables and percentage of correct responses over the 16 trials as the dependent measure shows a significant main effect for age ($F[1,70] = 10.51$, $p < 0.002$, with an effect size of 0.13 eta squared). There was no age × condition interaction and the main effect of age was still significant controlling for condition ($F[1,65] = 13.73$, $p < 0.001$; effect size = 0.17 eta squared).

Performance also varied significantly by condition ($F[2,65] = 26.00$, $p < 0.001$; effect size = 0.44 eta squared). Performance in both ditty conditions was comparable ($F[1,45] = 0.24$, NS) and better than in the standard (no ditty) condition (ditty with potentially relevant content versus standard: $F[1,45] = 17.13$, $p < 0.001$; effect size = 0.28 eta squared; ditty without relevant content versus standard: $F[1,45] = 21.0$, $p < 0.001$; effect size = 0.32 eta squared). Children were correct on 83% of trials (SD = 14%) with the content-relevant ditty and 80% of trials (SD = 19%) with the content-irrelevant ditty; that difference is negligible. On the other hand, children performed at chance (mean = 51%, SD = 21%) in the standard (no ditty) condition. That was significantly worse than their peers performed in either ditty condition (see above). See Fig. 2. Both younger 4-year-olds (less than 4.5 years) and older 4-year-olds (4.5 years or older) performed significantly better in both ditty conditions than in the standard condition and performed comparably in the two ditty conditions.

Looking at performance on the first 4 and last 4 trials, one can get a sense of what happened. The practice provided was sufficient for children in all conditions to start off performing well on the initial 4 trials. The mean percentage of correct responses across conditions over the first 4 trials was 80% (SD = 23%). There was no difference in performance between conditions on those initial trials. However, while children in the ditty conditions were able to sustain a high level of accuracy, achieving percentages of correct responses on the last 4 trials of 84% (SD = 21%; content-relevant ditty) and 77% correct (SD = 30%; content-irrelevant ditty), children in the standard condition could not sustain that level of performance (they were correct only 44% of the time on the last 4 trials [SD = 29%]). Using a linear mixed model because our dependent measure here is a difference score (accuracy on first 4 minus last 4 trials), there was a significant effect of condition on that difference score ($F[5,85] = 10.88$, $p < 0.001$). That was driven by the decrement in the performance of children in the standard condition. The difference in the performance of children in the standard condition on the first 4 and last 4 trials was a whopping 38% ($t[23] = 4.93$, $p < 0.001$; paired comparison t-test; effect size: $R^2 = 0.46$, $p < 0.001$), whereas there was essentially no difference in performance on the first and last 4 trials in the ditty conditions (the difference was 0% with the task-relevant ditty and −3% for the ditty without task-relevant content).

The whopping decrement in accuracy on the last four trials compared to the first four in the standard condition replicates what Gerstadt et al. reported back in 1994 for the standard condition. They found a whopping 28% decrement in percentage of correct responses from the first 4 to the last 4 trials in children of the same age as tested here (4–4½ years) on the standard

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condition. Indeed, including all ages in that study (3½–7 years) the decrease in accuracy across all 16 trials was significant ($F[1,2204] = 44.35$, $p < 0.001$), though the accuracy decrement over trials was greater for younger children than for older ones (as can be seen in the significant age × trial number interaction [$F[1,2204] = 8.02$, $p < 0.01$).

Although we did not collect reaction time data, Gerstadt et al. (1994) found that the decrement in accuracy over trials in the standard condition coincided exactly with the increase in speed of responding over those trials. Younger children in the standard condition could not sustain waiting long enough to answer correctly, so over trials as they answered more quickly they made more errors. The ditty helped children in the two ditty conditions in the present study to continue to wait longer to respond even on later trials, and so children continued to answer correctly.

Children were given more practice in the two ditty conditions so that cannot be ruled out as contributing to why they did better in those conditions. It should be noted, however, that in the ditty-between-trials condition of Diamond et al. (2002), where the ditty was chanted before the stimulus was revealed, children received the same amount of practice as in the ditty conditions here and as in the ditty condition in Diamond et al. (2002) where the ditty came after the stimulus was presented but before children could respond, yet children did not perform significantly better in the ditty-between-trials condition than in the standard condition and performed significantly worse in the ditty-between-trials condition than in the ditty condition where the singing came after stimulus presentation (as here). See Fig. 1. In this study we were most interested in whether there was a difference in performance in the two ditty conditions, and children received the same amount of practice in those conditions that were of primary interest.

4. Discussion

The presence of a ditty after the stimulus is displayed helps children of 4 years perform better on the day–night task. The content of the ditty does not seem to matter (benefits are comparable whether the ditty contains task-relevant information or not). A ditty imposes extra time between when the stimulus is presented and when a child can respond. Previous work by Simpson et al. (2012) has shown that children do not use that extra time to take longer to compute the answer, rather the extra time permits passive dissipation of the prepotent response. This scaffolds children's inchoate inhibitory control since by the time they are allowed to respond less inhibitory control is needed (the incorrect response that popped into mind first has already begun to subside).

