Research Article

Predicting Cognitive Control From Preschool to Late Adolescence and Young Adulthood

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ABSTRACT—*In this longitudinal study, the proportion of time preschoolers directed their attention away from rewarding stimuli during a delay-of-gratification task was positively associated with efficiency (speed and accuracy) at responding to targets in a go/no-go task more than 10 years later. The overall findings suggest that preschoolers' ability to effectively direct their attention away from tempting aspects of the rewards in a delay-of-gratification task may be a developmental precursor for the ability to perform inhibitory tasks such as the go/no-go task years later. Because performance on the go/no-go task has previously been characterized as involving activation of fronto-striatal regions, the present findings also suggest that performance in the delay-of-gratification task may serve as an early marker of individual differences in the functional integrity of this circuitry.*

Cognitive control is the foundation of the ability to guide and control behavior and optimize outcomes (Braver & Cohen, 2001; Miller & Cohen, 2001). When individuals perform tasks in the service of a desired goal, cognitive control enables them to suppress attention and responses to irrelevant information, even when that information is highly salient (Allport, 1987). Although individual differences in cognitive control seem to be evident as early as 18 months of age (Rothbart, Derryberry, & Posner, 1994), the degree to which these differences in early life predict cognitive control later in life has not been assessed. The present longitudinal investigation examined this ability with the delay-of-gratification task in preschoolers and the go/no-go paradigm when they became adolescents and young adults. Both tasks require the individual to effectively control attentional and behavioral responses to salient information, a hallmark of cognitive control and cognitive development (Casey, Durston, & Fossella, 2001).

Many developmental studies have shown that cognitive control becomes more efficient (i.e., faster and more accurate) with development (Keating & Bobbitt, 1978), not reaching full maturity until after age 12 (Passler, Isaac, & Hynd, 1985). The increase in efficiency from early childhood to adolescence is marked by a decrease in an individual's susceptibility to interference from competing information (e.g., Casey, Tottenham, & Fossella, 2002). To study cognitive control in children and adolescents, researchers have used a range of tasks, including Stroop-like (Tipper, Bourque, Anderson, & Brehaut, 1989), directed-forgetting (Harnishfeger & Bjorkland, 1993), and go/no-go tasks (Luria, 1961). In the go/no-go task, a well-studied measure of cognitive control, participants are instructed to respond to target stimuli, but to refrain from responding to non-target stimuli. Children ages 7 to 12 show greater difficulty than adults on this task (twice as many errors overall and slower reaction time; Durston, Thomas, Yang, et al., 2002). Moreover,

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parametrically increasing the number of target (go) stimuli preceding a nontarget (no-go) stimulus has been shown to increase the task difficulty. Specifically, as the number of preceding consecutive go trials increases, people show a greater proportion of false alarms to no-go trials (Durston, Thomas, Worden, Yang, & Casey, 2002) and longer reaction times to go trials (Liston et al., in press). This manipulation provides a particularly sensitive probe of developmental changes in attentional control (Durston, Thomas, Yang, et al., 2002; Liston et al., in press).

Performance in the classic delay-of-gratification task has been shown to reflect preschoolers' ability to control their attention in the face of temptation (Mischel, 1974; Mischel, Shoda, & Rodriguez, 1989). In this paradigm, preschoolers try to postpone immediate gratification in order to attain a more valued outcome later (e.g., two cookies instead of just one). Research using this paradigm has provided compelling evidence for meaningful individual differences in cognitive control (Rodriguez, Mischel, & Shoda, 1989). Although some children are able to wait the entire 15-min period in order to obtain the more valued reward, other children are not. Extensive research has shown that a key ingredient of success in the delay situation is the ability to allocate attention strategically during the waiting period (Mischel et al., 1989). Specifically, those children who are able to direct their attention away from the reward-related stimuli in the task (low temptation focus) are able to wait longer than those children who direct their attention toward the reward-related stimuli (high temptation focus).

