



## Introduction

We tested proactive and reactive control simultaneously in reaction times of kindergartners.

These cognitive control facets seem to develop throughout childhood, with a markedly increase during preschool and kindergarten years (de Mooij et al., 2022; Gonthier et al., 2019; Gupta et al., 2009; Lucenet & Blaye, 2014).

The current study assesses the development of reactive control in the form of post-error slowing (PES) and proactive control in the form of delayed disinhibition (DD) in kindergarten children, taking into account individual differences based on sex, age and IQ, and their plausible interactions.

## Method

### Participants:

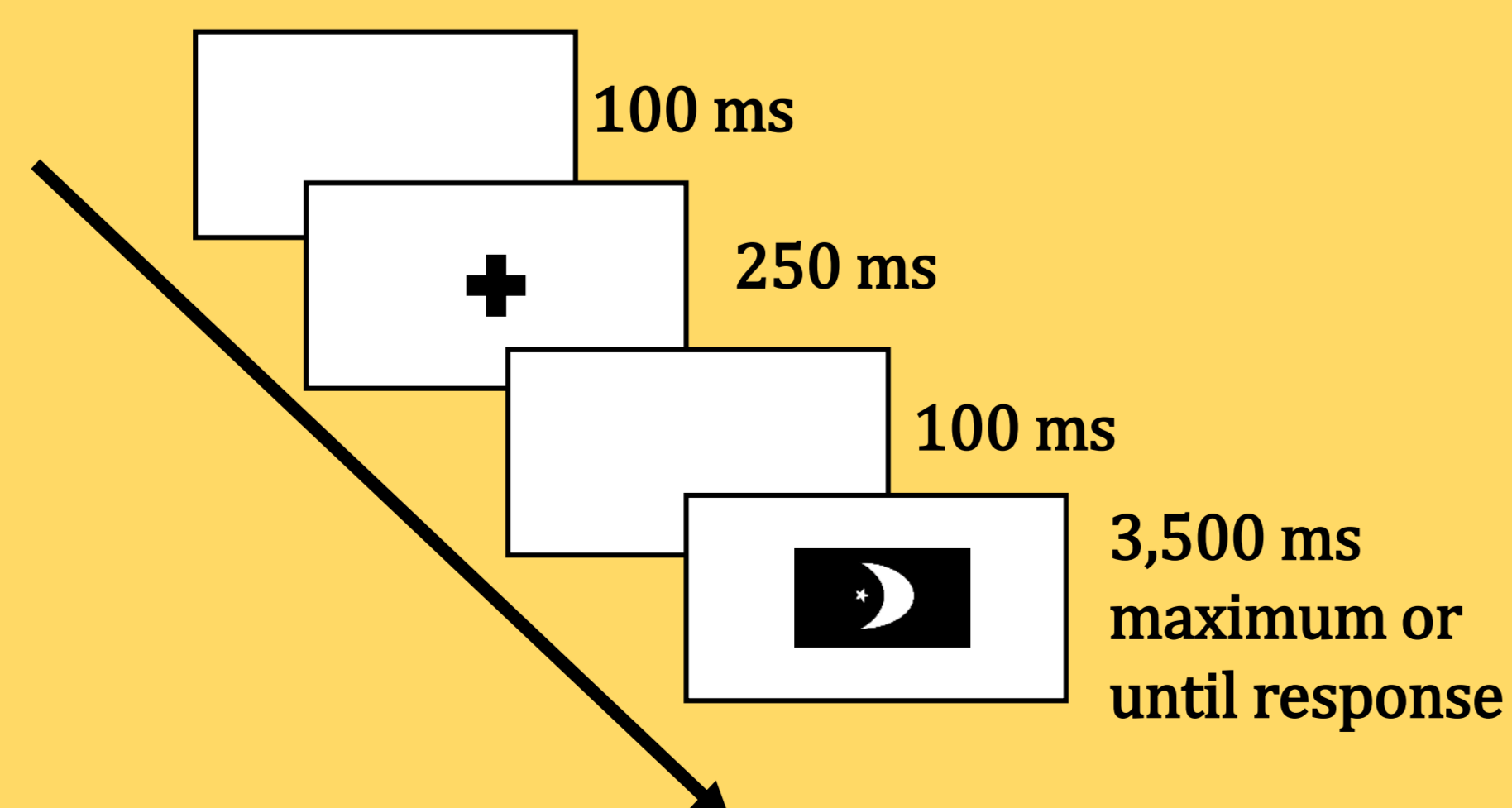
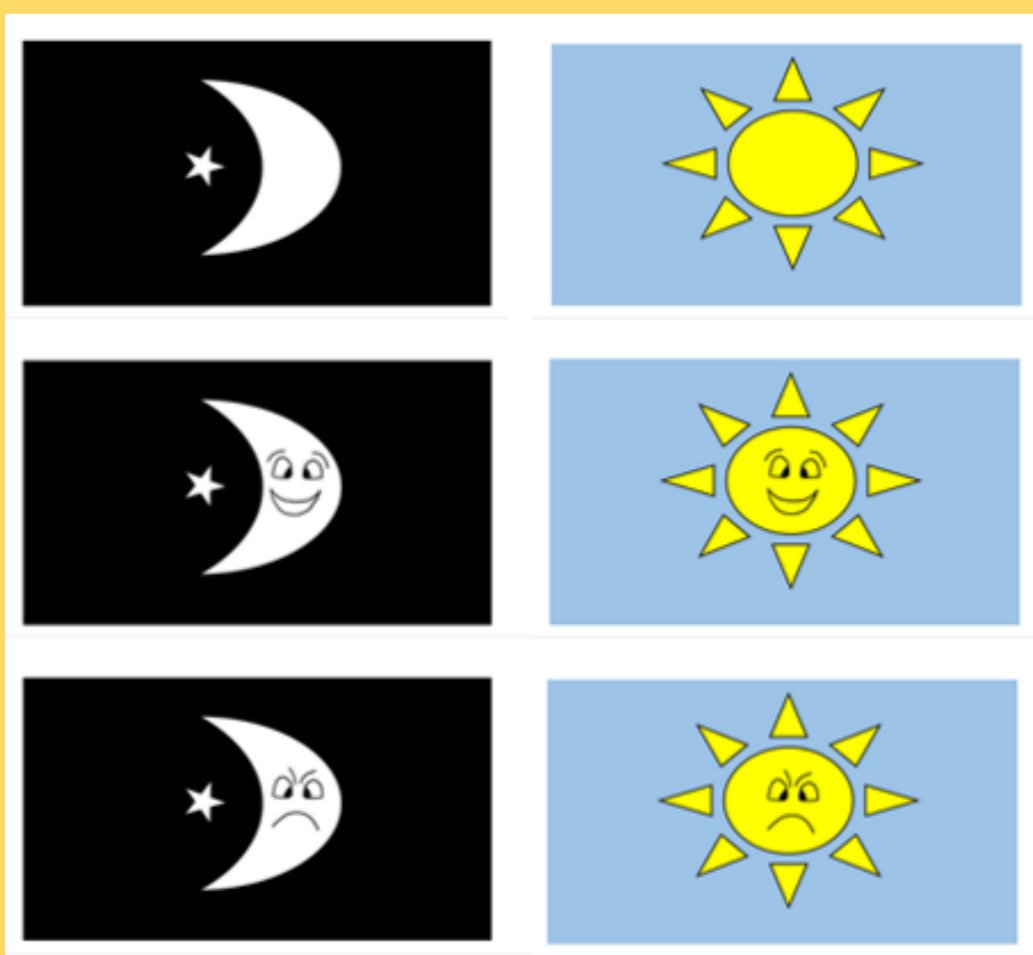
67 children ( $M_{age}$  = 5 years and 7 months  $\pm$  5 months; 4.61-6.52)

### Measures:

- Raven task (The Colored Progressive Matrix test; CPM – Children's Raven test; Raven et al., 1998)
- An adapted version of the "Emotional Day-Night Stroop" task (Ramon et al., 2011) that combines Go/No-Go and Stroop-like paradigms
- Four blocks (only the three congruent ones were used)
- 36 trials per block
- DD effect
- PES effect

