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Tactile sensory prediction and executive attention development at preschool age: perspectives for understanding neurodevelopmental disorders

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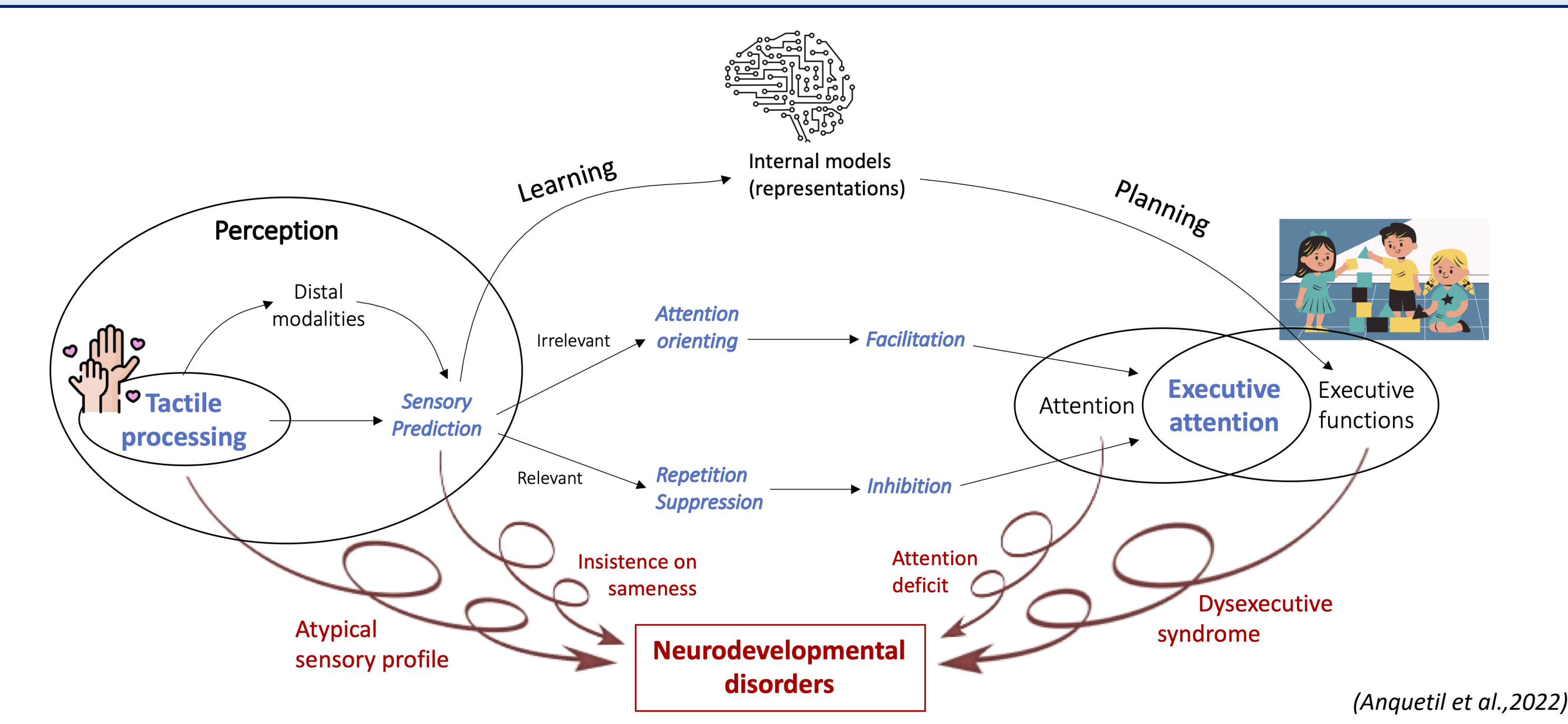
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INTRODUCTION

- The **tactile modality**, the first to develop, is the foundation of cognitive development.
- **Sensory Prediction (SP)** is a core mechanism sustained by our perceptions and allows the brain to anticipate future stimulations on the basis of previous sensory inputs (Friston, 2005). **Repetition Suppression (RS)** refers to the reduction of activity in the brain when a predicted stimulus is repeated or becomes irrelevant.
- **Sensory Prediction in the tactile modality** was suggested as an early precursor of cognitive development (Dumont et al., 2022).
- **Predictive mechanisms may form the basis of executive attention** development by sustaining self-regulation processes such as habituation or anticipation (Bubic et al., 2010).

The aim of this study is to investigate how tactile sensory prediction and other tactile processing phenomena are related to executive attention development at preschool age.