The delay-of-gratification task has been widely studied, in part, because 4-year-olds' performance in this task is diagnostic of consequential long-term outcomes, including adaptive social, cognitive, and emotional functioning in adulthood. For example, 4-year-old children who are more successful at waiting in the delay-of-gratification situation have been found to be more attentive, to be better able to concentrate, and to exhibit greater self-control and frustration tolerance than their peers when they are adolescents (Mischel, Shoda, & Peake, 1988; Shoda, Mischel, & Peake, 1990). They also score higher on the SAT and are perceived as more interpersonally competent by parents and peers (Mischel et al., 1989). As adults, they are less likely to use drugs (Ayduk et al., 2000).

It is noteworthy that there are significant procedural differences in the delay-of-gratification task and the go/no-go task. Nevertheless, the two paradigms share a fundamental feature: In both tasks, performance requires controlling a prepotent response, whether it is producing a behavioral response in the go/no-go task or attending to the temptations in the delay-of-gratification task. Performance on the two tasks may rely, in part, on similar neural circuitry. The go/no-go paradigm has been linked to the development of fronto-striatal and related circuitry (Booth et al., 2003; Casey, Trainor, Orendi, et al., 1997; Durston, Thomas, Worden, et al., 2002; Vaidya et al., 1998). Although no empirical study has directly examined the neural and biological basis of performance in the delay-of-gratification paradigm, existing research (e.g., Rothbart et al., 1994) suggests that prefrontal circuitry may account for individual differences in the ability to effectively and flexibly deploy attention during this task (Mischel & Ayduk, 2004). Thus, circumstantial evidence indicates that performance in the delay-of-gratification and go/no-go tasks reflects similar biological and neural systems.

In the present study, we examined whether the proportion of time preschoolers spent directing attention toward tempting stimuli in the delay-of-gratification task would predict their performance on a go/no-go task when the same individuals were late adolescents and young adults. Previous longitudinal work (Carlson, Mandell, & Williams, 2004) has demonstrated that individual differences in executive functioning, including attention deployment in delay tasks, are relatively stable between the ages of 24 and 39 months. However, the extent to which individual differences in early life predict abilities in late adolescence and young adulthood has not yet been examined. We hypothesized that compared with preschoolers who focused on the salient and tempting aspects of the delay situation (individuals with high temptation focus), those who were able to focus their attention away from those features (individuals with low temptation focus) would later be more able to focus on the task demands of the go/no-go task (i.e., responding to targets but not to distractors), as indexed by faster reactions to go trials and fewer false alarms to no-go trials. The number of consecutive go trials preceding a no-go trial was used to increase the tendency to respond and thus the need for cognitive control, as discussed in more detail in the Method section. Thus, we predicted that individual differences in cognitive control would be most visible in conditions in which cognitive demands were highest (i.e., when multiple consecutive go trials preceded a no-go trial).

METHOD

Participants

Fifteen females and 19 males participated in a delay-of-gratification assessment when they were approximately 4 years of age (mean age = 4 years 10 months, *SD* = 3 months; range = 4.33–5.25 years). At follow-up, they were approximately 14 years older (mean age = 18 years 2 months, *SD* = 3 years 3 months; range = 11.36–22.82 years old). The mean estimated IQ of the participants, based on subtests of the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999), was 119 (*SD* = 10, range = 105–138). Written consent (and assent when applicable) was obtained prior to testing, and procedures followed all applicable guidelines for human research subjects.

Procedure

Delay-of-Gratification Situation

At age 4, each participant was asked by a female experimenter to indicate a preference for either a smaller reward (e.g., one cookie) or a larger reward (e.g., two cookies). Each children selected the larger reward. The experimenter then explained to the child the rules of the game. The child was told that the experimenter would have to leave the room for a while to prepare for the next activity. If the child waited for the experimenter to return, without eating the reward or getting up from the seat, the child would receive the larger reward. If instead the child did not want to wait, he or she could ring a desk bell to summon the experimenter and receive the smaller reward. After confirming the child's understanding of the game, the experimenter seated the child at a table with the two rewards and the bell. There were no toys, books, pictures, or other potentially distracting items in the room. The experimenter left the room and did not return until 15 min had passed or the child had rung the bell, eaten the rewards, stood up, or shown any signs of distress.