### Analytical plan:

- Three-step HLM (nested data) and ROI analyses
- DV: Response Time
- IDV:
- Fixed effects:
- DD (0 = NDD, 1 = DD) + PES (0 = NPE, 1 = PE) + Sex (0 = Male, 1 = Female) + Age (Standardized) + Raven (Standardized) + Interactions
- Random effects:
- DD + PES



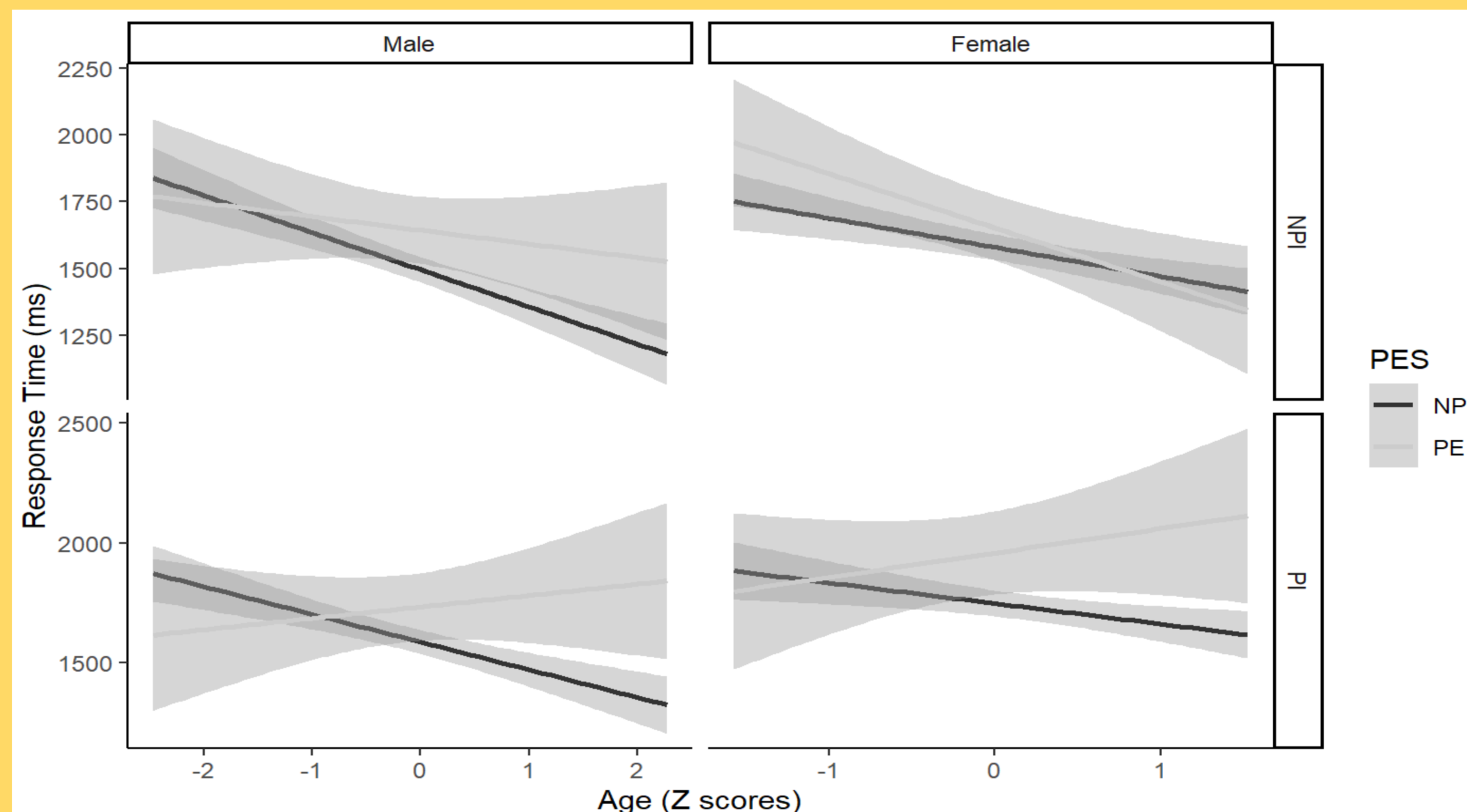
## Results

### Zero-order correlations

Variables	1.	2.	3.	4.	M	SD	IQR	Range
1. DD effect	-				83.83	189.12	-36.74, 184.97	-271.11, 962.97
2. PES effect	-.27*	-			215.56	358.26	5.44, 374.34	-586.20, 1443.31
3. Sex	.21 <sup>+</sup>	-.08	-					
4. Age	.18	.21 <sup>+</sup>	.11	-	5.57	0.41	5.28, 5.88	4.61, 6.52
5. Raven	-.06	.23 <sup>+</sup>	-.05	.29*	18.81	4.38	16, 22	9, 30