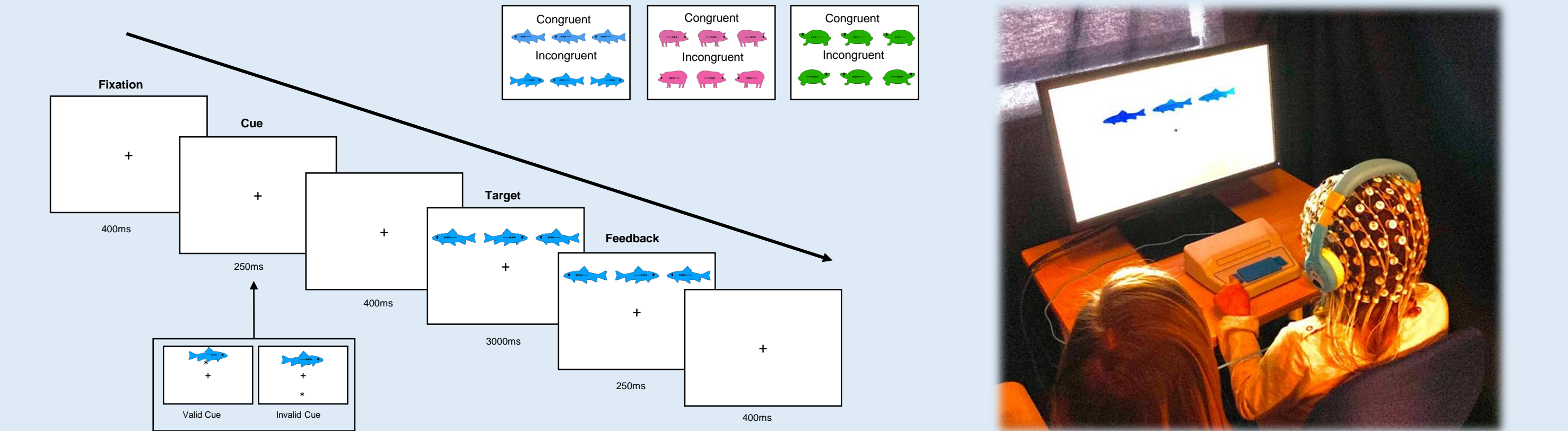
- For executive attention, we investigate the modulation of the N2 component, between congruent and incongruent conditions.
- For tactile sensory processing, we assess repetition suppression, i.e., the decrease in somatosensory evoked potential (SEP) between the familiarization and the control sequence during the oddball omission-paradigm in the somatosensory cortex. We also assess potentials evoked by deviant stimulations.

We hypothesize a relation between brain evoked potentials at tactile sensory oddball paradigm and brain evoked potentials at Child-ANT: the modulation of N2 component is associated with repetition suppression. We also hypothesize that SEP are associated with behavioral measurements and parental questionnaires of executive attention and executive functions.

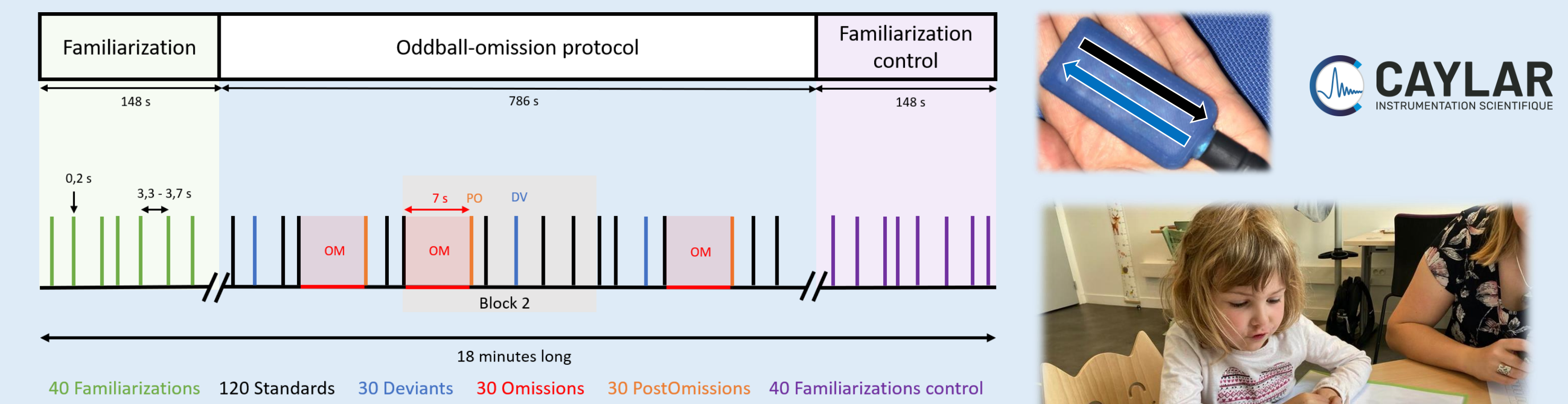
METHODS

28 children between 48 and 60 months perform the following tasks in random order while 128-electrodes electroencephalography (Magstim EGI) is being acquired:

- an adapted version of the **Child-Attention Network Task (ANT)**, a measure of executive attention (Rueda et al., 2004)