This is consistent with several other findings. When the prepotent response is not the correct response on a task, it has repeatedly been shown that when more time (a few moments) is interposed between stimulus presentation and when children can respond, preschoolers consistently do better than if allowed to respond right away. This has been shown on theory of mind (Heberle, Clune, & Kelly, 1999), go/no-go (Jones, Rothbart, & Posner, 2003), Piagetian search (Riviere & Lecuyer, 2003), and box opening (Simpson et al., 2012) tasks.

This is also consistent with the finding that when the experimenter chants the ditty *between trials* on the day–night task, before the stimulus has been displayed, it does not aid preschoolers' performance (Diamond et al., 2002)—the prepotent response only gets triggered once the stimulus is presented (before that the child does not know whether he or she will see a sun or a moon on the upcoming trial). Performance in the ditty-between-trials condition was not significantly better than in the standard (no ditty) condition and was significantly worse than in the ditty condition (ditty chanted after the stimulus was revealed; Diamond et al., 2002). Of course, if the content of the ditty was the determining factor in reminding children what they should be doing, then whether the ditty is chanted between trials or after the stimulus is presented should not matter.

There is no question that children in all conditions understood what they were supposed to do because across conditions children performed extremely well on the initial test trials, indicating that the practice they received had been sufficient for them to grasp the rules. Children in the ditty conditions sustained that high level of performance over the 16 trials, but children in the standard condition did not. Although we cannot be sure why that difference in performance occurred here, Gerstadt et al. (1994) showed that the same decline in accuracy over trials as we found here in the standard condition was accompanied by an increase in speed of responding. Children in the standard condition could not continue to inhibit the temptation to blurt out the first response that came to mind. A ditty helped children to wait to respond and thus they were able to continue to respond correctly.

Montgomery and Fosco (2012), using a variant of the day–night task (say 'car' to boat and 'shirt' to pants), found results that parallel those of Diamond et al. (2002). They presented three conditions: standard, transparent-delayed (where children could see the card while waiting to respond (as in the Diamond et al. ditty condition) and opaque-delayed (cardboard covered the stimulus card while child waited to respond [thus children did not know during the delay which card they would see on that trial as in Diamond et al.'s ditty-between-trials condition]). Each child was tested by Montgomery and Fosco in both the standard condition and one of the delay-variants, with order counterbalanced and testing on the second condition conducted two days after testing on the first.

They found that only in the transparent-delay condition (where children could see the stimulus but were not able to respond immediately) did preschoolers perform significantly better than in the standard condition. This addresses whether the content of the ditty mattered because here no ditty was used; a different method was employed to keep children from responding immediately and this helped just as chanting a ditty does. Just as Diamond et al. (2002) found somewhat better performance in the ditty-between-trials condition than in the standard condition (though the difference did not approach significance), Montgomery and Fosco (2012) found somewhat better performance in the comparable opaque-delay condition

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(though the difference there also did not approach significance)—and in the latter case one cannot attribute that hint of an improvement to task-relevant information in the ditty, for they had no ditty at all.

The results of the current study and of Gerstadt et al. (1994), Diamond et al. (2002), Simpson and Riggs (2005), Simpson et al. (2012), and Montgomery and Fosco (2012) indicate that the problem preschoolers have in performing the day–night task is not with remembering the rules or what they should do, but rather it is with suppressing the impulse to respond immediately to the stimulus with the first association that pops into their head. The simple passage of time allows that prepotent response to subside (making it easier to inhibit the response) and gives the considered response more time to rise to the response threshold.

Combining these results with similar findings on quite different tasks (theory of mind: Heberle & Fletcher, 1999; go/no-go: Jones et al., 2003; Piagetian search: Riviere & Lecuyer, 2003; box opening: Simpson et al., 2012) provides strong converging evidence that this is a general principle, not one specific to any single paradigm like day–night. Young children are so eager to respond that they often have difficulty inhibiting the impulse to respond right away though the first response that comes to mind is often incorrect. We have shown here (as did Gerstadt et al. [1994]) that 4-year-olds are able to succeed in taking the time they need (inhibiting the temptation to blurt out the first thing that occurs to them) on the early trials (thus respond correctly on those) but often cannot sustain that without help and so start responding faster and making more mistakes on later trials.

Different methods that researchers (Gerstadt et al., 1994; Heberle & Fletcher, 1999; Jones et al., 2003; Riviere & Lecuyer, 2003; Simpson et al., 2012; and the present study) have used with diverse experimental paradigms consistently show that artificially imposing a momentary delay reveals that preschoolers are capable of continuing to respond correctly when they wait just a moment or two before responding. Artificially causing preschoolers to momentarily delay responding reduces the demand on inhibitory control because it provides time for the response-to-be-inhibited to start to fade. Helping preschoolers to wait enables them to reveal a competence (knowing the correct response) that appears to be absent when they are allowed to respond as quickly as they would like.

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