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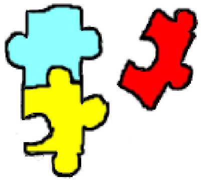

The Neural Correlates of Inhibitory Control in Preschool Children: Go/No-Go Task Demands Influence ERP Amplitude and Latency

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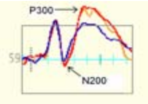
Introduction

▪Inhibitory control is a central construct in theories of attentional control (Desimone & Duncan, 1995), executive functioning (Friedman & Miyake, 2004), psychopathology (Nigg, 2000), and cognitive development (Harnishfeger & Bjorklund, 1993)
▪Inhibitory control undergoes rapid developmental change during the preschool years (Espy, 2004; Klenberg et al, 2001)
▪In everyday life, as children grow older, they increasingly must use inhibitory control to suppress inappropriate behavior depending on the context (e.g., delaying gratification, following different rules at home or preschool)
▪The go/no-go task requires the ability to stop or interrupt a motor response in both adults and children—participants must respond to the majority of trials, but withhold a response to specific stimuli
▪Task parameters such as the proportion of go vs. no-go trials, rate of stimulus presentation, and local stimulus probabilities influence inhibitory demands (Durston et al., 2002; Simpson & Riggs, 2005)
▪Event-related potentials (ERPs) have proven to be a useful tool for studying brain-behavior relations in preschool children, who have difficulty complying with the demands of fMRI (e.g., tolerating noise, keeping still; Nelson & Monk, 2001)
▪Furthermore, ERPs have excellent temporal resolution, and high-density recording allows for adequate spatial resolution
▪Many previous studies have used ERP with go/no-go tasks in children (e.g., Davis et al., 2003) and adults (e.g., Kiefer et al., 1998)
▪Previous work has found that specific components of the ERP waveform were modulated by the inhibitory demands of the go/no-go tasks, in particular the N200 and P300 components, with maximal differences at fronto-central scalp electrodes



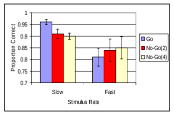
▪In the present study, we used electrophysiological methods to explore the neural correlates of inhibitory control, as measured by the go/no-go task, in a sample of 5-year-old children
▪We varied several task parameters previously linked to task inhibitory demands, to examine their effects on ERP waveforms
▪No-go trials (those requiring response suppression) followed a variable number of go trials, expected to influence children's bias to respond (Durston et al., 2002)
▪Stimulus presentation rate was varied between subjects, so that some children had to respond quickly whereas others had longer to determine whether a response was required (Simpson & Riggs, 2005)

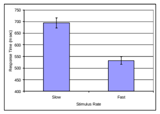
Method

▪The sample included 25 preschool children (15 girls, 10 boys) who ranged in age from 5.01 to 6.01 years (mean 5.68 years)
▪Children were fitted with a 128-channel EGI Hydrocel Geodesic Sensor Net, and then completed the Go/No-Go task after a short practice phase.
▪In the Go/No-Go task, the child pressed a button to "catch" fish stimuli within a set time (75% of trials), but had to inhibit the button response for shark stimuli (25% of trials).
  ▪Children in the "Slow" condition had 1500 msec to respond, whereas children in the "Fast" condition had to respond within 750 msec of stimulus onset
  ▪No Go trials, and followed either 2 or 4 Go stimuli
▪Children completed 160 trials ("Slow" condition) or 200 trials ("Fast" condition; more trials were added to compensate for poorer behavioral performance, because ERP waveforms were created using only correct trials)

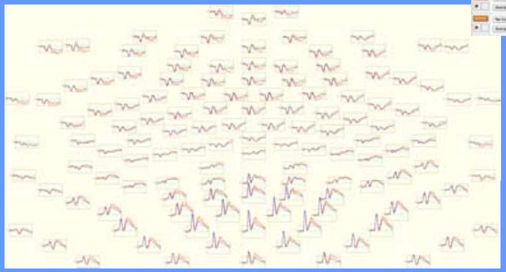
Results: Behavioral Performance

▪Proportion correct scores were analyzed in a 3 (Trial Type: Go, No-Go (2), No-Go(4)) x 2 (Stimulus Rate: Slow, Fast) ANOVA
  ▪Children performed better in the Slow than the Fast condition: $F(1, 23) = 11.01$, $p < .005$
  ▪There was also a trend toward a Trial Type x Stimulus Rate interaction: $F(1, 23) = 2.35$, $p = .10$
  ▪In the Slow condition, Go performance was significantly better than either No-Go trial type, which did not differ, $F(2, 26) = 4.56$, $p < .05$
  ▪In the Fast condition there was no significant Trial Type effect
▪Children responded more quickly in the Fast stimulus rate condition than in the Slow condition: $t(23) = 5.53$, $p < .0001$

