Developmental Science

Developmental Science 17:5 (2014), pp 797–807 DOI: 10.1111/desc.12168

SHORT REPORT

Previous reward decreases errors of commission on later 'No-Go' trials in children 4 to 12 years of age: evidence for a context monitoring account

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Abstract

Inhibitory control is widely hypothesized to be the cornerstone of executive function in childhood and the central deficit in a number of developmental disorders, including attention-deficit/hyperactivity disorder (ADHD). However, recent evidence from adults indicates that performance on response inhibition tasks may primarily reflect non-inhibitory *attentional control (context monitoring) processes. Yet it may be that inhibition plays a more central role in childhood – a time when the architecture of cognitive processes might be more transparent due to wide variability in skill level. Here we directly test inhibitory and context monitoring explanations of task performance on a Go/No-Go task in a large group of children 4–12 years of age. We conclude that traditional inhibitory conceptualizations of task performance on the Go/No-Go task cannot account for our findings, calling into question evidence supporting a central role for inhibitory control in cognitive development or developmental psychopathology.*

Introduction

Regulating one's behavior to attain goals and adapt to changing environments is commonly understood to require suppressing unwanted but prepotent response tendencies – a cognitive function referred to as inhibitory control (Barkley, 1997; Nigg, 2000) and hypothesized to be one of a set of executive functions (EF). Inhibitory control is historically understood to be both related to and distinct from other EF constructs such as selective attention, updating working memory, and shifting task sets (Huizinga, Dolan & van der Molen, 2006; Lehto, Juujärvi, Kooistra & Pulkkinen, 2003; Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000; van der Sluis, de Jong & van der Leij, 2007). Performance on tasks that measure inhibitory control is associated with a variety of outcomes including early educational achievement (Espy, McDiarmid, Cwik, Stalets, Hamby & Senn, 2004; Blair & Razza, 2007), alcohol abuse and illicit drug use in adolescence (Nigg, Wong, Martel, Jester, Puttler, Glass, Adams, Fitzgerald & Zucker, 2006), and symptoms of attention-deficit/hyperactivity disorder (ADHD; Alderson, Rapport & Kofler, 2007; Schoemaker, Bunte, Wiebe, Espy, Deković & Matthys, 2012; Willcutt, Doyle, Nigg, Faraone & Pennington, 2005). An inhibitory control deficit has been posited as the central deficit in ADHD (Barkley, 1997; Nigg, 2001). Finally, inhibitory control has been hypothesized to be the fundamental cognitive capacity whose developmental progression across childhood supports the maturation of other EFs and overall self-regulatory competence (Diamond, 2002; Ridderinkhof & van der Molen, 1997).

Interestingly, more recent theories of EF suggest that the cognitive function described as inhibition may be due to motor and attention processes engaged in both inhibitory and non-inhibitory tasks (Friedman, Miyake, Young, DeFries, Corley & Hewitt, 2008; Friedman, Miyake, Robinson & Hewitt, 2011; Munakata, Herd, Chatham, Depue, Banich & O'Reilly, 2011; van der Sluis *et al.*, 2007). Converging evidence suggests that in the

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Stop-Signal task, which has historically been understood to measure inhibitory control, patterns of behavioral performance and neural activity are more reflective of target detection in the service of response selection, sometimes called context monitoring, than of the assumed response suppression process (Boehler, Appelbaum, Krebs, Chen & Woldorff, 2011; Chatham, Claus, Kim, Curran, Banich & Munakata, 2012; Hampshire, Chamberlain, Monti, Duncan & Owen, 2010). Further evidence in confirmation of this theory, particularly evidence acquired in children, would call into question the notion that inhibitory control serves as a building block of the development of EF across childhood.

The development of inhibitory control

Generally speaking, there is robust evidence that performance on tasks which purport to assess inhibitory control improves from preschool into late childhood (for review, see Best, Miller & Jones, 2009; Garon, Bryson & Smith, 2008) and predicts self-regulatory skills in everyday life (González, Fuentes, Carranza & Estévez, 2001; Simonds, Kieras, Rueda & Rothbart, 2007). Interpretation of these results is complicated, however, by the diversity of functions subsumed under the label of inhibitory control and the multitude of different tasks measuring such functions. According to a prominent taxonomy, varieties of inhibitory control include response inhibition (i.e. withholding or stopping a prepotent motor response), interference control (i.e. protecting correct performance against task-irrelevant information), cognitive inhibition (i.e. excluding activated information from further processing), and oculomotor inhibition (i.e. suppressing a reflexive eye movement). Furthermore, there are striking inconsistencies in developmental effects across different tasks targeting the single inhibitory control process of response inhibition.