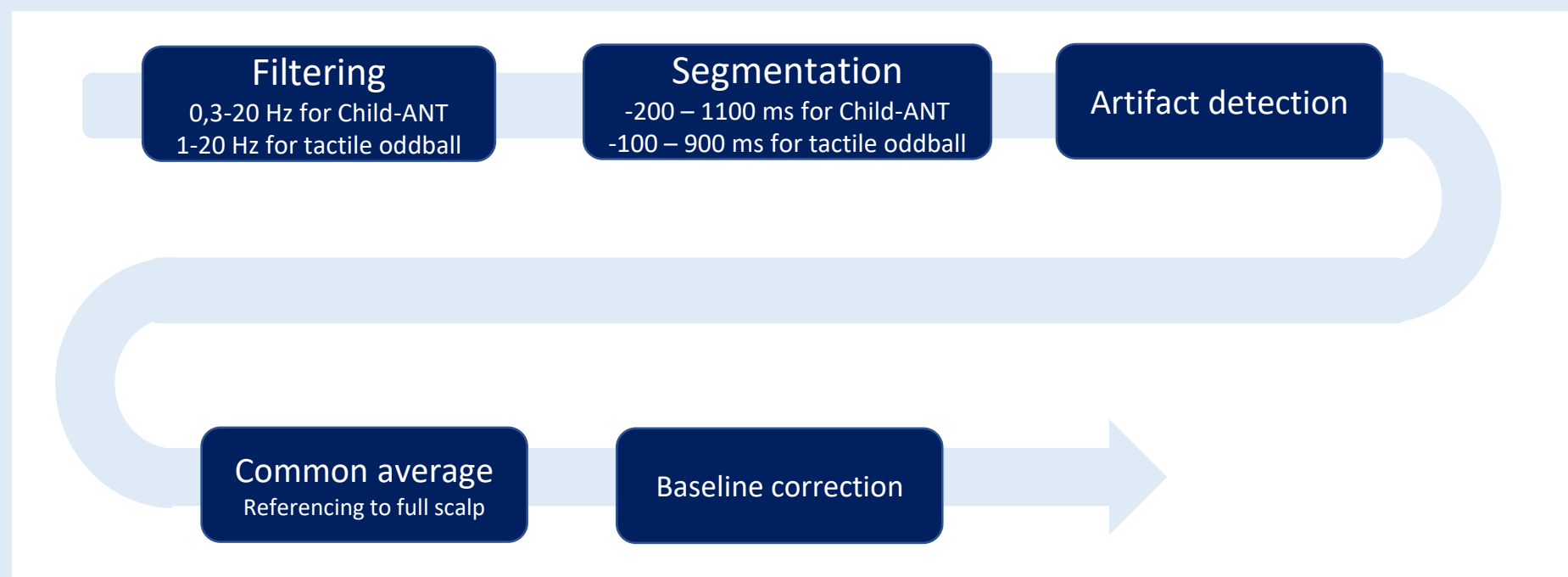
- a **tactile oddball-omission paradigm** (vibrotactile stimuli are presented on the forearm randomly interspersed with deviant and omitted stimuli).



- Children also perform the following behavioral tasks in random order:
- **Movement Assessment Battery for Children 2nd edition (MABC-2)**
 - **Stroop task** adapted for non-reading children (Wright et al., 2003)
 - **Head-Toes-Knees-Shoulders (HTKS)** task (McClelland et al., 2014)

Parents are also invited to complete 3 questionnaires: **Dunn's Full Sensory Profile**, **BRIEF-P** and **ESSENCE 2-5**.

- **EEG preprocessing for Child-ANT and for Tactile oddball paradigm**



- **Statistical analysis**

We computed the mismatch between the different conditions for each subject in order to determine the peak amplitude of interest for the analyses. We then carried out Student or Wilcoxon comparison tests depending on the normality of the sample.

To quantify the link between brain activity in the tactile oddball paradigm and during the Child-ANT, we used the generalized linear model. We used the same method to compare tactile repetition suppression and executive functions.

