Development of Infant Sustained attention and Its Relation to EEG Oscillations: An EEG and Cortical Source Analysis Study

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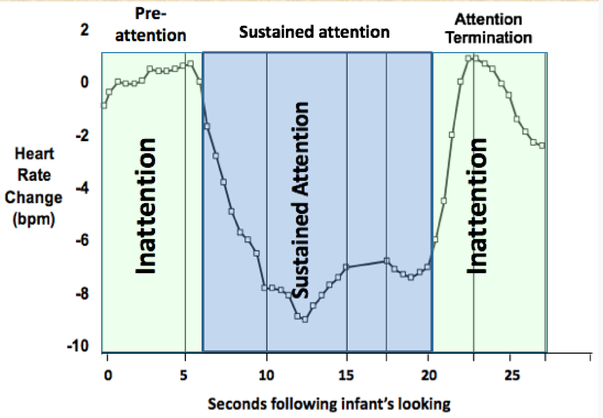
Abstract

- **The current study examined the relation between infant sustained attention and infant EEG oscillations.**
  - We measured infant theta, alpha, and beta rhythmic activation[1,2,3].
  - We used heart rate changes to define different attention phases[4].
  - We investigated the development of the relation between infant attention and EEG oscillations between 6 and 12 months of age.
- We found an increase of the theta power (i.e., theta synchronization) and an attenuation of the alpha power (i.e., alpha desynchronization) during infant sustained attention.
  - The theta effect was shown in 10- and 12-month-old groups.
  - The alpha effect started to emerge at 10 months and became well established at 12 months.
- **The current study also aimed to determine the cortical generators of the infant theta and alpha effects found during sustained attention.**
  - Cortical source analysis was conducted with infant MRI models.
- The theta synchronization effect was localized to the orbital frontal, temporal pole, and ventral temporal areas.
- The alpha desynchronization effect was localized to the brain regions composing the default mode network (DMN) including the posterior cingulate cortex and precuneus, medial prefrontal cortex, and inferior parietal lobe.
- **Conclusion:** The current study established a connection between infant sustained attention and EEG oscillations, and demonstrated how this connection developed from 6 to 12 months of age.

Methods

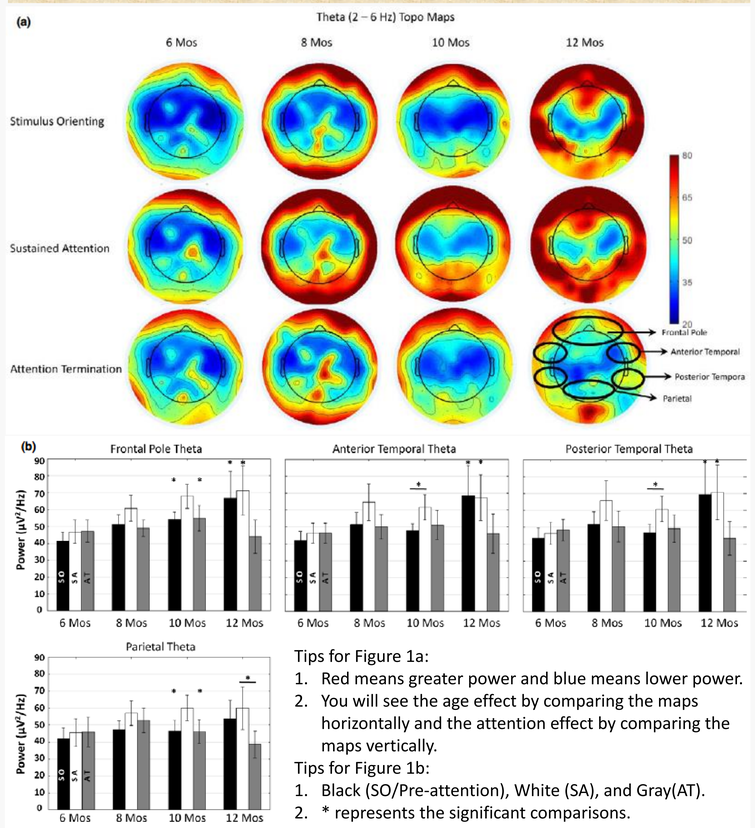
- *Participants*
  - 6 (N=15), 8 (N=17), 10 (N =14), and 12 (N = 13) months of age.
- *Procedures*
  - Infants were watching dancing Sesame Street characters.
  - These characters might dance and sing at one location, move from one location to another on the screen, or disappear as it was moving across the screen.
  - We only used the data collected when the character appeared on the screen.
- *ECG & EEG acquisition and analysis*
  - EGI GSN and HGSN 124 electrodes nets + 2 EOG + 2 ECG
  - The EEG data were segmented into 1s epochs. They were categorized into three attention phases: preattentoin/stimulus orienting, sustained attention, and attention termination based on HR changes
  - Fast Fourier Transform was applied on EEG epochs with 1s-width Hannning window and 50% overlap, and power was calculated for the theta (2 – 6 Hz), alpha (6 – 9 Hz), and beta (9 – 13 Hz) frequency bands.
- *Cortical source analysis*
  - Realistic infant MRIs from the Neurodevelopment MRI Database[5]
  - Fieldtrip toolbox and in-house custom MATLAB scripts.