Response inhibition tasks require the participant to prevent a prepotent response to a particular stimulus or stimulus set. These tasks may either rely on existing prepotent stimulus–response associations, or create them within the task by presenting Go and Stop trials at different frequencies. In some versions of response inhibition tasks, Go trials require participants to make a speeded response based on discrimination between two Go stimuli (e.g. pressing one button to the letter X and another to the letter O). On a minority of trials, either Go stimulus is followed by a Stop signal (e.g. buzzer) that indicates that the participant must cancel the prepared motor response. This version of a response inhibition task, referred to as the Stop-Signal task (SST), elicits age-related decreases in the time required by a child to stop their response (Huizinga *et al*., 2006), even after controlling for non-inhibitory processes related to Go performance (e.g. Bedard, Nichols, Barbosa, Schachar, Logan & Tannock, 2002; Ridderinkhof, Band & Logan, 1999; Urben, van der Linden & Barisnikov, 2011; Williams, Ponesse, Schachar, Logan & Tannock, 1999).

In other versions of response inhibition tasks, a majority of presented trials require a single Go response (e.g. one button press) and no response on a minority of trials. In this case, the only response decision that is required is the decision *not* to press. This form of response inhibition task, termed the Go/No-Go (GNG) task, is often *not* associated with age-related decreases in errors of commission on No-Go trials (Cragg, Fox, Nation, Reid & Anderson, 2009; Maguire, White & Brier, 2011; Tamm, Menon & Reiss, 2002; Torpey, Hajcak, Kim, Kujawa & Klein, 2011), with the exception of studies that did not control for the more robust age-related improvements in Go trial performance (e.g. Brocki & Bohlin, 2004; Cragg & Nation, 2008; Tottenham, Hare & Casey, 2011).

One explanation for such inconsistent developmental findings is that performance requirements for these two tasks differentially tax confounding *non-inhibitory* processes, for instance, vigilance and task goals maintenance. Replicating and extending previous studies in confirmation of this view (Dodds, Morein-Zamir & Robbins, 2011; Hampshire *et al*., 2010; Sharp, Bonnelle, De Boissezon, Beckman, James, Patel & Mehta, 2010), Chatham *et al*. (2012) found in a modified SST that patterns of neural activity were indistinguishable across Stop trials and 'Double-Go' trials in which equally rare, secondary Go signals required a second response (but see Cai & Leung, 2011, for a counter-example). Consistent with this finding, Verbruggen, Aron, Stevens and Chambers (2010) observed, using trans-cranial magnetic stimulation, that disrupting function in the inferior frontal gyrus, the putative neural substrate of response suppression (Aron, 2007), affected both stopping and dual task performance. It is possible, then, that the discrepancies in developmental results between single-Go response inhibition tasks and forced-choice response inhibition tasks reflect their different demands on this potentially more central context monitoring process, rather than on inhibitory control. Due to the forced-choice component of Go trials on the SST, participants must monitor not only for Stop signals but also for the different identities of Go signals, increasing the attentional control requirements of the task. On single-Go tasks like the GNG, participants can bias attention towards No-Go signal detection without imposing a cost on Go accuracy because all Go trials require the same response (Nieuwenhuis, Yeung, van den Wildenberg &

Ridderinkhof, 2003), resulting in lower attentional control demands. Such a difference in attentional control demands may account for discrepant developmental findings in the GNG and SST.

Identifying what change in cognitive ability is associated with developmental improvements in response inhibition tasks is an important goal for our understanding of both cognitive development and developmental psychopathology. If changes in target detection account for developmental change on these tasks and for task performance more generally, this would constitute emerging evidence against standard views of the primacy of response suppression in cognitive development (e.g. Diamond, 2002). In addition, it could shift focus in studies of children with ADHD from deficits in response suppression toward a possible deficit in monitoring the environment for goal-relevant stimuli. While some parametric manipulations of GNG task difficulty have allowed more subtle quantification of developmental changes in task performance (e.g. Durston, Thomas, Yang, Ulug, Zimmerman & Casey, 2002), no modification of the GNG task as yet has tested this alternative account. The current study directly addresses this hypothesis within the GNG task by pitting traditional inhibitory and context monitoring predictions against each other. According to the traditional account, manipulations that increase response prepotency should impose a cost on inhibitory control (i.e. increase errors of commission). According to a context monitoring account, these same manipulations should *decrease* errors of commission because they would facilitate No-Go stimulus detection. Since reinforcing a response with reward increases both the response's prepotency (Campbell & Seiden, 1974) and the perceptual salience of response targets (Anderson, Laurent & Yantis, 2011), we predicted that rewarding responses to a stimulus later used as a No-Go cue would *improve* No-Go trial accuracy.