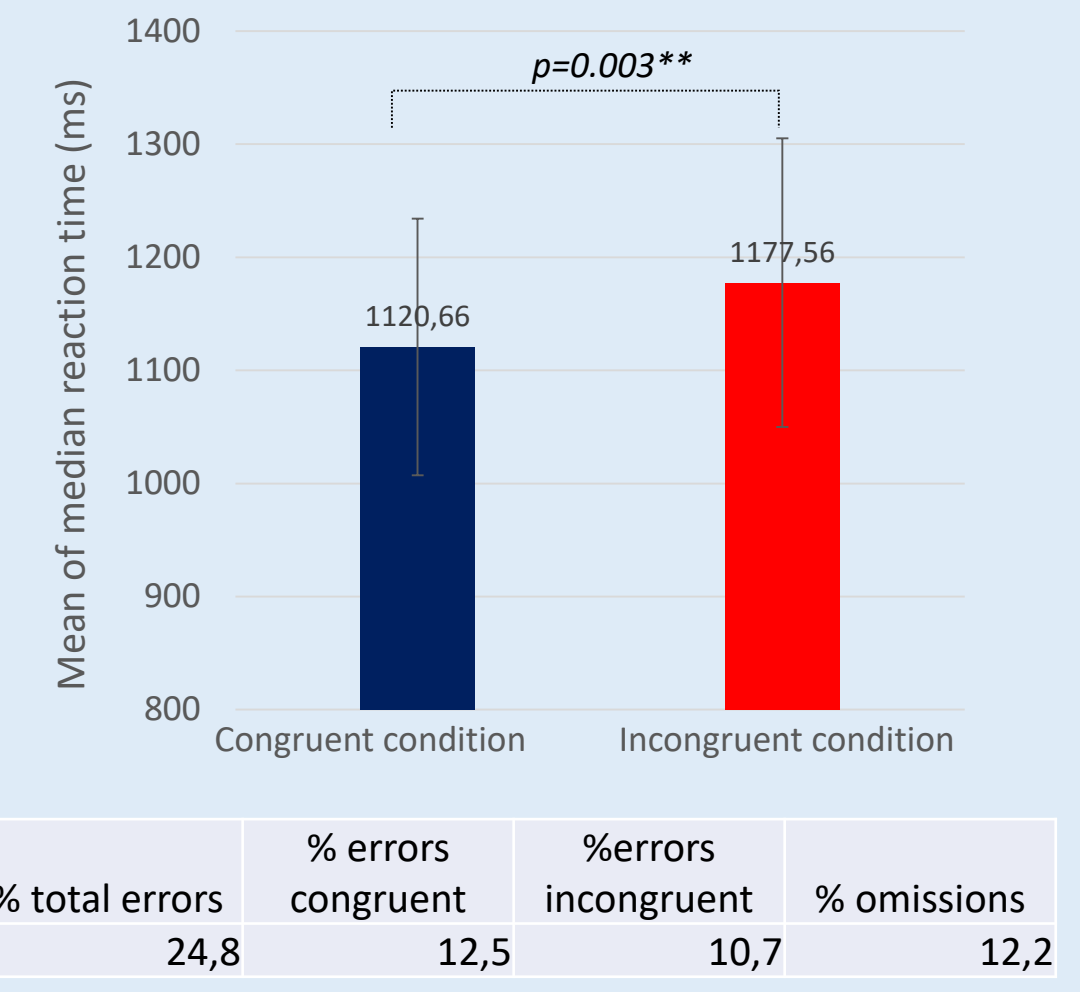
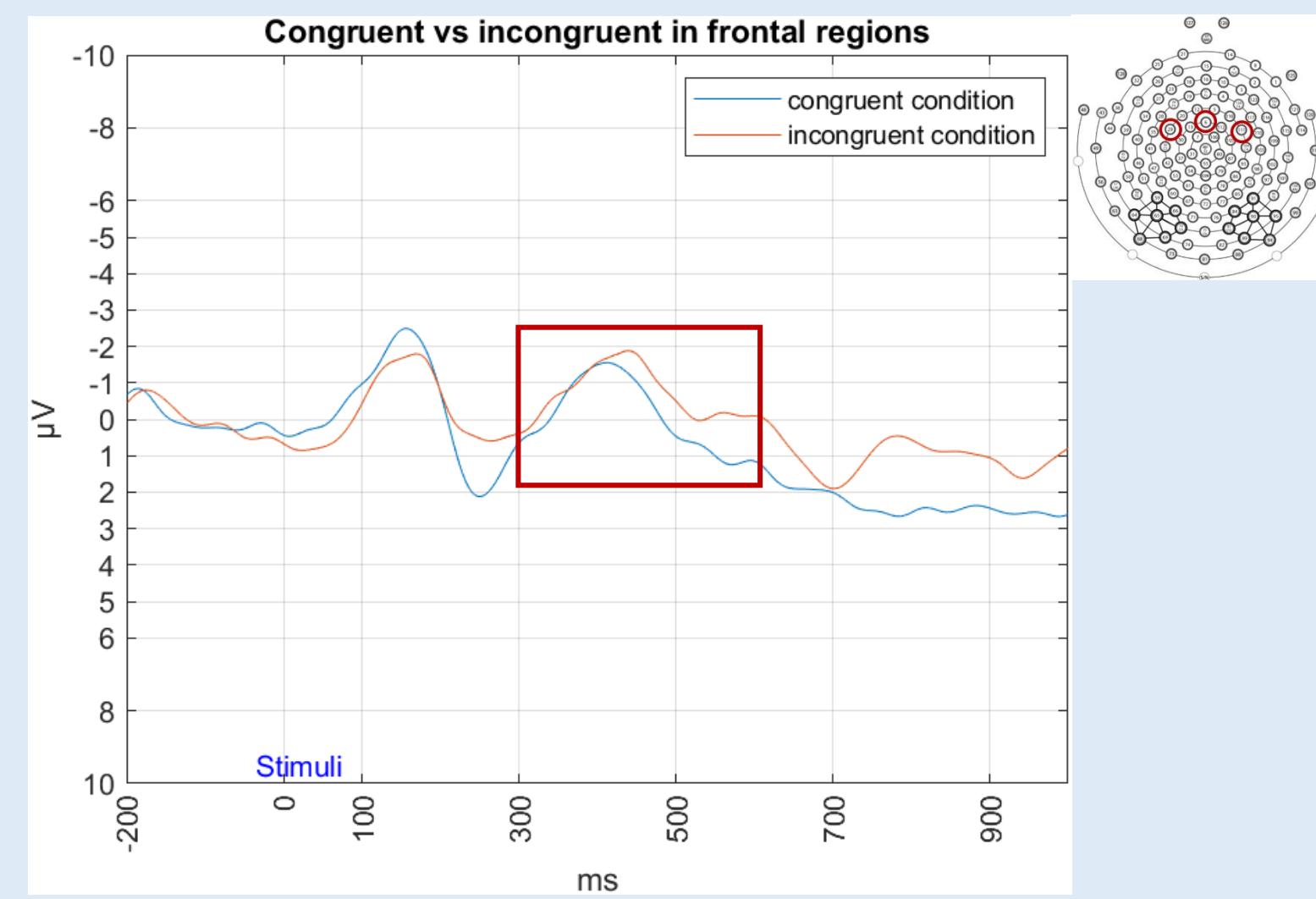
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RESULTS

