



Examining Whether Age Moderates the Relationship Between Anxiety and the ERN in Youth

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INTRODUCTION

- Childhood anxiety characterized by poor self-regulation and cognitive control [3, 6, 11]
 - Predicts risk of anxiety as an adult [1;16]
- Neural marker of cognitive control-related error monitoring is error-related negativity (ERN), a brain wave occurring within 100ms of error commission [9;15]
- The Compensatory Error Monitoring Hypothesis (CEMH; [13])
 - Worry causes distractions in anxious individuals
 - Use compensatory method of allocating extra cognitive resources to refocus attention on the task after making an error to perform as well as non-anxious individuals
- Past research
 - Anxious adults characterized by enlarged ERN [14, 19]
 - Older children with anxiety show enlarged ERN, but young children with anxiety show smaller ERN [10, 15]
- Age effect on cognitive control & ERN
 - Cognitive control increases with age [2, 12, 17] as does the ERN; increase in ERN across development is associated with improved cognitive control [18]
- Δ ERN, performance & anxiety
 - Larger Δ ERN associated with fewer errors in children [10]
 - Greater anxiety related to more errors & smaller Δ ERN [10]
 - Based on CEMH, anxious older children may perform better than the anxious younger children because they have the ability to compensate for anxiety (with Δ ERN indicating compensatory effort)

Aims and Hypotheses

- Test age as a moderator of the Δ ERN -anxiety relationship
 - H1: Anxious older children \rightarrow larger Δ ERN
 - H2: Anxious younger children \rightarrow smaller Δ ERN
- Test age as a moderator of the SAD-performance relationship
 - H3: Anxious older children will have better performance compared to anxious younger children

METHODS

- Participants**
 - $n = 152$
 - Age: 4-13 years ($M = 8.61$, $SD = 2.60$)
 - Recruitment: online advertising site and laboratory database
 - Half sample at risk for substance use disorder
- Materials**
 - Developmentally-appropriate Go/No-Go task [8]



- Mother-reported Revised Child Anxiety and Depression Scale (RCADS-P; [5]) assess for separation anxiety disorder (SAD)
- Analyses**
 - Moderated multiple regression analysis using Hayes PROCESS MACRO in SPSS
 - Dependent variable: ERN-CRN Difference (Δ ERN)
 - Explanatory variable: SAD
 - Moderator: Age

Table 1 Bivariate correlations between ERPs, behavioral performance, SAD, and age

Variable	1	2	3	4	5	6	7
1. Δ ERN FCz	--						
2. M GoCorr RT	.215**	--					
3. M NoGoErr RT	.272**	.885**	--				
4. GoCorr Acc	-.376**	-.388**	-.528**	--			
5. NoGoErr Acc	.217**	.034	.215**	-.396**	--		
6. SAD	-.032	.193*	.131	.012	-.011	--	
7. Age	-.210**	-.758**	-.786**	.591**	-.362**	-.227**	--
M	-7.13	503.36	423.07	223.79	26.96	.54	8.61
SD	5.94	82.91	72.30	25.83	11.09	.49	2.60

Note. SAD Separation Anxiety Disorder

* $p \leq 0.05$

** $p \leq 0.01$

Model 1: Reaction Time (RT)

Significant main effect of age ($B = -24.09$, $p < 0.001$)

Significant SAD X Age interaction is depicted in Figure 2 ($B = -8.81$, $p = 0.032$)

- SAD and RT in younger children (1 SD below mean)
 - Trend for significant relationship ($B = 21.40$, $SE = 12.37$, $p = 0.086$)
 - SAD associated with longer RTs
- SAD and RT relationship in older children (1 SD above mean)
 - No significant relationship ($B = 23.29$, $SE = 15.76$, $p = 0.142$)

Model 2: Accuracy

Significant main effect of age ($B = -1.78$, $p < 0.001$)

No moderation of SAD and accuracy relationship by age ($B = -0.50$, $p = 0.51$)

RESULTS

Δ ERN larger on errors compared corrects, as expected

- $t(df) = -14.80$, $p = 0.000$

Older children show a larger Δ ERN (Figure 3)