Note.  $N = 67$ . DD = Delayed Disinhibition (PI – NPI), PES = Post Error Slowing (PE – NPE), Sex (0 = Male, 1 = Female). IQR = Inter-Quartile Range. Mean and standard deviation of DD and PES are in ms, age is in years and Raven is in raw score (the count of correct answers). <sup>+</sup> $p < .1$ ; \*  $p < .05$  two-tailed.

### Four-way interaction



## Discussion

This is the first empirical study behaviorally testing proactive and reactive control simultaneously, while previous studies have compared proactive control versus reactive performance (Chatham et al., 2009; Gonthier et al., 2019; Lucenet & Blaye, 2014). We also fine-tuned the age point of the behavioral manifestation within the tested age period. The basic results supported the importance of taking into consideration the interactions between sex and age, as well as the exact combination of the types of control required in each situation and each trial. Overall, the findings supported the notion that girls begin to manifest cognitive control (proactive and reactive) earlier than boys. Moreover, our findings indicated that about 5 years and 6 months is the critical age for the appearance of individual differences in proactive and reactive control.

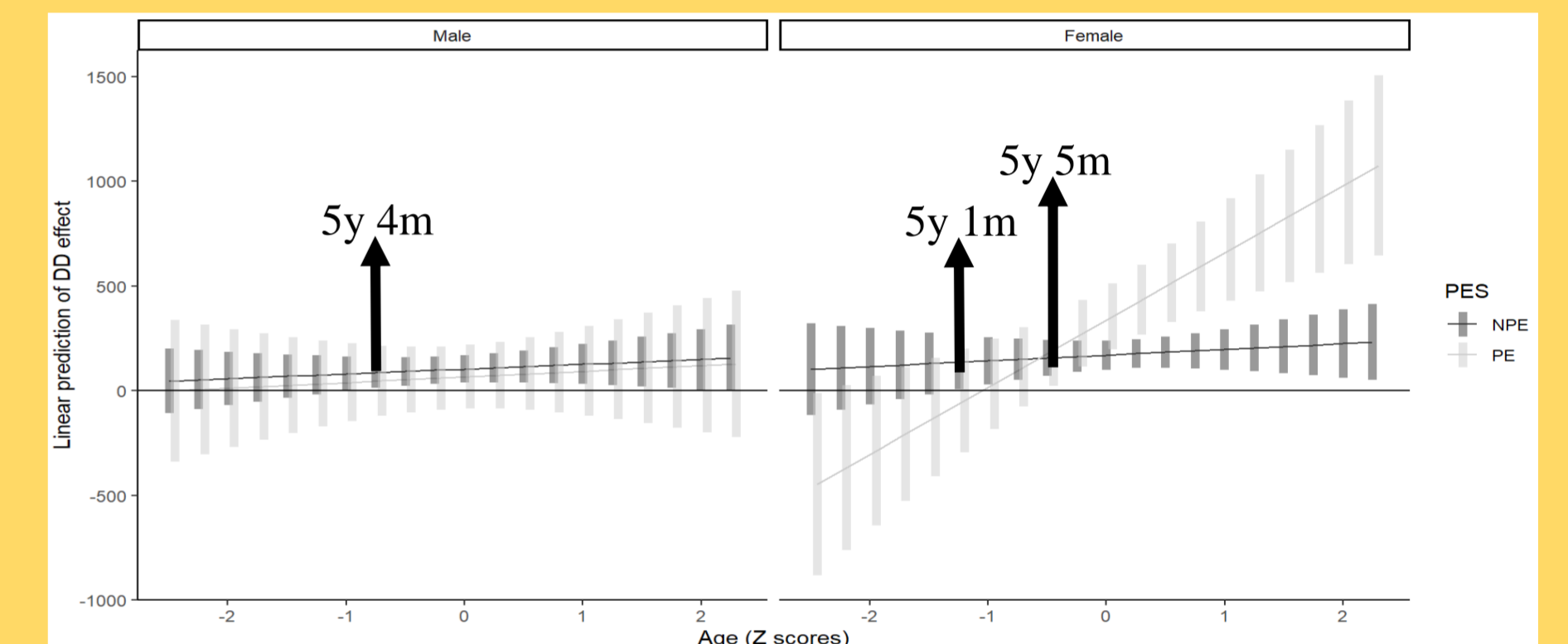
During kindergarten years, children can exert these two types of control simultaneously; however, this is not without cost, as there is a tradeoff between them during this age period. Moreover, in boys, when such simultaneous control effort is required, we do not yet see significant evidence for proactive control.