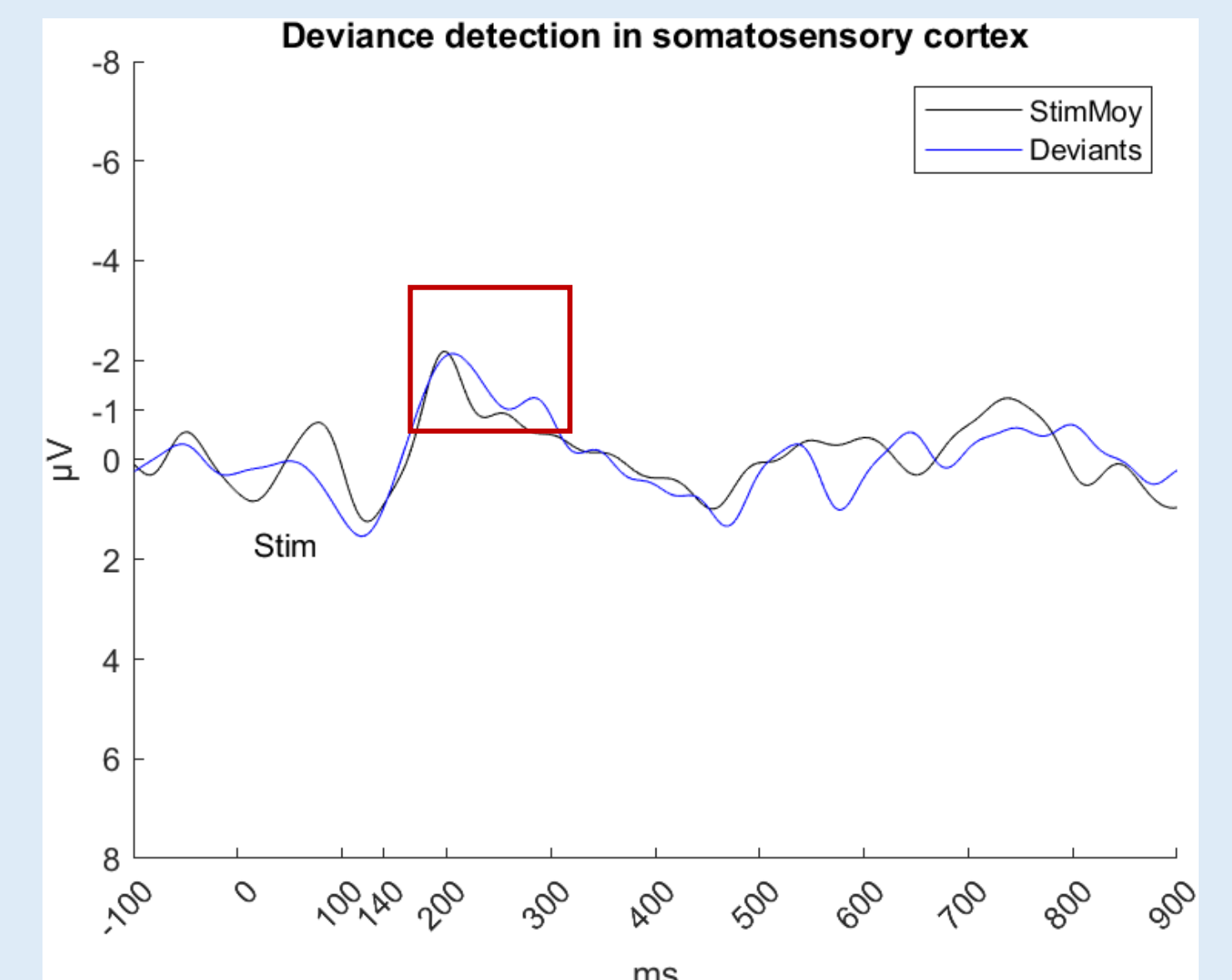
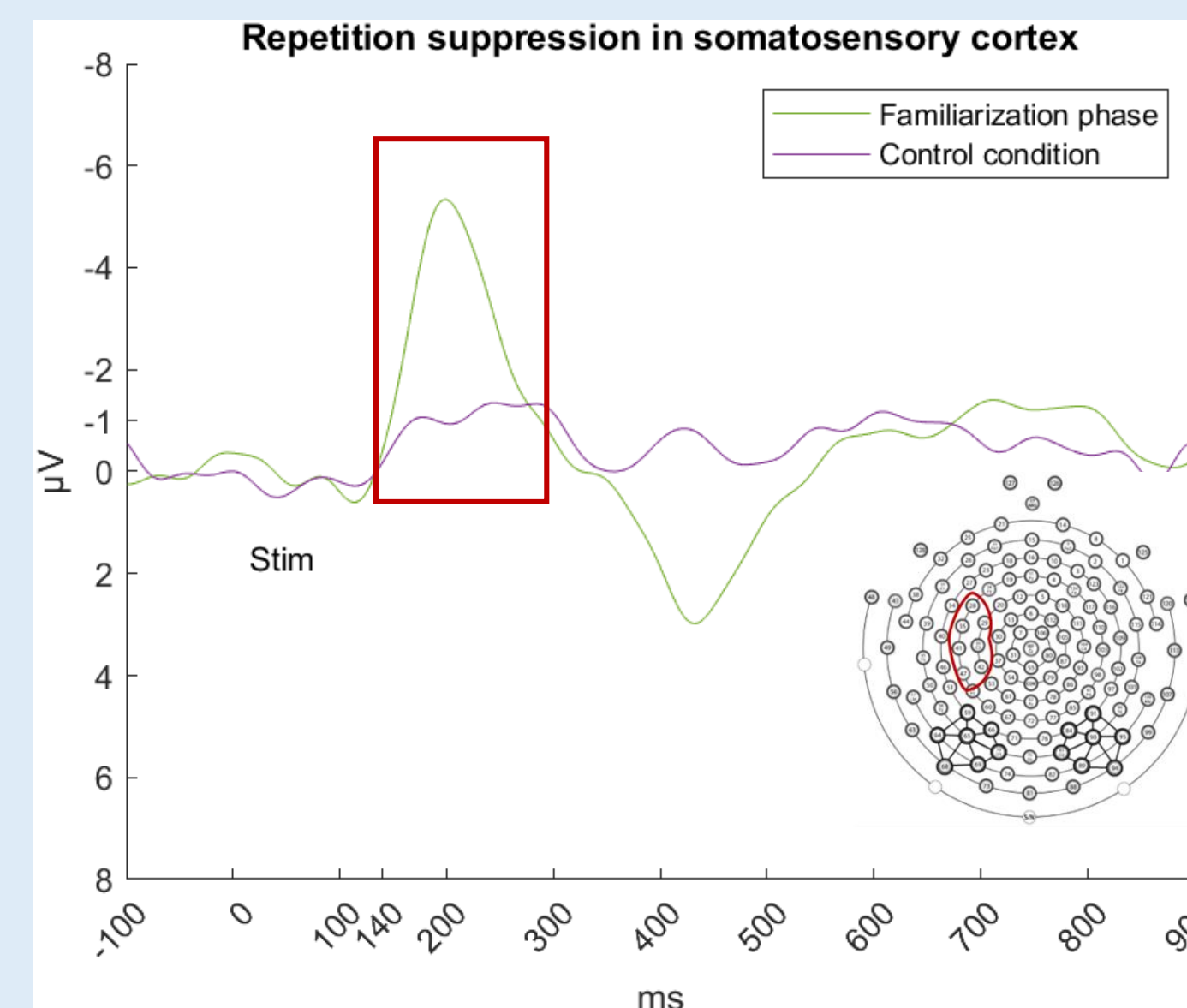
N = 28 (4 children were removed after EEG analysis)
 (11 ♀, 17 ♂; m = 53 months ± 3 months)