Δ ERN is related to behavioral performance

SAD related to slower GoCorr RT and younger age

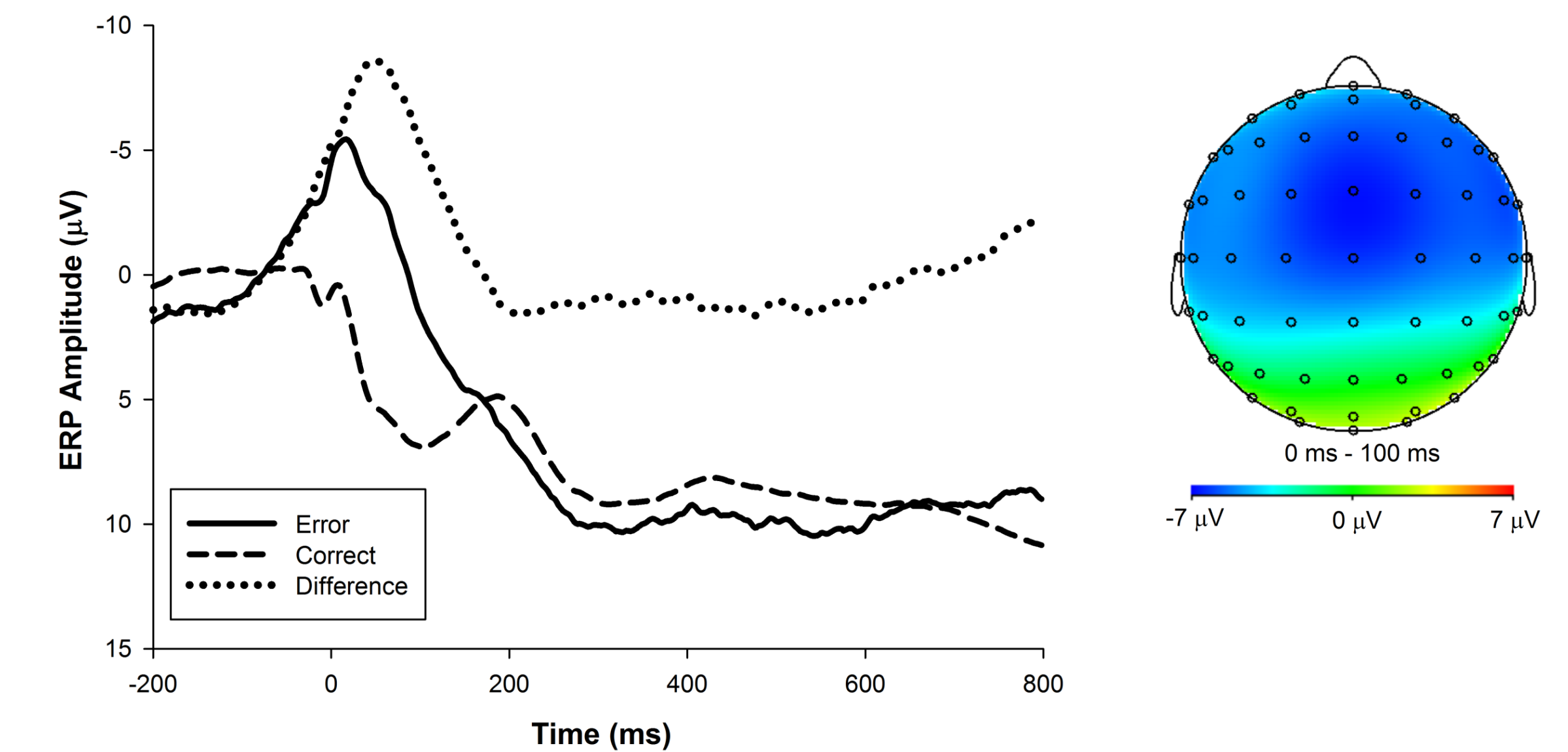


Figure 1. ERP waveforms for error and correct trials

Model 3: ERN

- Significant main effect of age
- Age does not significantly moderate the Δ ERN-anxiety relationship ($p = .72$)