Study 1

Participants

Participants were 77 typically developing children (27 males) ranging in age from 4 years 9 months to 12 years 11 months. Mean age was 8.2 years, with a standard deviation of 1.97 (see Figure 1 for age distributions). Sixty-five percent of the sample was female. Twenty-eight participants were tested but excluded from the main analyses for omitting more than 50% responses during training. Participants were recruited and tested at the Boston Children's Museum during its normal hours of operation. In Studies 1 and 2, participants' parents or legal guardians provided informed consent under a protocol approved by the Boston Children's Hospital Institutional Review Board and the board of directors at Boston Children's Museum.

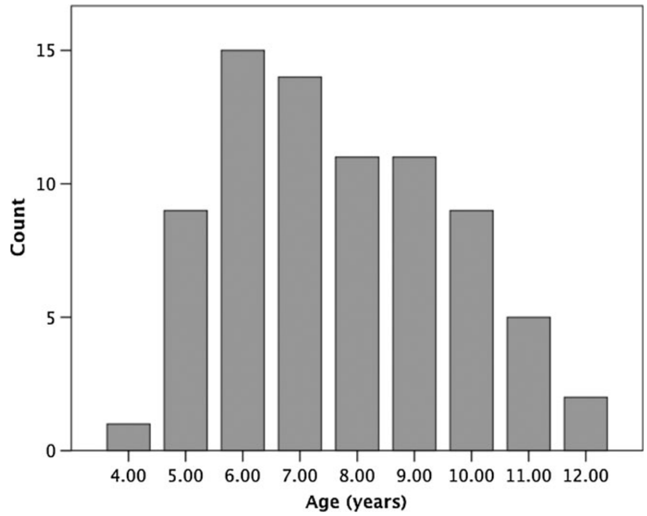

Figure 1 *Number of subjects by age in Study 1.*

Design and procedure

We employed a two-part modified GNG task consisting of an initial training (or Go only) phase and a testing (or Go/No-Go) phase. Accuracy and RT were recorded for all trials and phases. The training phase consisted of central presentations of eight different targets (Figure 2a), all of which were to be 'captured' with a spacebar press. Participants first chose a potential prize from an array of small toys and stickers. For one target, participants were told that if they pressed quickly enough they would receive their chosen prize after the training phase. To increase response time pressure, children were only given 600 ms to respond, and accuracy and RT were only included for responses within this 600 ms window. Responses to this target that occurred within the 600 ms window resulted in a rewarding display. This target and a second, non-rewarded target were shown 10 times, all other targets were shown five times each (50 total training trials). Presentation order was random and participants were instructed to press to every target during training. After training every child received the prize they chose. See Figure 2 for an illustration of the task design.

This training phase was designed to establish two levels of response prepotency and salience: (1) a baseline level of prepotency and salience built up by repeated, speeded Go responses to a target (prepotent target, P_target), and (2) an increased level of prepotency and salience, strengthened by rewarding Go responses to

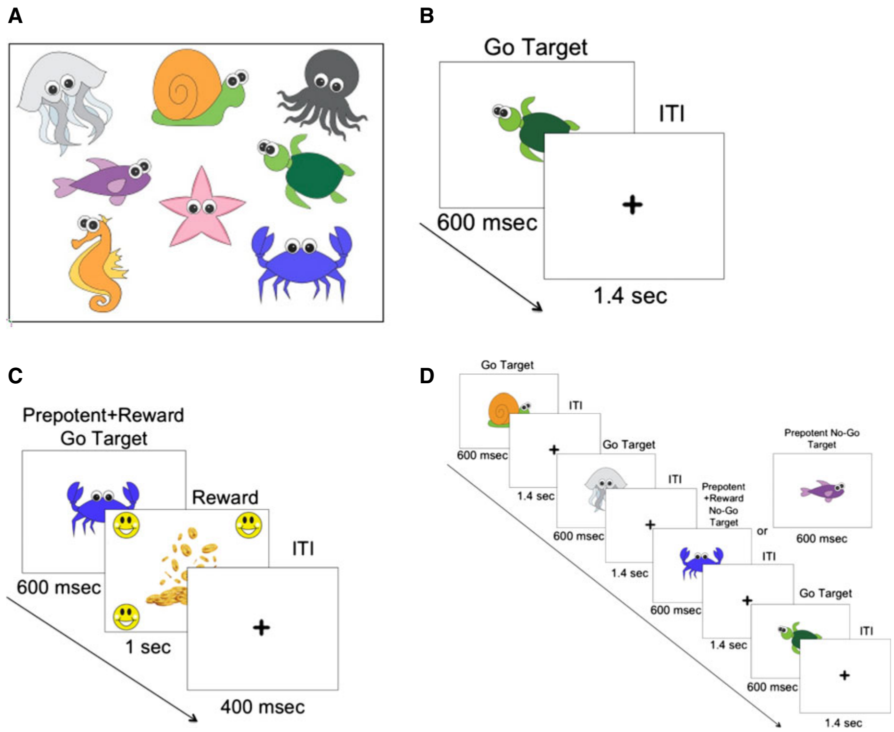

Figure 2 *Illustration of the task. (A) The stimuli that served as all Go targets during the training phase of Studies 1 and 2. In Study 1, the blue crab served as the PR target in the training phase and as one of the two No-Go targets in the testing phase; the purple fish served as the second No-Go. (B) The sequence of events following non-rewarded targets in the training and testing phases in Study 1. (C) The sequence of events in the training phase of Study 1. (D) A sequence of trials in the testing phase of Study 1 (GNG task). Multiple Go targets preceded No-Go stimuli and were followed by a 1.4 second ITI regardless of response.*