- **Frontal activity and behavioral performance at the executive attention task of the Child-ANT (all participants)**



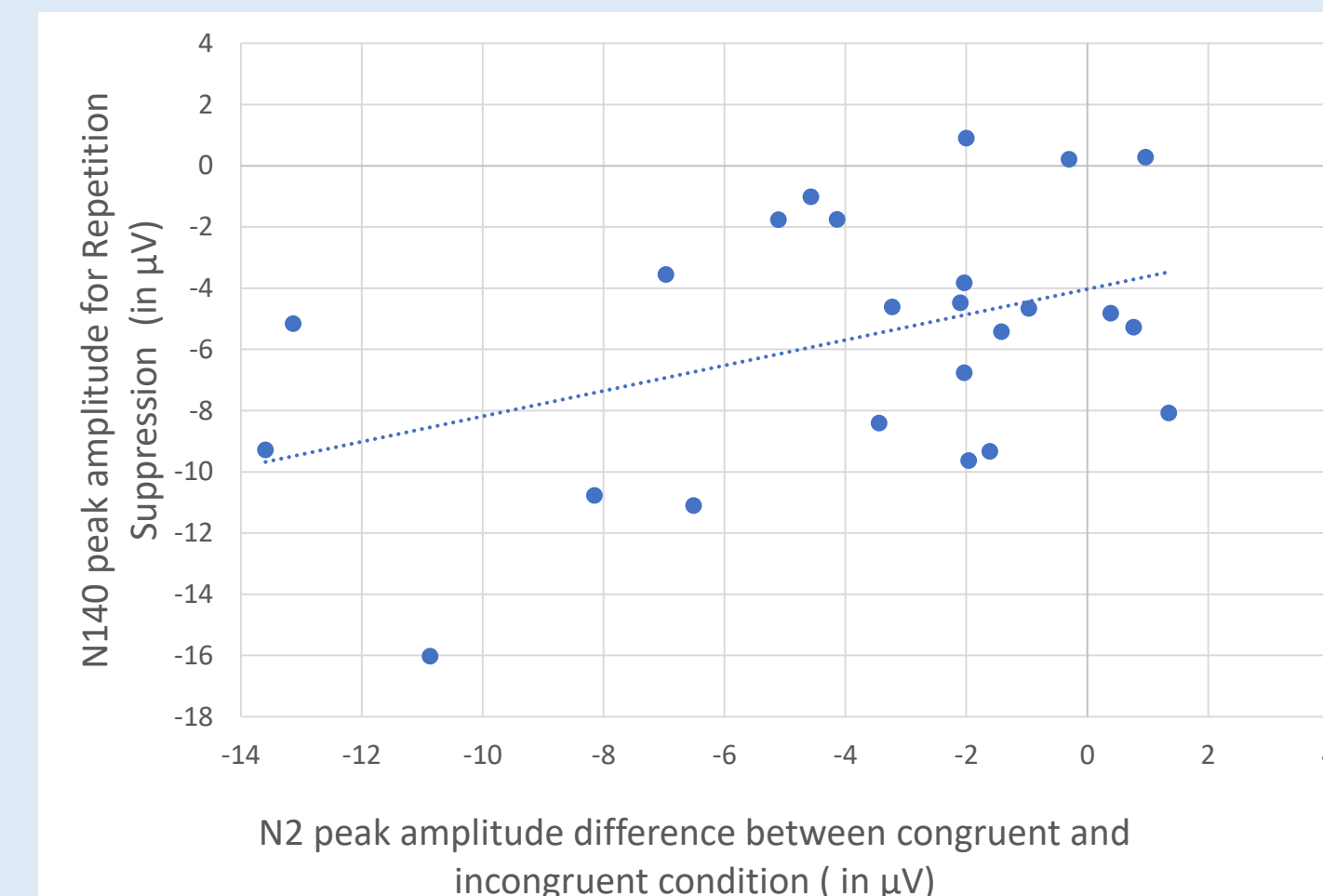
- There is a significant difference between congruent and incongruent conditions in terms of reaction time ($p < 0.001$).
- This difference is also significant for N2 peak amplitude between conditions ($p < 0.001$): children are sensitive to cognitive conflict.