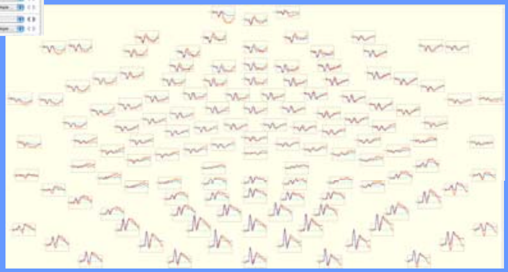




"Slow" Condition (1500 msec)



"Fast" Condition (750 msec)



Results: ERP Component Amplitude and Latency

▪ERP waveforms were analyzed separately for children in the Slow and Fast stimulus rate conditions
▪Three sets of analyses were conducted: N200 and P300 peak amplitude and latency were examined separately at anterior midline leads, anterior lateral leads, and posterior lateral leads, based on the existing literature and visual inspection of the waveforms
▪For the Slow condition, at anterior midline and lateral leads, the N200 was most negative for No-Go(2) trials, and smaller to Go and No-Go(4) trials, which did not differ: $Fs(2, 26) = 4.13$ and 4.17, $ps < .05$
  ▪The P300 differed by trial type in all lead groupings; at anterior leads, the P300 was largest to No-Go(4) trials, $Fs(2, 26) = 9.46$ and 6.97, $ps < .005$, for midline and lateral leads respectively, whereas at posterior leads both No-Go(2) and No-Go(4) trials produced a significantly larger P300 than did Go trials, $F(2, 26) = 16.55$, $p < .0001$
▪For the Fast condition, at posterior leads, the N200 differed in latency depending on trial type: $F(2, 20) = 1.66$, $p < .05$; latency was significantly faster for Go trials than for No-Go(2) trials, and No-Go(4) latency was intermediate and did not differ from the others
  ▪For N200 peak amplitude, there was an interaction between Trial Type and Condition: $F(18, 180) = 1.66$, $p < .05$; at leads 65, 90, 59, and 91, there was a trend-level effect of Trial Type, with a larger N200 for No-Go trials ($ps < .10$)
  ▪P300 amplitude was greater to both No-Go trial types than to Go trials at anterior midline and posterior leads: $Fs(2, 20) = 8.09$ and 4.20, $ps < .05$; at posterior leads only, P300 latency differed by Trial Type, paralleling the N200 findings: $F(2, 20) = 4.20$, $p < .05$

ERP-Behavior Correlations

▪To examine correlations between ERP waveforms and behavior, behavioral performance measures for each trial type at the reference electrode and lead #11 (roughly corresponding to leads Cz and Fz in the 10-20 system)
▪Although power is limited because of the small sample size, there are indications that children who are less impulsive (i.e., respond more slowly on Go trials) and perform better on the task overall evidence larger amplitude ERP waveforms and longer latencies to peak

	N200				P300			
Behavioral Performance	Amplitude		Latency		Amplitude		Latency	
	Fz	Cz	Fz	Cz	Fz	Cz	Fz	Cz
Slow Stimulus Rate (n=15)								
Go	-.31	-.29	.15	-.51+	-.08	.32	-.43+	-.16
Go RT	.67*	.62*	-.12	.37	.58*	-.20	.06	-.46+
No-Go(2)	-.37	-.11	.04	-.43	-.24	-.41	.02	-.38
No-Go(4)	.13	.67+	-.20	-.09	.26	-.09	-.06	.12
Fast Stimulus Rate (n=11)								
Go	.39	.35	-.69*	-.59+	-.04	.30	-.46	-.13
Go RT	-.29	-.08	.37	.25	-.04	.13	-.03	.42
No-Go(2)	.22	-.09	.30	-.38	.54*	.00	.21	-.02
No-Go(4)	.62*	.35	-.18	-.12	.50	.30	-.25	.03

Discussion

▪Go/no-go task parameters that were predicted to affect inhibitory demands had an impact on both behavioral performance and neural activity as indexed by ERPs
▪Requiring children to respond more quickly resulted in poorer performance and a change in the distribution of ERP waveforms: for children in the Slow condition, trial type effects were observed primarily at frontal leads, whereas for children in the Fast condition, trial type effects were more posterior on the scalp and were apparent in latency rather than amplitude differences, perhaps reflecting a greater reliance on earlier, more automatic processes
▪The number of preceding Go trials did not influence behavioral performance on No-Go trials, but did influence ERPs—for children in the Slow condition, the No-Go(2) trial type elicited the largest N200 (typically interpreted as reflecting inhibition), whereas the No-Go(4) elicited a larger P300
▪In contrast, Durston et al. (2002) found that No-Go trials' inhibitory requirements increased with more preceding Go trials; however, they included more trial types (1 vs. 3 vs. 5); our findings may be attributable to children's implicit learning over the course of the task, in that No-Go(2) trials may have been unexpected and thus recruited more executive processes
▪Many factors influence the cognitive processes underlying Go/No-Go performance, and vary the extent to which children need to or are able to exercise inhibitory control

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Acknowledgments

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