another target presented an equivalent number of times (prepotent+reward target, PR_target).

After the first wave of data collection (Study 1a; N = 61), we piloted the feasibility of a longer training phase where the prepotent targets were presented 30 times each and all other targets were presented five times each (Study 1b; N = 16). This change in number of presentations was instituted to test the hypothesis that simply enhancing reward during training would impact performance during testing. Results are not different when including or excluding these final participants and there were no significant differences in performance between Studies 1a and 1b in training phase (errors of omission to either the PR target ($t(75) = 1.15$, $p = .26$) or the P target ($t(75) = 0.13$, $p = .90$)); or testing phase (errors of commission to either the PR target ($t(75) = -1.310$, $p = .194$) or the P target ($t(75) = -1.02$, $p = .31$)). Thus, we discuss Studies 1a and 1b together here.

The testing phase consisted of two 50-trial blocks, each of which presented Go and No-Go targets randomly intermixed at a ratio of 80% to 20%. Before starting the testing phase, participants were shown the same eight targets and were instructed to capture six of these targets (Go targets) by pressing the spacebar as quickly as possible when they appeared, but to not capture two of the targets (No-Go targets). Of these No-Go targets, one was the PR target which had been rewarded during training (PR_No-Go) and the other was the P target (P_No-Go) which had no reward history but was matched for motor prepotency. The PR_No-Go and P_No-Go each appeared on 10% of the total trials. For both phases all stimuli were presented centrally on a 14' color monitor through a task programmed with E-Prime (version 2.0, Psychology Software Tools) and implemented on an IBM laptop. Participants viewed the monitor from a distance of approximately 50 cm and wore noise-cancelling headphones.

Analysis

First we examined the effect of reward (PR_targets vs. P_targets) on performance (errors of omission, reaction time (RT)) across all individuals using within-subject t-tests for the training phase. Next we examined the effect of previous reward on No-Go performance by directly comparing errors of commission on PR and

P_No-Go trials. We report effect sizes using Cohen's *d*. Next we examined the effect of age on performance, separately by phase (training, testing) and experimental condition (PR_No-Go, P_No-Go), using ordinary least-squares (OLS) linear regression. We estimated two models: Model 1 estimated the effect of age on task performance controlling for gender, and Model 2 additionally controlled for PR target errors of omission in the Go-only training phase (cf. Criaud & Boulinguez, 2012). PR targets in the training phase are roughly matched in frequency (i.e. they occur on 20% of training trials) to No-Go trials in the testing phase and are visually identical, but require no inhibition. Thus this final model accounts for general context monitoring processes involved in, but not specific to, No-Go performance that may contribute to developmental change in task performance over our wide age range. Only Model 1 was estimated for the training phase. We present standardized betas and associated *p*-values for the association between age and task performance.

Results and discussion

Training

During the training phase participants made errors of omission on 12% of all trials, mean RT = 359 ms ($SD = 55$). Participants made similar levels of errors of omission to the P target as to other targets during the training phase ($t(76) = 0.24$, $p = .81$). However, when responding to the PR target, participants made fewer errors of omission ($M = 9\%$) than when responding to all unrewarded targets ($M = 12.3\%$; $t(76) = 2.18$, $p = .03$, $d = 0.28$) and had faster reaction times (RT; $M = 350$, $SD = 56$) compared to unrewarded targets ($M = 361$, $SD = 58$; $t(76) = 2.92$, $p = .005$, $d = 0.33$). We concluded based on this data that our reward manipulation was effective in increasing participants' vigilance towards and motivation to respond to the PR target.

Linear regression revealed associations between age and omissions to the PR target ($\beta = -0.444$, $p < .001$), unrewarded targets ($\beta = -0.546$, $p < .001$), RT to the PR target($\beta = -0.343$, $p = .003$), and RT to unrewarded targets ($\beta = -0.419$, $p < .001$). Consistent with previous findings, these data indicate that there were general non-inhibitory performance improvements across age, which should be controlled for in subsequent analyses.