- **Tactile sensory processing (all participants)**



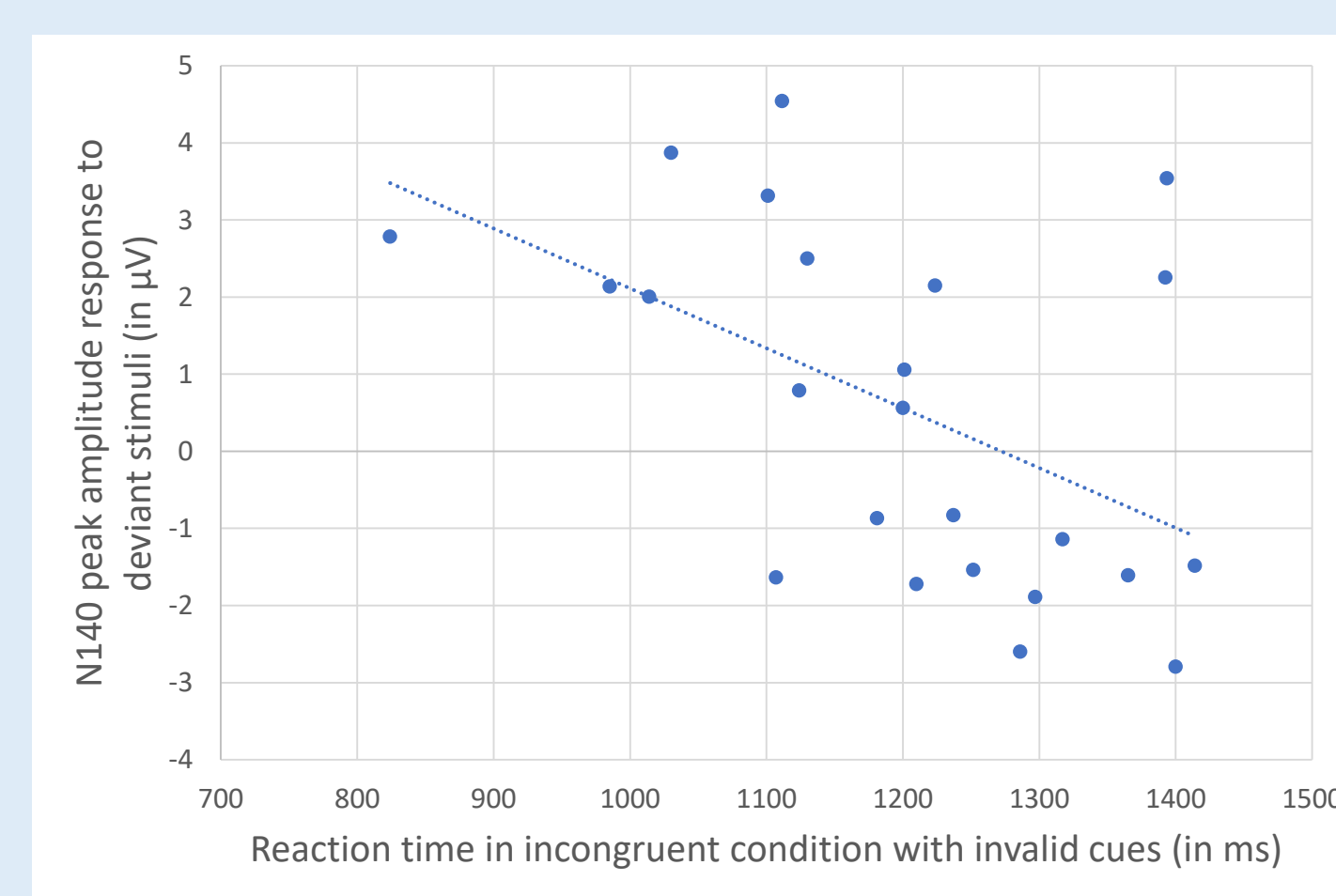
- **Repetition suppression**: the amplitude of SEP at N140 decreases across the sequence. There is a significant difference between familiarization phase and control condition ($p < 0.001$).
- **Deviance detection**: the amplitude of SEP at N140 during deviant stimulations is higher compared to an equal number of standard stimulations ($p < 0.001$).