The child's behavior during the waiting period was videotaped unobtrusively through a one-way mirror and subsequently coded second by second to provide fine-grained measures of attentional control. *Temptation focus* was the proportion of time that the child spent attending to consummatory aspects of the task, specifically, looking at or touching the bell or rewards. This score ranged from 0 (no time attending to the bell or rewards) to 1.0 (100% of the time attending to the bell or rewards). *Delay time* was recorded as the number of seconds that the child was able to wait before ringing the bell, eating the rewards, or leaving his or her seat.

The Go/No-Go Paradigm

The computer-administered go/no-go task (see Fig. 1) required the subject to press a button whenever a target (go) stimulus was present (75% of trials), but not to respond to an infrequently presented nontarget (no-go) stimulus (25% of trials). The task included a manipulation of context (i.e., the number of consecutive go trials that preceded a no-go trial). No-go trials were pseudorandomly presented following a series of 0 to 6 go trials. This manipulation also provided go trials that were pseudorandomly presented following 0 to 5 go trials. Thus, "no-go-1" refers to no-go trials that followed a single go trial, "no-go-2" to those following 2 go trials in a series, and so on. "Go-1" refers to go trials that immediately followed a no-go trial, "go-2" to go trials that followed a single go trial, and so on. There were 16 trials in each go and no-go condition, with the exception of go-6 (go trials following 5 go trials) and no-go-6 (no-go trials following 6 go trials), for which there were 8 trials each in order to keep the design balanced.[1] As the number of sequential go trials increased, the salience of the "go" response increased, as did the probability of a no-go trial (e.g., the probability of a no-go trial following a single go trial was .18; the probability of a no-go trial following a series of 5 go trials was .66). Thus, the parametric manipulation of increasing the number of preceding go trials was expected to increase conflict between the two response options, requiring greater cognitive control to perform the task.

[1]To avoid strategic responding, we also included 8 no-go-0 catch trials (no-go trials following another no-go trial). Results for these trials were not analyzed.

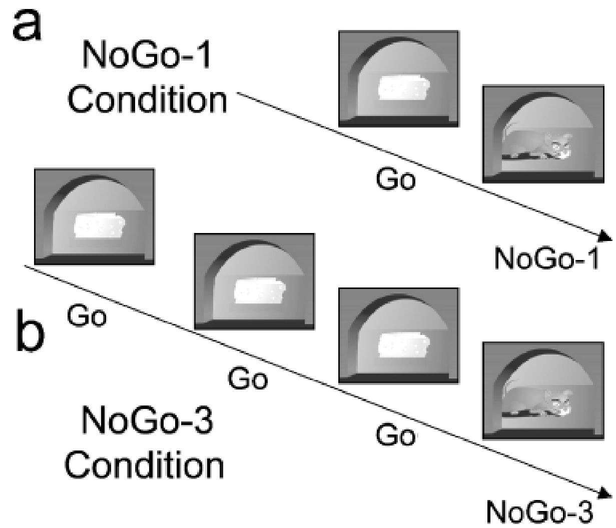

Fig. 1. Schematic representation of the go/no-go task. Stimuli were presented for 500 ms, and the interstimulus interval was 1,000 ms (trial length = 1,500 ms). Participants were instructed "to feed a mouse by pressing to get the cheese, but not to press otherwise." The target (go) stimulus was a picture of cheese; the nontarget (no-go) stimulus was a picture of a cat. The illustrations depict (a) the trial sequence for the no-go-1 condition (i.e., a no-go trial preceded by 1 go trial) and (b) the sequence for the Nno-go-3 condition (i.e., a no-go trial preceded by a 3 go trials). The task consisted of 384 trials divided into two 192-trial runs, and lasted 576 s. Cartoons were chosen as stimuli because related studies (e.g., Davidson et al., 2004) have found them to be appropriate and motivating for both children and young adults.

RESULTS

In the delay-of-gratification task, the children waited an average of 530 s, or 8.8 min (range = 12–900 s, SD = 365 s). A total of 13 children waited for the entire 900-s period, and 21 did not. As in previous studies (Peake, Hebl, & Mischel, 2002), children who waited the full 900 s spent proportionally less time attending to the bell than other children did (7%, SD = 0.05, vs. 13%, SD = 0.11), $t(31.06) = 2.04$ (t test adjusted for unequal variances), $p = .05$, p_{rep} (i.e., the probability of an exact replication; Killeen, 2005) = .88, Cohen's $d = 0.62$. We created high- and low-temptation-focus groups by dividing the sample at the median score for temptation focus (.35). Table 1 presents demographic data for the two groups.