Testing

During the testing phase, participants made errors of omission on 23% of the Go trials and errors of commission on 33% of the No-Go trials. Participants made twice as many errors of omission in the testing phase as they did in the training phase. While we cannot know why this is, as there are many differences between these two phases, we speculate that the enhanced demands of the testing phase (e.g. more task goals, greater switching demands between Go and NoGo trials) may have decreased task performance overall. This hypothesis is corroborated by the fact that RT also increased on Go trials in the testing phase, indicating that the testing phase was overall harder than the training phase. Mean RT on correct hits was 386 ms ($SD = 38$) and 349 ms ($SD = 83$) on errors of commission. Participants made fewer errors of commission on PR_No-Go trials ($M = 0.30$, $SD = 0.16$) than on P_No-Go trials ($M = 0.37$, $SD = 0.18$), $t(76) = 3.68$, $p < .001$, $d = 0.42$ (Figure 3). We interpret this effect as resulting from PR_No-Go target's heightened salience, which facilitated its detection as participants monitored for it and the P_No-Go target. While inconsistent with an inhibitory account of GNG task performance, this finding is consistent with a context monitoring account and suggests that difficulty of stimulus detection determines No-Go performance more than does difficulty of response inhibition.

Consistent with the context monitoring account, our regression model revealed a significant association between age and rate of omissions ($\beta = -0.688$, $p < .001$), as well as between age and RT on Go trials ($\beta = -0.312$, $p = .006$) in the testing phase. However, we observed no significant association between age and errors of commission on either PR or P_No-Go trials either before (Model 1) or after (Model 2) controlling for errors of omission in the training phase (see Table 1).

In Study 1 we contrasted the traditional, inhibitory account of GNG performance and a context monitoring account by evaluating their divergent predictions about the effects of a reward manipulation on No-Go accuracy. While we were able to increase participants' attention to

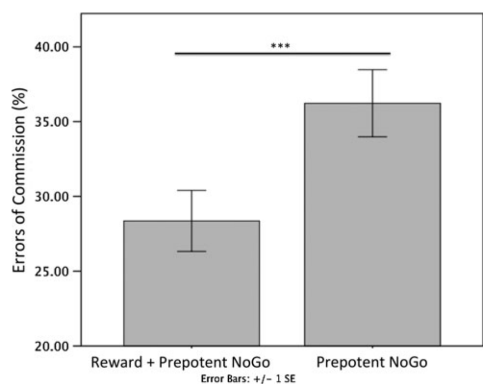

Figure 3 *Mean rates of errors of commission, expressed in percentage, in the testing phase of Study 1. Error bars represent one standard error of the mean. ***p < .001, two-tailed.*

Table 1 *In Study 1, the effect of age on errors of commission or previously rewarded No-Go targets (PR_No-Go) and previously unrewarded No-Go targets (P_No-Go) in two OLS regression models. Model 1 controls for gender, Model 2 controls for gender and errors of omission to the PR target during the Go-only training phase*

	Model 1		Model 2	
	PR_No-Go	P_No-Go	PR_No-Go	P_No-Go
Variable	β	β	β	β
Age	−0.108	−0.094	−0.141	−0.090
Gender	0.184	0.287*	0.174	0.288*
PR target omissions			−0.073	0.009

β = standardized betas. *p < .05, two-tailed.

the PR_No-Go target, as evidenced by their faster and more consistent responding during the training phase, this only served to decrease their errors of commission to this target during the test phase. This finding suggests that the reward manipulation's salience-enhancing effects overrode any inhibitory costs introduced by strengthening associated response prepotency and lends support to the context monitoring account of GNG task performance, which predicts that traditionally described inhibitory performance on this and similar tasks depends more on stimulus detection than motor inhibition.

Study 2

In Study 2 we non-selectively increased overall task vigilance for all participants and conditions by including a feedback event (a net falling down over the target) which signified to participants the causal efficacy of their responses, and which was non-evaluative in that it displayed after both correct and incorrect responses of ≤ 600 ms latency and conveyed no overt reward or punishment signal to the participant. We first demonstrate the effect of non-evaluative feedback by directly comparing errors of omission in Studies 1 and 2 to non-rewarded stimuli during the training phase. Next, as in Study 1, we examine the effect of reward on No-Go performance in the context of this enhanced task vigilance. This design modification permitted us to test another pair of diverging predictions. Both the inhibitory account and a context monitoring account of GNG performance would predict that increasing the salience of Go trials should impair performance on No-Go trials (by enhancing response prepotency, or by taxing limited selective attention resources for detecting rare No-Go targets). Only a context monitoring account, however, would predict that the additional salience of the PR_No-Go should protect it from such impairment. Thus, consistent with the context monitoring account, we hypothesized that P_No-Go but not PR_No-Go performance would be impacted by the introduction of non-evaluative feedback.