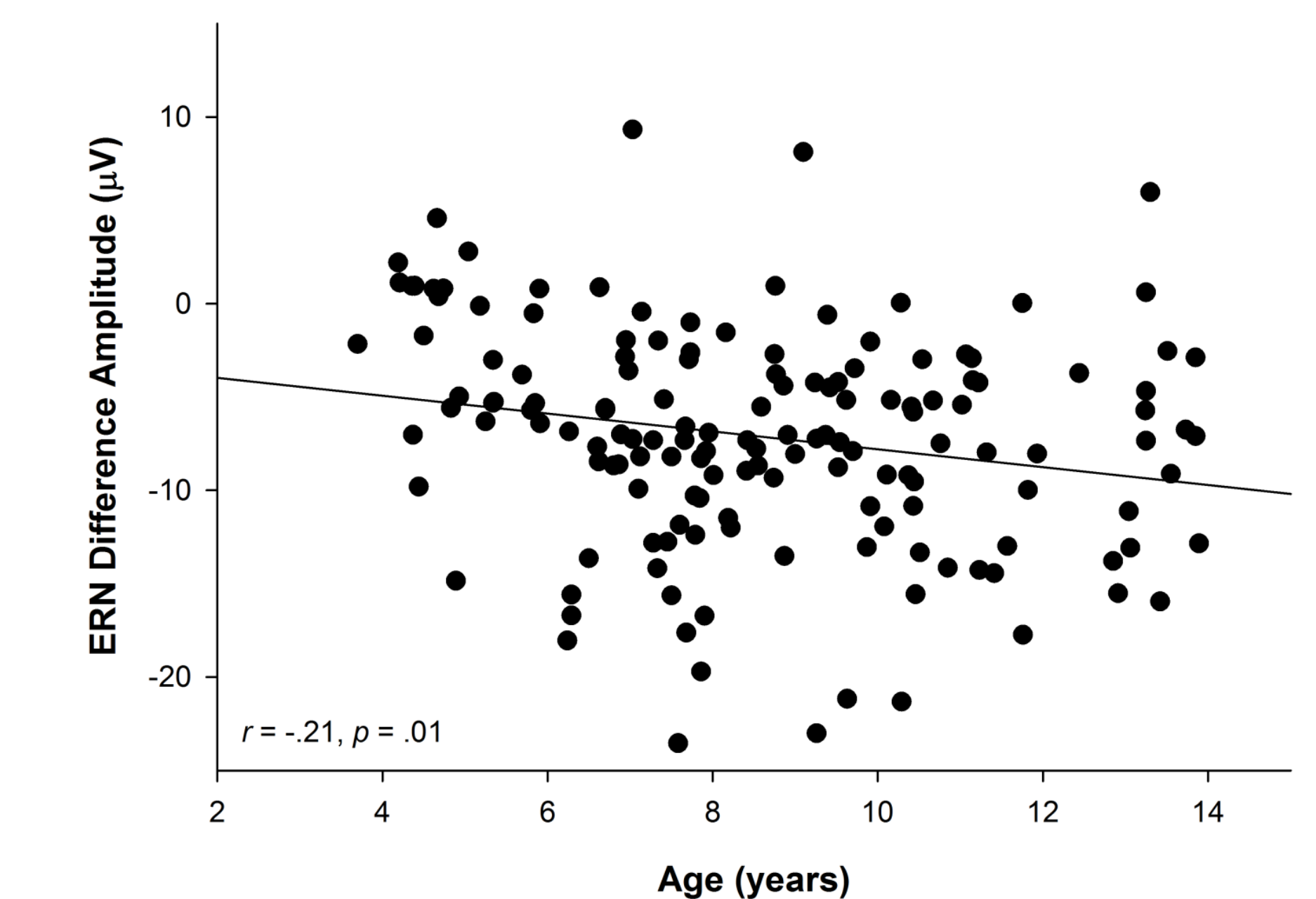


Figure 3. Scatter plot of the relationship between age and the Δ ERN difference amplitude