Age and Performance on the Go/No-Go Task

False alarm errors to no-go trials ($M = .15$, $SD = .15$) were negatively correlated with age at follow-up, $r = -.64$, $p < .0001$, $p_{rep} = 1.0$.[2] Correlations between age and false alarms on no-go trials as a function of the number of preceding go trials were as follows: no-go-1, $r = -.57$, $p < .001$; no-go-2, $r = -.41$, $p < .02$;

[2]All analyses were also performed using hierarchical linear modeling, which simultaneously models both within- and between-subjects effects, represented as continuous variables. The results obtained (available on the Web at http://shodalab.psych.washington.edu/collaborative/eigsti05hlm.pdf) were highly similar to those reported here.

TABLE 1
Characteristics of the High- and Low-Temptation-Focus Groups

Variable	Temptation focus[a] High (n = 18)	Temptation focus[a] Low (n = 16)
Mean proportional temptation focus	.49 (*SD* = .11; range = .36–.78)	.22 (*SD* = .09; range = .08–.35)
Mean age in years	17.3 (*SD* = 3.4; range = 11–22)	18.3 (*SD* = 3.1; range = 11–22)
Mean delay time in seconds	514 (*SD* = 388; range = 12–900)	549 (*SD* = 349; range = 13–900)
Number who waited the full 900 s in the delay task	11	10
Gender	10 male, 8 female	9 male, 7 female
Estimated IQ[b]	120 (*SD* = 10; range = 105–138)	119 (SD = 10; range = 105–135)
Socioeconomic status[c]	64 (*SD* = 5; range = 50–66)	63 (*SD* = 4; range = 53–66)

[a]The temptation-focus groups were created by splitting temptation focus in the delay-of-gratification task at the median (.35). Compared with low-temptation-focus participants, high-temptation-focus participants spent a greater proportion of time focusing their attention toward tempting features (the rewards or bell).
[b]IQ was measured with the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999).
[c]Socioeconomic status (SES) was coded using the Hollingshead Four-Factor Index of Social Status (Hollingshead, 1975). All participants fell into the highest or next-highest stratum. Although SES is a strong predictor of many achievement measures (e.g., literacy, language skills, and academic test scores), it does not seem to be related to performance on delay-of-gratification tasks (Noble, Norman, & Farah, 2005). Thus, although the SES range of this sample was limited, the results are likely applicable beyond this range.

no-go-3, $r = -.64$, $p = .0001$; no-go-4, $r = -.47$, $p < .01$; no-go-5, $r = -.55$, $p < .001$; no-go-6, $r = -.49$, $p < .003$.[3] Similarly, although misses (i.e., incorrectly failing to respond to go trials) were infrequent ($M = .02$, $SD = .04$), the number of misses correlated with age ($r = -.50$, $p = .002$, $p_{rep} = .98$). These results suggest that older participants made fewer false alarms and misses than younger participants.

To test for the interaction between age and context in the data for false alarms, we divided participants into younger (18 years old and younger) and older (19 years old and older) groups. A mixed analysis of variance (ANOVA) with age as the between-subjects factor and the six levels of context (i.e., number of go trials preceding a no-go trial) as the within-subjects factor indicated a significant Age × Context interaction, $F(5, 160) = 3.68$, $p = .03$, $p_{rep} = .90$, $\eta^2 = .10$.[4] The main effects of age and context were also significant, $F(1, 32) = 8.70$, $p = .006$, $p_{rep} = .97$, $\eta^2 = .21$, and $F(5, 160) = 7.99$, $p = .001$, $p_{rep} = .99$, $\eta^2 = .20$, respectively. As shown in Figure 2, false alarm rates increased as the number of preceding go trials increased; the test for the linear contrast was significant, $F(1, 32) = 10.10$, $p = .003$, $p_{rep} = .98$, $\eta^2 = .24$, indicating that the context manipulation effectively increased the task difficulty. Moreover, the difference in false alarm rates between adolescents and adults increased linearly (Age × Context linear contrast interaction), although the increase was not significant at $p < .05$, as the number of preceding go trials increased; that is, the younger participants made relatively more false alarms as the number of preceding go trials increased, $F(1, 32) = 3.54$, $p = .07$.