### HLM analysis

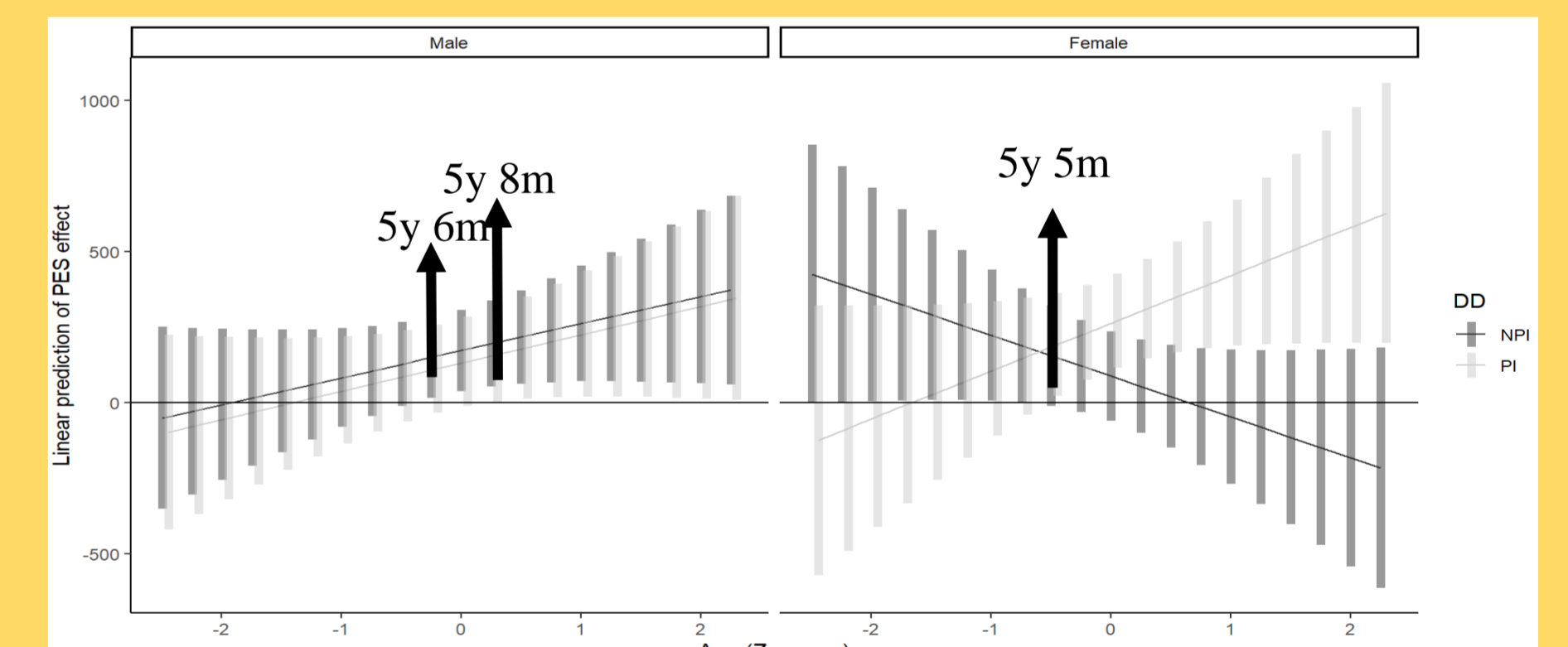
All multi-level indexes supported that the preferable model was the third model ( $\Delta AIC_{model\ 2-model\ 3} = 5, ; \chi^2_{(5)} = 14.75, p = .011$ ) with a significant four-way interaction ( $t(2598.72) = 2.45, p = .014$ ).