In addition, as our task used complex stimuli of varying colors, we tested the possibility that our results in Study 1 were affected by attributes of the stimuli themselves by counterbalancing the stimulus used for the PR target across participants. We observed that there were no differences between the two counterbalanced conditions in errors of omission to the PR target ($t(58) = -0.41$, p = .68) or the P target ($t(58) = -0.69$, p = .50) during the training phase. Nor were there differences across participants in the testing phase between the two conditions in errors of commission in response to either the PR_No-Go ($t(58) = -0.65$, p = .52) or the P_No-Go ($t(58) = 0.1$, p = .92) target. Consequently, we collapsed across both conditions for our analyses.

Participants

Participants were 60 typically developing children (25 males) ranging in age from 3 years 11 months to 12 years (see Figure 4 for the distribution of participants across age). An additional five children were tested but excluded from our analyses for failing to meet the criterion of less than 50% errors of omission.

Design and procedure

The apparatus, materials, and stimuli were the same as those of Study 1, with the addition of non-evaluative feedback and counterbalancing of PR and P targets (see

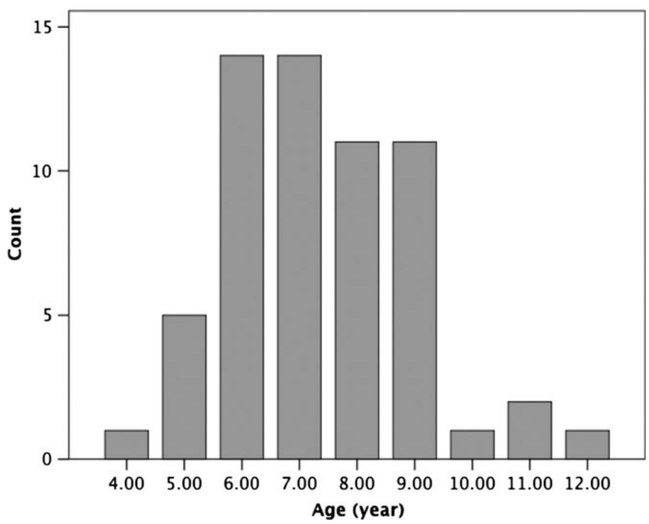

Figure 4 *Number of subjects by age in Study 2.*

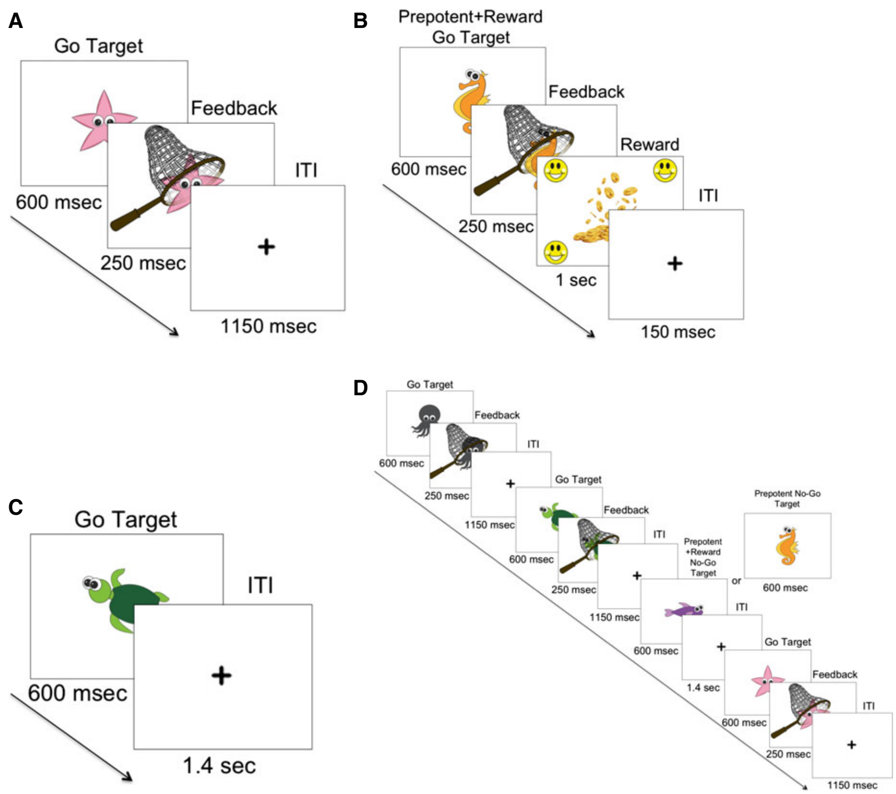

Figure 5 *Illustration of the task in Study 2. (A) The sequence of events following non-rewarded targets in the training and testing phases. (B) The sequence of events in a trial with a PR target in the training phase. (C) The sequence of events in any Go trial where the response was either omitted or occurred after 600 ms. Omitted or late responses to any of the targets resulted in 1.4 sec of the fixation cross and no feedback. (D) A sequence of trials in the testing phase (GNG task). Multiple Go targets preceded either PR_No-Go or P_No-Go targets, and all responses of ≤ 600 ms latency were followed by a non-evaluative feedback screen regardless of target type or response accuracy. For 38 participants (Study 2a), the yellow seahorse was the PR target in the training and testing phases and the purple fish was the P target in both phases, whereas for 22 participants (Study 2b), the purple fish was the PR target and the yellow seahorse was the P target.*