For the entire sample, the mean reaction time on go trials was 318 ms (SD = 37 ms). Age was not significantly associated with average reaction times on go trials ($r = -.24$, $p = .18$). ANOVA results showed a significant main effect of context on reaction time, $F(5, 160) = 4.73$, $p = .007$, $p_{rep} = .97$, $\eta^2 = .13$, with a statistically significant cubic function, $F(1, 32) = 15.14$, $p < .001$, $p_{rep} = .99$, $\eta^2 = .32$, and no significant main effect of age, $F(1, 32) = 2.13$, $p = .15$, or Age × Context interaction, $F(5, 160) = 0.88$, $p = .44$.

Individual Differences in the Delay Task and Go/No-Go Task Performance

No significant correlations were found between delay time and false alarms ($r = .11$, $p = .55$), misses ($r = -.17$, $p = .34$), or mean reaction time ($r = .17$, $p = .33$); results were essentially identical when delay time was log-transformed (rs were .07, −.11, and .14, respectively, all ps n.s.). Thus, delay time was not significantly related to performance on the go/no-go task, assessed more than 10 years later. We consider these null findings further in the Discussion section.

Temptation focus, defined as the proportion of delay time preschoolers spent attending to the reward and bell, was positively correlated with mean reaction time to go trials ($r = .38$, $p = .03$, $p_{rep} = .91$). The correlations between temptation focus and reaction times on go trials as a function of the number of preceding go trials were as follows: go-1, $r = .27$, n.s.; go-2, $r = .37$, $p = .03$; go-3, $r = .34$, $p = .05$; go-4, $r = .39$, $p < .02$; go-5, $r = .41$, $p < .02$; go-6, $r = .31$, $p < .08$.[5]

[3]Because there were half as many trials in the no-go-6 condition as in the other conditions, the reliability of the proportion of false alarms for no-go-6 trials was reduced, and the correlation involving these trials is likely to be an underestimate. Similarly, the fewer items a self-report questionnaire contains, the less reliable it will be, and the more attenuated its expected correlations with other measures will be.

[4]Because variances for differences among the within-subjects conditions were not all equal, p values reported here were corrected using Greenhouse-Geisser's formula.

[5]For the same reason described in footnote 3, the correlation involving go-6 trials is likely to be an underestimate.

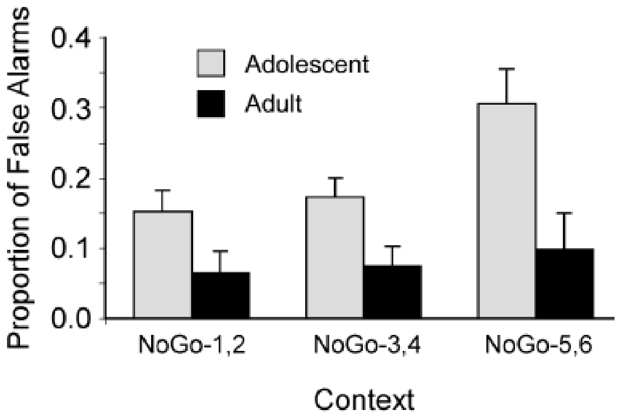

Fig. 2. False alarm rates on no-go trials as a function of age (adolescent vs. adult) and context (number of preceding go trials). Participants who were 11 through 18 years old were classified as adolescents, and those who were at least 19 years old were classified as adults. Bars represent 1 *SEM*. The values presented are the means for the indicated no-go conditions (e.g., the value for no-go-1,2 is the mean proportion of false alarms for the no-go-1 and no-go-2 conditions).