- **Tactile repetition suppression as a function of executive attention**



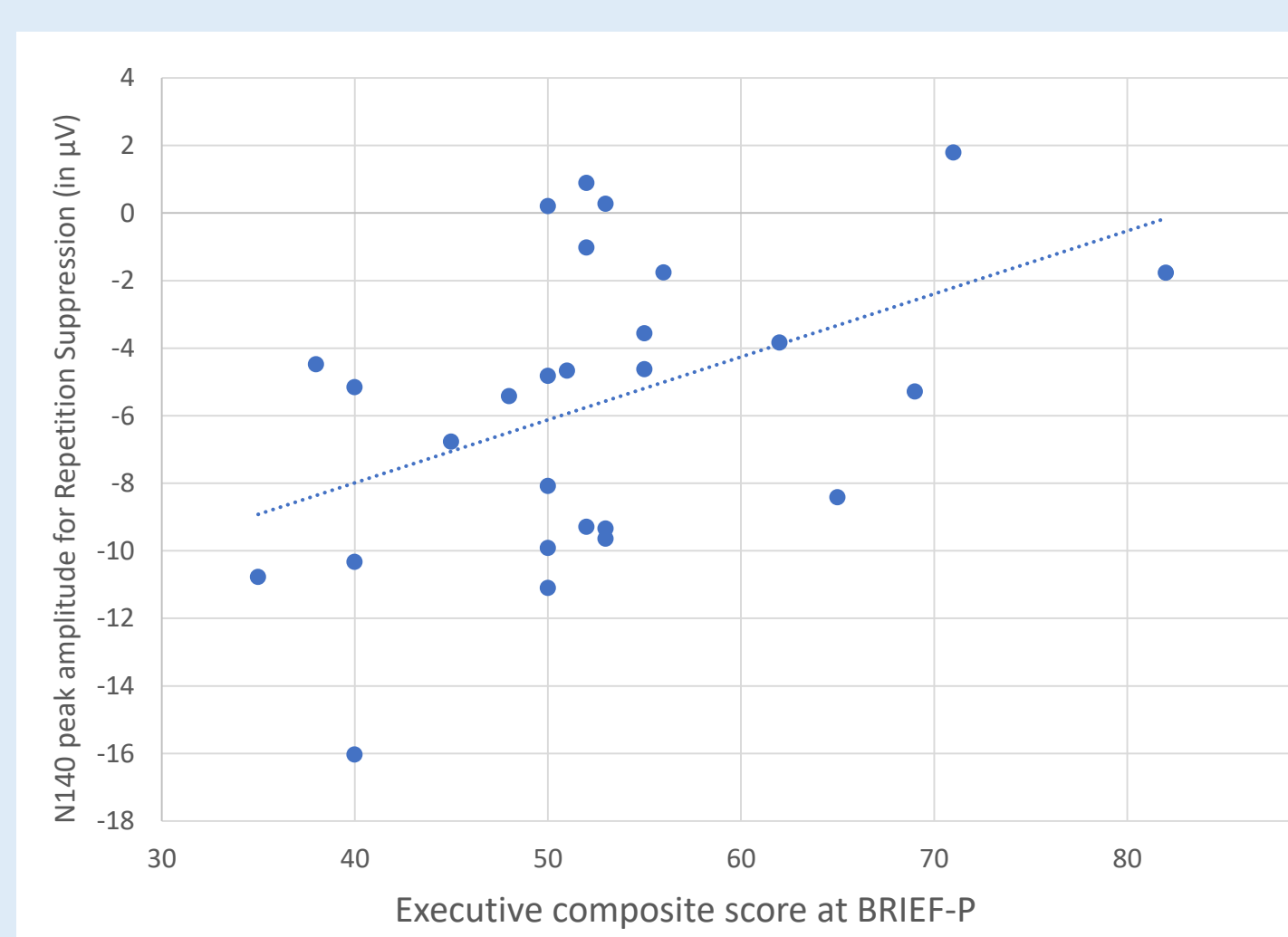
- N140 amplitude for Repetition Suppression during the tactile oddball paradigm decreases with N2 amplitude difference between congruent and incongruent condition at the Child-ANT ($p = 0.041$): the children who do not suppress tactile information during the sequence are not sensitive to cognitive conflict during the Child-ANT task.

- **Tactile deviance detection as a function of executive attention**



- N140 amplitude for deviant stimuli during the tactile oddball paradigm is associated with reaction time in incongruent condition with invalid cues before stimuli at the Child-ANT ($p = 0.011$): the children who strongly respond to deviant stimuli across the sequence need more time to respond to incongruent stimuli preceded by invalid cues.

- **Tactile repetition suppression as a function of executive functions**



- Repetition suppression of the tactile N140 is associated with BRIEF-P executive composite score ($p = 0.019$): children who do not suppress tactile information across the sequence have higher BRIEF-P composite scores, reflecting impaired executive functioning.

CONCLUSION

- We found a relationship between the quality of tactile sensory processing and executive attention at preschool age: brain activity in the tactile oddball paradigm is associated with brain activity at the Child-ANT.
- Our results highlight the importance of tactile sensory processing in early development and also during preschool period when executive attention develops rapidly.
- Such findings could help for early attention disorders diagnosis.