Figure 5). As in Study 1b, the training phase contained 90 randomized Go trials: 30 PR targets, 30 P targets, and 30 of the six other targets.

Analysis

First we used independent sample *t*-tests to directly compare average errors of omission, intra-subject variation in errors of omission, and RT for non-rewarded trials during the training phase. The other analyses in Study 2 directly replicated Study 1.

Results and discussion

Training

The introduction of non-evaluative feedback in Study 2 significantly decreased errors of omission to non-rewarded targets during the training phase ($t(135) = 2.13$, $p = .04$), decreased intra-subject variability in response ($t(135) = 2.18$, $p = .04$), and trended toward decreasing RT for these trials ($t(135) = 1.78$, $p = .07$) compared to Study 1. We take this as evidence supporting the hypothesis that introducing non-evaluative feedback enhanced task vigilance.

In the training phase of Study 2, participants made errors of omission on 8% of all trials and had a mean RT of 342 ($SD = 51$). Rates of omission to the P target did not differ from rates of omission to the other targets ($t(59) = 0.96$, $p = .34$). As in Study 1, participants again made fewer errors of omission to the PR target ($M = 7\%$) than to the nonrewarded targets ($M = 9\%$, $t(59) = -3.12$, $p = .003$, $d = 0.34$). Likewise, age was again related to errors of omission ($\beta = -0.377$, $p = .003$) and RT ($\beta = -0.317$, $p = .007$) on PR trials and errors of omission and RT on unrewarded target trials ($\beta = -0.368$, $p = .004$; $\beta = -0.319$, $p = .009$). See Figure 7 for scatterplots of age associations across Studies 1 and 2. Unlike Study 1, RT did not differ across P and PR target types in Study 2 ($t(59) = 0.56$, $p = .58$).

Testing

In the testing phase, participants committed errors of omission on 22% of the Go trials and errors of commission on 39% of the No-Go trials. Participants' mean RT on correct hits was 401 ms ($SD = 47$) and 373 ms ($SD = 64$) on errors of commission.

As in Study 1, participants made fewer errors of commission to PR_No-Go ($M = 35\%$) than to P_No-Go targets (42%; $t(59) = -1.99$, $p = .05$, $d = 0.26$; see Figure 6). This replication further supports the view that context monitoring plays a central role in GNG task performance.

While most findings concerning the effect of reward on performance were not different between Studies 1 and 2, the association between age and these metrics differed between Studies 1 and 2. In Studies 1 and 2, age was negatively related to errors of omission (Study 2,$\beta = -0.689$, $p < .001$) and RT on Go trials (Study 2,$\beta = -0.389$, $p = .001$). In Study 2 there was no association between age and rate of commissions for PR_No-Go trials. However, for P_No-Go trials, age was negatively related to errors of commission before, but not after, controlling for errors of omission to the PR target in the training phase (see Table 2). While a traditional view of the GNG task offers no explanation for these results, conceptualizing GNG task performance as primarily driven by context monitoring sheds light on them. In this view, feedback to all responses increased task vigilance uniformly, making it difficult to selectively monitor for the No-Go targets. Under these heightened demands on selective attention, age-related differences were *more* observable for monitoring processes targeted towards the P_No-Go target than towards the PR_No-Go target, as the latter's greater salience facilitated its detection. Furthermore, only a context monitoring view would predict that controlling for omissions (Model 2) would account for variance in No-Go performance. Our findings support the interpretation that age-related reductions in errors of commission on P_No-Go trials are driven more by improvements in context monitoring than by improvements in inhibitory control processes.