Infant Heart Rate Model for Sustained Attentoin



Results

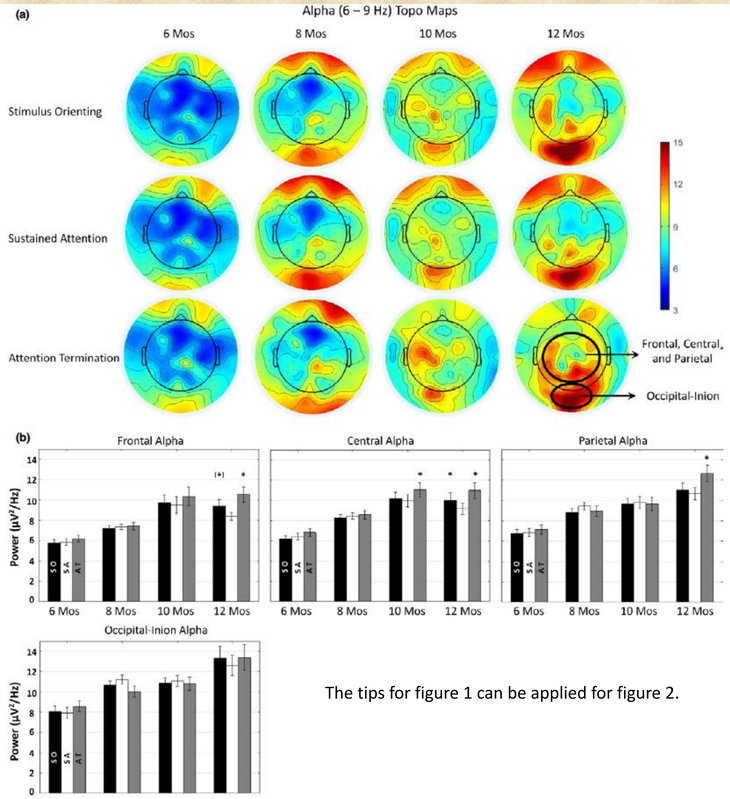
FIGURE 1 | Theta power during different attention phases across ages



Tips for Figure 1a:
1. Red means greater power and blue means lower power.
2. You will see the age effect by comparing the maps horizontally and the attention effect by comparing the maps vertically.

Tips for Figure 1b:
1. Black (SO/Pre-attention), White (SA), and Gray(AT).
2. * represents the significant comparisons.