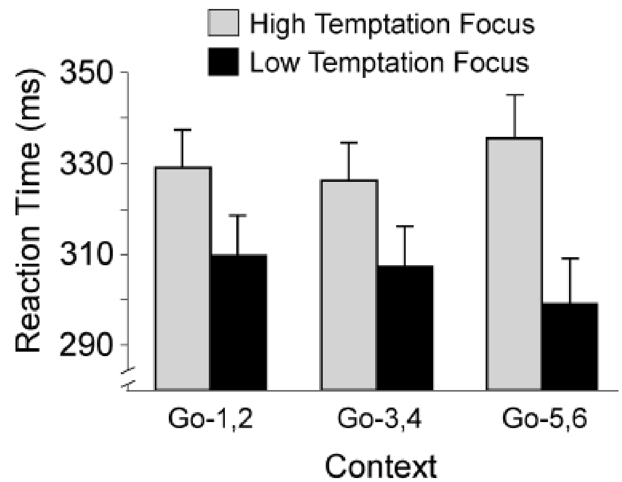

Fig. 3. Mean reaction time on go trials as a function of temptation focus (high vs. low) and context (number of preceding go trials). Bars represent 1 *SEM*. The values presented are the means for the indicated go conditions (e.g., the value for go-1,2 is the mean reaction time for the go-1 and go-2 conditions).

Temptation focus was not significantly associated with false alarms or misses, although correlations (r = .15, n.s., and r = .10, n.s., respectively) were in the expected direction. ANOVA results showed a significant main effect of context on false alarms, $F(5, 160) = 8.14$, $p < .001$, and no main effect of temptation focus, $F(1, 32) = 0.18$, $p = .68$, or Temptation Focus × Context interaction, $F(5, 160) = 0.70$, $p = .49$. The rates of false alarms and misses, however, were very low, especially among older participants, as in previous studies (Durston, Thomas, Yang, et al., 2002), and the resultant floor effect may have masked individual differences.

Reaction times were not significantly correlated with misses (r = .05, n.s.) or false alarms ($r = -.11$, n.s.), indicating that faster reaction times on go trials were not at the expense of greater error (i.e., were not due to a speed-accuracy trade-off). In addition, temptation focus and reaction times remained significantly correlated when controlling for IQ ($pr = .38$, $p = .03$, $p_{rep} = .91$), age ($pr = .34$, $p = .05$, $p_{rep} = .87$), and accuracy ($pr = .40$, $p = .02$, $p_{rep} = .93$). These results indicate that individuals who focused their attention away from tempting aspects of the delay situation were, on average, faster, though no less accurate, in performing the go/no-go task than were individuals who focused more on the temptations in the delay situation.

A mixed ANOVA performed on the median split ($Mdn = .35$) of temptation focus showed a significant Context × Temptation Focus interaction term, $F(1, 30) = 3.87$, $p = .01$, $p_{rep} = .95$, $\eta^2 = .11$ (see Fig. 3).[6] Moreover, the test for the linear effect of the context-by-temptation-focus interaction was statistically significant, $F(1, 32) = 4.98$, $p = .03$, $p_{rep} = .91$, $\eta^2 = .14$, supporting our prediction that as the need for cognitive control increased, differences between low- and high-temptation-focus individuals in their reaction time on go trials would also increase. The finding that the magnitude of the temptation-focus effect depended on the task context suggests that differences in performance as a function of temptation focus are not due simply to differences in general speed of processing (e.g., Kail & Salthouse, 1994), but reflect differences in cognitive-control abilities.

The main effect of temptation focus was also significant, $F(1, 32) = 4.30$, $p < .05$, $p_{rep} = .88$, $\eta^2 = .12$. This result, which is consistent with the correlations reported earlier, indicates that the low-temptation-focus group exhibited faster reaction times overall. The main effect of context was also significant, $F(5, 160) = 4.77$, $p = .005$.

DISCUSSION

Cognitive control, broadly defined, involves the ability to inhibit task-irrelevant responses that may occur at different stages of processing (Casey et al., 2002). A notable aspect of the present findings is that preschoolers' cognitive control at the level of stimulus selection, assessed in the delay-of-gratification situation, predicted their performance more than 10 years later on a task that required cognitive control at the level of response execution. Specifically, compared with preschoolers who directed their attention toward the rewarding aspects of the classic delay-of-gratification situation (the high-temptation-focus group), preschoolers who directed their attention away from those features (the low-temptation-focus group) were faster at performing the go/no-go task without making more errors. Although false alarm rates are one way to index cognitive control in this task, the present findings are consistent with research demonstrating effects on reaction times to go trials (Liston et al, in

[6]When 3 individuals whose scores were exactly at the median were excluded from analyses, the Context × Temptation Focus interaction remained similar to that reported here, although it was no longer statistically significant ($p = .097$).