### Region of Significance analyses and confidence intervals

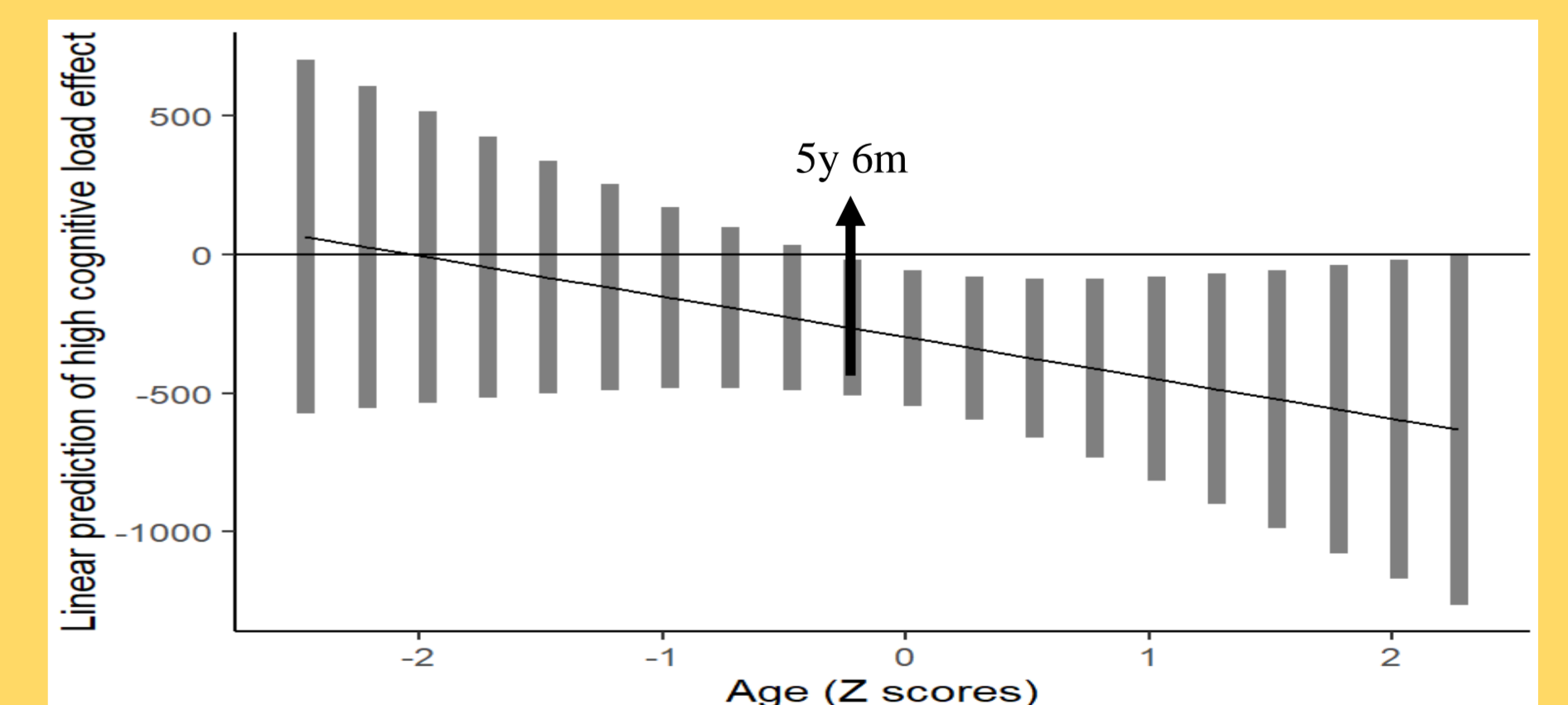
### Delayed Disinhibition effect by sex, age and PES



### Post Error Slowing effect by sex, age and DD



### Difference of response times at high cognitive load between the sexes and by age



## References

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