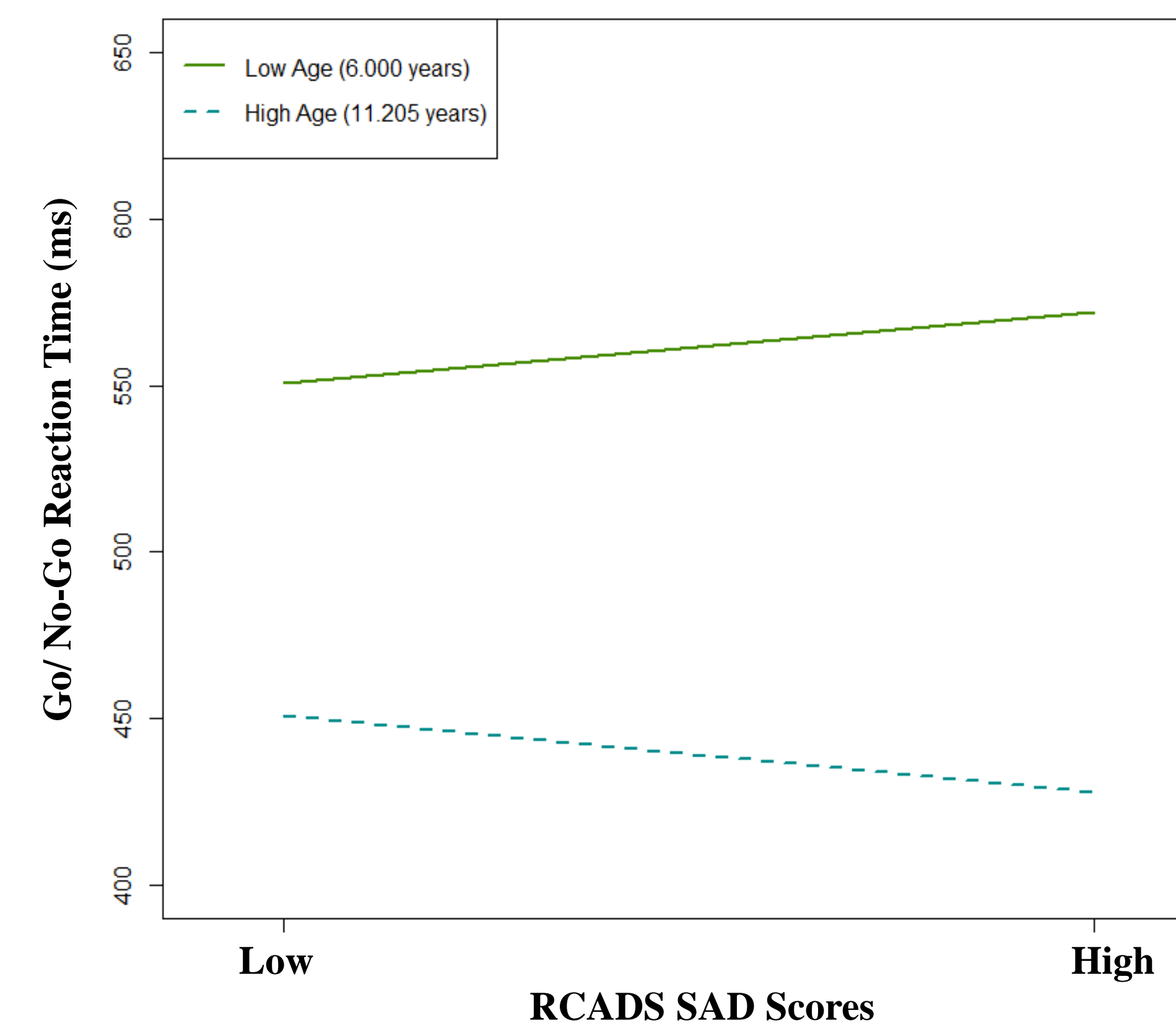


Figure 2. Regression for model of SAD-RT relationship moderated by age.

DISCUSSION

- Age significantly moderates anxiety-RT relationship
 - Anxious young children showed slower RT
 - Based on CEMH; younger children lack the mechanism to compensate for their worry (as shown by a smaller Δ ERN), which could manifest in slower RT
 - Anxious older children show no behavioral impairment
- Age does not significantly moderate anxiety-accuracy relationship
 - Tradeoff in accuracy and RT
 - Slowing RT could improve accuracy and nullify anxiety effects on accuracy
- Age does not significantly moderate anxiety- Δ ERN relationship
 - Sample mostly young children; in addition, a wide age range reduced the statistical power for test of younger vs. older children
 - Age may be poor proxy for cognitive control
 - Anxiety- Δ ERN relationship in children tenuous

Limitations

- Cross-sectional design does not account for developmental differences across time
- Parent reported measures may be effected by parent psychopathology [4, 7]
- Δ ERN differences in non-clinical vs. clinical samples

Future Research

- Larger sample needed to determine anxiety-ERN relationship moderated by age
- Replication using a clinical sample in order to see how children with high levels of anxiety display the Δ ERN and behavioral performance as they age
- Exploring other possible variables responsible for Δ ERN and behavioral changes across age

References

Will be provided upon request

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