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press), as well as with the classic Stroop effect and a variety of interference-suppression paradigms in which cognitive control is reflected in reaction times (e.g., Fan, Fossella, Sommer, Wu, & Posner, 2003).

The go/no-go task in the present study also included a parametric manipulation to increase the need for cognitive control. As participants encountered an increasing number of consecutive go trials, the "go" response became increasingly salient and automated. At the same time, the probability of the next trial being a no-go trial increased. Thus, a greater number of consecutive go trials resulted in greater conflict between the two response options, which in turn required greater cognitive control for the task to be performed quickly and accurately. As in previous research (Durston, Thomas, Worden, et al., 2002; Durston, Thomas, Yang, et al., 2002), and providing support that the parametric manipulation increased task difficulty, rates of false alarms increased as the number of preceding go trials increased, and this effect was more pronounced for younger than for older participants. Although an age-by-context interaction was not observed for reaction times to go trials, there was an interaction of temptation focus and context. Specifically, differences between the high- and low-temptation-focus groups were greater as the number of consecutive preceding go trials increased. This suggests that in order to perform with a low error rate similar to that of low-temptation-focus participants, high-temptation-focus participants compensated by slowing down their speed of responding, particularly in trials following a large number of consecutive go trials.

Surprisingly, findings did not indicate a relation between go/no-go task performance and the number of seconds of waiting time measured in the preschool delay task more than 10 years earlier. One possible explanation of these null findings lies in the fact that the distribution of the delay-time variable, even when log-transformed, was characterized by a significant proportion of scores at ceiling (13 participants waited the entire 15-min period). More generally, it may be that delay time depends not only on effective attentional control, but also on a number of other factors, such as motivation to obtain the delayed rewards. Preschoolers' focus in the delay task, in contrast, is a more direct measure of attentional control, which appears to be particularly heuristic for predicting self-regulatory competence (e.g., Derryberry & Rothbart, 1988; Sethi, Mischel, Aber, Shoda, & Rodriguez, 2000).

A possible alternative interpretation of the present findings is that the relation between attentional control in the delay task and reaction time in the go/no-go task reflects a more general speed-of-processing ability (Kail & Salthouse, 1994) rather than cognitive control. However, if the results were mainly due to differences in speed of processing, the high- and low-temptation-focus groups should have differed in reaction time regardless of the number of preceding go trials, our manipulation of the need for cognitive control. Instead, reaction time differences between high- and low-temptation-focus participants increased as a function of the number of preceding go trials (i.e., increased as greater cognitive control was required to meet the interference between competing task demands). This result is consistent with our interpretation that individual differences at age 4 predict cognitive control as assessed by the go/no-go task,

Previous studies have documented striking individual differences in the efficiency of cognitive control (Fan, McCandliss, Sommer, Raz, & Posner, 2002) and, further, have found promising links between these individual differences and genetic variability (Fan et al., 2003). Extending this work, the present findings suggest that an effective attentional control system, as reflected in preschoolers' ability to direct attention away from tempting aspects of the rewards in a delay-of-gratification task, may share a common mechanism with, or serve as a precursor for, long-term ability to inhibit attentional and behavioral responses, as reflected years later in performance on the go/no-go task. Moreover, because inefficient performance in the go/no-go task has been well documented as being associated with immature development of fronto-striatal and related circuitry (Booth et al., 2003; Casey, Trainor, Giedd, et al., 1997; Davidson et al., 2004; Durston, Thomas, Worden, et al., 2002; Durston, Thomas, Yang, et al., 2002; Durston et al., 2003; Konishi et al., 1999; Vaidya et al., 1998), the findings suggest that temptation focus in the delay-of-gratification task at age 4 may already be a marker of the subsequent development of individual differences in this system in adolescence and adulthood.

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