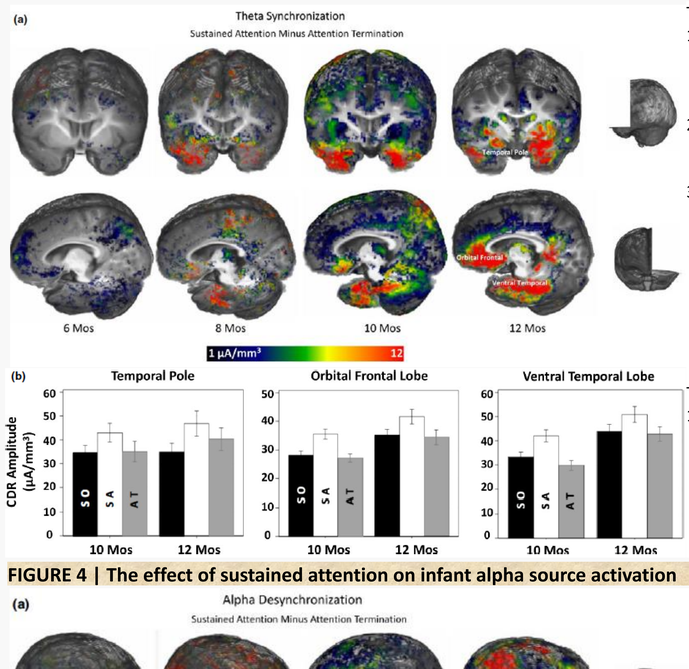
FIGURE 2 | Alpha power during different attention phases across ages



The tips for figure 1 can be applied for figure 2.

Cortical Source Analyses Results

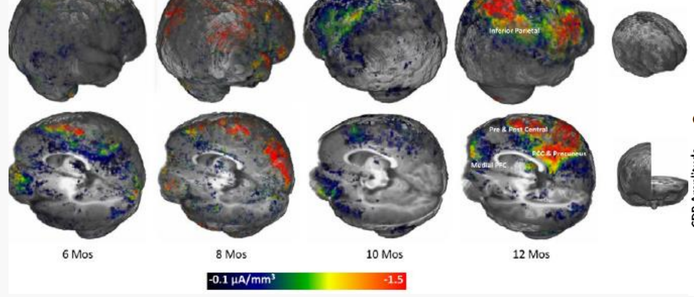
FIGURE 3 | The effect of sustained attention on infant theta source activation



Tips for Figure 3a:
1. "Red" means greater source activity for the theta rhythm during sustained attention than attention termination.
2. The attention effect is clearly shown for 8 and 12 mos.
3. The attention effect is predominately shown in the Orbital frontal, temporal pole, and ventral temporal regions.

Tips for Figure 3b:
1. Black (SO/Pre-attention), White (SA), and Gray(AT).

FIGURE 4 | The effect of sustained attention on infant alpha source activation



Tips for Figure 4a:
1. "Red" means lower/attenuated source activity for the theta rhythm during sustained attention than attention termination.

Functional Connectivity Analyses Results

FIGURE 5A | Functional connections between DMN's components for different attention phases across ages

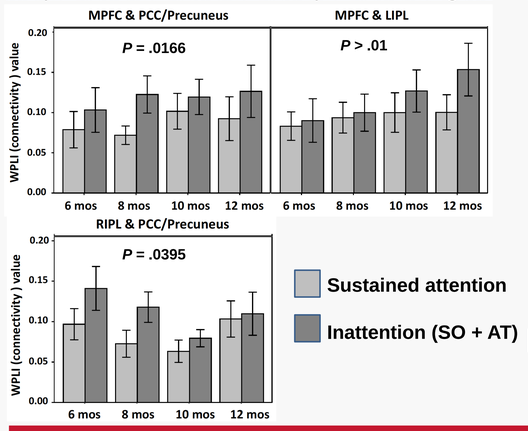
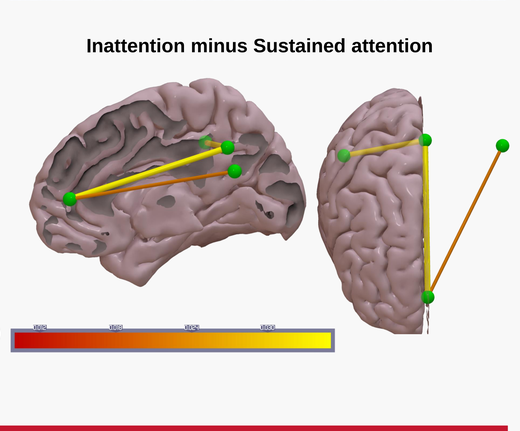


FIGURE 5B | The difference in the functional connections between sustained attention and inattention



References

The reference of the current study: **Xie W, Mallin BM, Richards JE. Development of infant sustained attention and its relation to EEG oscillations: an EEG and cortical source analysis study. Dev Sci 2017: 00; e12562. https://doi.org/10.1111/desc.12562**

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