Resting-State EEG Theta/Beta Ratio and Executive Function During Infancy

UCONN

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INTRODUCTION

Co-occurring oscillatory brain rhythms (e.g., theta, alpha, beta) underlie neural computation, communication, and transmission of information between networks (Lopes da Silva, 2013). **Resting-state (or baseline) EEG** provides information about neural oscillations and their intrinsic dynamics when individuals are awake and not involved in active processing.

The **theta/beta power ratio** has been conceptualized to reflect balancing of the brain's cognitive and motivational systems, including bottom-up subcortical excitatory input (*resting-state theta activity*) and top-down regulation and attentional control via cortical inhibitory input (*resting-state beta activity*; Schutter et al., 2017).

- Resting-state frontal theta/beta ratio is inversely related to 3- to 9-year-old children's executive functions (Perone et al., 2018). Children with more beta oscillatory resting-state activity in comparison to theta activity, displayed enhanced cognitive control.

Is the resting-state theta/beta ratio associated with variations in executive function (EF) during infancy?

METHOD

Participants

- 43 eight-month-olds (22 boys; range: 8.0-8.75 months)

Resting-State (Baseline) EEG

- Infants sat on their parent's lap and watched an experimenter manipulate a colorful ball popping toy for 1 min.

Executive Function

- Looking A-not-B Task (Bell & Adams, 1999)
  - Spatial working memory
  - Infants searched for a hidden toy by making an eye movement.

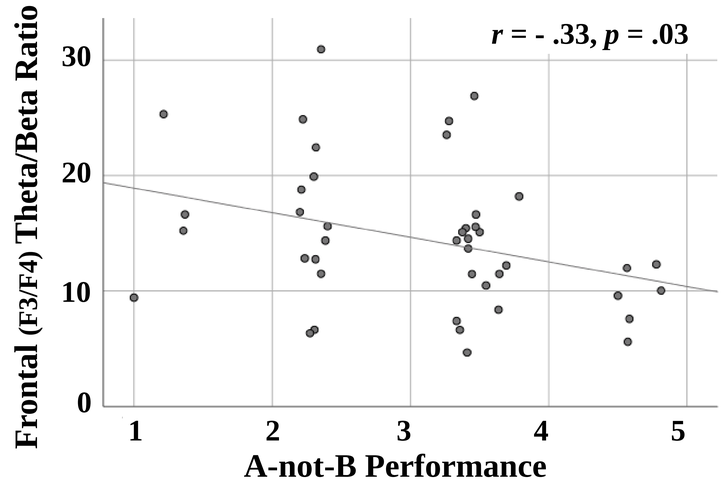
- *Performance* = (Ordinal scale score) + (% Correct).
  - The scale score represented the infant's best performance at that session.
    1-2 = found object partially (*1*) or completely (*2*) hidden at one location
    3-4 = found object hidden at 1 of 2 possible locations with multiple displacements (*4*) or erred when object hidden in opposite location (*3*)

EEG Acquisition & Processing

- Data were analyzed using EEG Analysis System software (James Long Company).
  - We calculated the ratio between theta (2-5 Hz) and beta (10-13 Hz) power at frontal (F3/F4) and posterior (O1/O2) sites.

RESULTS

- **Resting-state frontal theta/beta power ratio was inversely related to 8-month-olds' executive function.**
- Infant EF was not associated with other resting-state measures:
  - Posterior theta/beta ratio
  - Frontal or posterior theta power
  - Frontal or posterior beta power



DISCUSSION

Our findings highlight the importance of considering the interrelations between multiple neural rhythms during early development in general, and the potential value of the frontal theta/beta power ratio.

- In line with anticipated maturational changes in "slower" (theta) versus "faster" (beta) rhythms, infants with more frontal beta oscillatory resting-state activity in comparison to theta activity (lower theta/beta ratio), displayed enhanced spatial working memory.
- Associations between resting-state EEG and EF were specific to frontal theta/beta ratio and did not extend to individual oscillatory rhythms or other scalp regions.

Interactions among neural rhythms are critical for the coordination of cognitive and affective processes (Jensen & Colgin, 2007), but the developmental literature on resting-state theta/beta ratio has primarily focused on ADHD (Clarke et al., 2020).

Future Directions

- *Does the theta/beta power ratio exhibit cross-context stability during infancy?*
- *How does developmental resting-state EEG methodology impact identification of reliable markers of behavioral correlates?*
- *What is the developmental trajectory of the theta/beta ratio? Are individual differences in growth trajectories associated with changes in self-regulation?*
- *Is infant theta/beta ratio associated with future measures of EF or ADHD?*
- *Are other inter-rhythm measures (e.g., delta-beta coupling; Brooker et al., 2016) also informative of early self-regulation; and how do these measures relate?*