Neural correlates of response inhibition in young children

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Introduction

Executive Function (EF):

- Response inhibition— the ability to withhold an automatic response— is one factor of EF that undergoes significant development during the preschool years [1,2].
- Event-related potentials (ERPs) provide valuable information regarding neural activity that is time-locked to a stimulus. The N2, a negative-going ERP between 200-600 ms post-stimulus onset, has been identified as a neural marker of response inhibition [3,4].

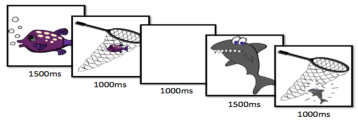
Physiological Reactivity:

- Respiratory sinus arrhythmia (RSA) is an index of parasympathetic control of the heart [5]. Baseline RSA (bRSA) is a measure of reactivity and physiological readiness to respond flexibly to environmental cues. Higher levels of bRSA are associated with the capacity to regulate affect to meet external demands [6,7].

Aim: Very few studies have examined neural correlates of response inhibition in young children [8]. This study seeks to investigate the neural correlates of response inhibition in a typically-developing sample of 3-year-olds utilizing physiological, behavioral, and temperament measures.

Method

- **Participants:** Twenty-four 3-year-olds (M= 38.4 months, SD = 2.09 months; 13 males)
- **Physiological assessment:** Electrocardiography (ECG) recorded using Biopac MP150 between 4-6 months and at 36 months as part of longitudinal study
  - bRSA calculated from inter-beat-intervals (IBIs) as a measure of parasympathetic control of heart rate within the frequency band of respiration (0.24 - 1.04 Hz.)
- **Procedure:** Participants completed the Fish-Sharks Go-NoGo response inhibition task [2], an oddball paradigm consisting of 75% Go trials and 25% NoGo trials while electroencephalography was continuously recorded from a 64-channel EGI sensor net with a Net Amps 300 series amplifier. All sensor impedances were kept below 50 kΩ throughout the study.



- On average, 63 Go & 25 No-Go trials remained after using ICA to remove blinks/muscle artifacts.

Measures

Behavioral measures of response inhibition:

Baby Stroop [9]

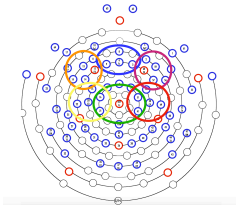
Shape Stroop [10]

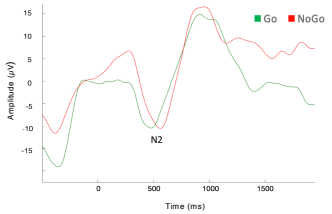
Delay of Gratification [11]

- Parents completed Child Behavior Questionnaire [CBQ; 12] to assess child temperament; interest in *Inhibitory Control* subscale

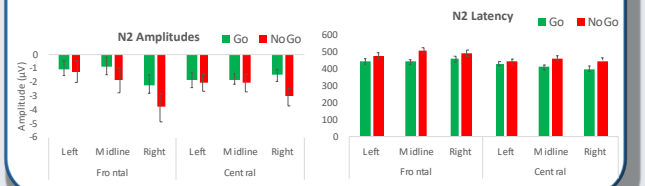
Results

- ***Behavior:*** Children were highly accurate on both Go (M= 80.2%, SD= 15.8%) and No-Go trials (M= 77.8% , SD= 20.3%).
- ***ERP:*** The N2 was identified as the peak negative deflection between 200-600 ms post-stimulus onset over fronto-central sites. Peak latency refers to the timing of the N2 amplitude peak.





- ***N2 Amplitude:*** The N2 amplitude was larger for NoGo compared to Go trials across fronto-central sites, $F(1,23) = 5.63$, $p = 0.03$, particularly in the right hemisphere, $F(2,46) = 3.78$, $p = 0.03$.
- ***N2 Latency:*** The N2 latency was significantly later for NoGo compared to Go trials across fronto-central sites, $F(1,23) = 16.14$, $p = 0.001$. There was also a Condition X Location interaction with larger differences between conditions at midline and right sites, $F(2,46) = 3.27$, $p = 0.05$.



Results

- To understand what factors influence NoGo amplitude across fronto-central sites, a hierarchical linear regression was conducted:

Predictor	B	SE	β	t	p	R^2
Intercept	-6.90	1.77		-3.91	.001	
Step 1						0.24
Infant bRSA	1.50	0.62	0.49	2.42	.03*	
Step 2						0.44
Inhibitory Control (CBQ)	3.20	1.34	0.45	2.39	.03*	
Response Inhibition	-0.95	0.72	-0.25	-1.31	.21	

Note: * = p <0.05; Response Inhibition= composite z-score of three RI tasks

Discussion

- These results extend previous research supporting the N2 as neural marker of response inhibition in older children [13,14] to typically developing 3-year-olds.
- Moreover, we extend previous results of latency differences between Go and NoGo trials found in 5-year-olds [15]. This result suggests that although children improve their behavioral task performance on response inhibition tasks across the preschool period [2], the brain is already distinguishing between activation (go) and inhibition (no-go) trials at 3 years of age.
- Higher infant bRSA, but not concurrent toddler bRSA, was associated with smaller (i.e. less negative) N2 NoGo amplitudes, suggesting better response inhibition for children with a higher physiological capacity to meet regulatory demands.
- Children with higher inhibitory control, as assessed via parental reports on the CBQ, also showed smaller (i.e. less negative) N2 NoGo amplitudes [16]. Response inhibition, as assessed by behavioral performance, was unrelated to N2 NoGo amplitude.

References

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