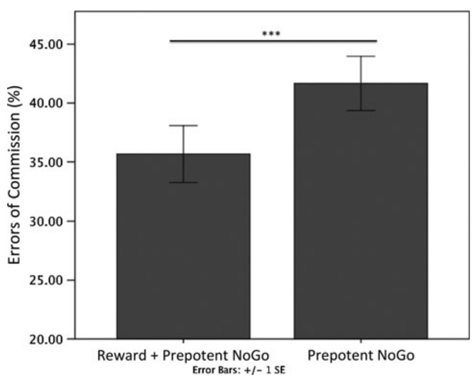

Figure 6 *Mean rates of errors of commission, expressed in percentage, in the testing phase of Study 2. Error bars represent one standard error of the mean. * p = .05, two-tailed.*

Conclusion

In two experiments with children 4–12 years of age, we examined diverging predictions from two accounts of GNG task performance. According to the traditional inhibitory account of this task, No-Go trial accuracy primarily reflects the ability to *suppress* prepotent responses and should therefore be hindered by manipulations that increase response prepotency. According to a context monitoring view, No-Go trial accuracy primarily reflects the ability to detect rare signals and should consequently be aided by manipulations that increase No-Go stimulus salience. We pitted these predictions against each other by using No-Go stimuli that were previously associated with rewarded Go responses. Consistent with the context monitoring account but not the inhibitory account, participants made fewer errors of commission to PR_No-Go targets than to P_No-Go targets.

Limitations

One potential limitation of our study is that our reward manipulation may have been insufficient in potency or length of exposure to yield a conditioned response to the PR_target. It remains to be established whether further reward learning or use of existing incentives (e.g. positive social stimuli) can produce evidence for an inhibitory process in the GNG task beyond the context monitoring processes we observe here.

Much as recent studies have challenged standard inhibitory views of the SST's 'stopping' measure in adults (Chatham *et al.*, 2012; Hampshire *et al.*, 2010), our findings motivate a reassessment of the widely held assumption that No-Go accuracy in the GNG task directly reflects inhibitory control. Further, our associations with age in Study 2 provide a counterpoint to the idea that developmental gains in inhibition underlie the emergence of mature self-regulation (Diamond, 2002) and lend support to views emphasizing the primacy of attentional control to the development of self-regulation (Garon *et al.*, 2008). While the self-regulation of

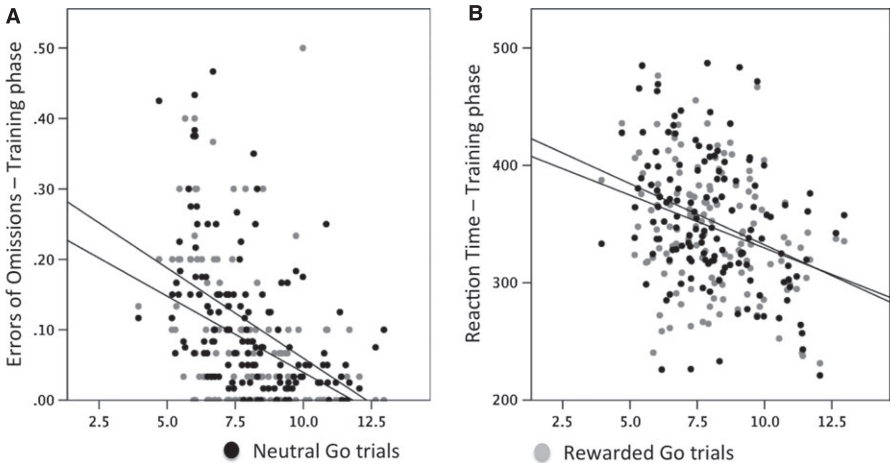

Figure 7 *Linear association between age and (A) errors of omission and (B) reaction time during the training phase for Prepotent and Prepotent+Reward Go trials; collapsed across Study 1 and Study 2.*

Table 2 *In Study 2, the effect of age on errors of commission for previously rewarded No-Go targets (PR_No-Go) and previously unrewarded No-Go targets (P_No-Go) in two OLS regression models. Model 1 controls for gender, Model 2 controls for gender and errors of omission to the PR target during the Go-only training phase*

	Model 1		Model 2	
	PR_No-Go	P_No-Go	PR_No-Go	P_No-Go
Variable	β	β	β	β
Age	−0.199	−0.248*	−0.142	−0.179
Gender	0.026	0.255*	0.025	0.253*
PR target omissions			0.150	0.184

β = standardized betas. * $p < .05$, two-tailed.

unwanted actions is unquestionably a skill that improves from childhood to adulthood, our results call into question the interpretation of age-related improvements in GNG task performance as evidence that inhibitory control underlies this maturation. We find support for the view that top-down control of attention better explains variance in performance on a measure traditionally assumed to reflect response inhibition.

Authorship

MS developed the study concept. Both authors contributed to the study design, data collection, data analysis, and interpretation. Both authors approved the final version of the paper for submission.

Acknowledgements

This work was generously supported by the NIMH (MH092555) to Sheridan. The authors wish to thank Michelle Schamberg, who oversaw data collection; Kate McLaughlin and Maria Kharitonova for their careful editing of the final manuscript; the Boston Children's Museum for opening their doors to our data collection team; and the many families and children who participated in this project.

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Received: 17 July 2013
Accepted: 23 October 2013