A New Method for Measuring Infant's Multimodal Experiences: Combining Head-Mounted Eye-tracking and Electroencephalogram (EEG) Techniques

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Background

Eye-tracking and EEG methods are both widely used methods to understand human behaviors.

- While eye-tracking studies have provided precise information on the distribution of everyday attention behaviors [1], little is known about the cognitive significance of these behaviors [2].
- Though EEG studies offer a glimpse into brain activity, the presence of ocular artifacts has limited the interpretability of relevant neural activities [3].
- The combined method allows researchers to obtain a more comprehensive understanding of early attention behaviors and their significance for learning experiences by obtaining increased temporal resolution data.
  - The use of eye-tracking data can provide more precise attention behaviors, such as blinks and gaze shifts, that are associated with brain activity.
  - The use of EEG data can help identify artifacts and noise out of the relevant brain activities.

Unlike previous studies that have used structured tasks [1], the present study observed infants and their parents engaging in free object play, allowing for more naturalistic observation of infant behaviors and a better understanding of the influence of social interaction on early attention behaviors and associated brain activities.

Study Aims & Hypothesis

To explore the feasibility of using a combined eye-tracking and EEG method and ultimately study the comprehensive understanding of infant gaze behavior:

- Describe the procedure and discuss potential benefits of this method to inform future research on the topic.
- Test infants (between the ages of 6 to 12 months) with the newly developed method.

We expect that children's brain waves will differ when focusing their gaze and maintaining attention on people and objects in the play context. Specifically, we expect there will be differences in frontal activities during different types of attention engagement, which will be associated with brain activity. These differences in brain activity may be related to factors such as social interaction, attentional process, and engagement in play.

Method

Participants:

- Subject 1: Female, 6.8 months, typically-developing.
- Subject 2: Male, 10.2 months, typically-developing.

Procedure:

- Parent-infant play with six toys for a six-minute play-session.
- Infant wore a head-mounted eye-tracker and EEG cap together.

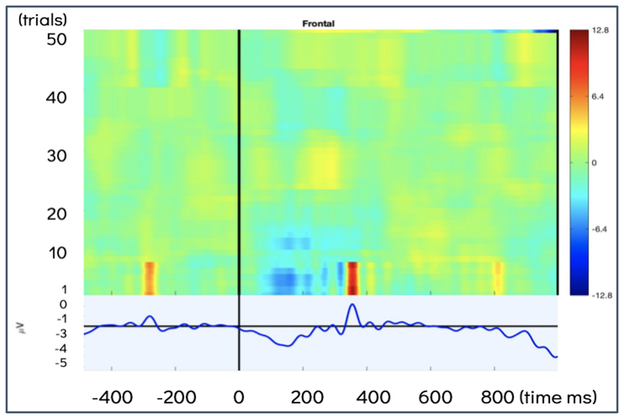
Data Processing:

- Process the parent and child mobile eye-tracking data from the play-session using the Yarbus software.
- Annotated videos frame-by-frame for child attention on **four target regions of interests**: objects, parent's hands, parent's face, child's own hands in the Datavyu software.
- Process the EEG data by using EEGLAB in MATLAB.

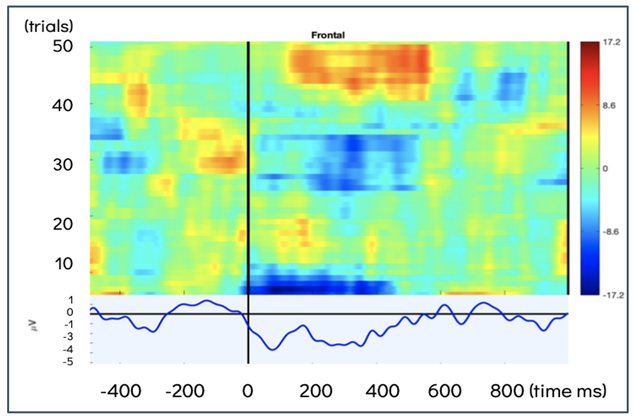
Preliminary Findings

- The present study characterized the spectrum changes in the frontal area (i.e., F3, F4, Fz) given the onset of stable attention on any target region of interest (i.e., ≥1 sec on objects/parent's face/hands/child's own hands).
- Both subjects exhibited negative waves in the amplitude between 0 and 200 seconds after gaze focusing.

Subject 1:



Subject 2:



Discussion

- The present study presents an exploratory methodology development which combines head-mounted eye-tracking and EEG methods inside a semi-naturalistic task context (e.g., parent-infant play in a lab environment). In the current study, we successfully:
  - Captured both eye-tracking and EEG data from infants;
  - Achieved synchronization across the two devices at 90 fps.
- The present study is still in its pilot phase and focuses on characterizing changes in brain activity associated with maintaining meaningful attention. Specifically, we aim to analyze and compare a variety of spectral activities in relation to different types of gaze behaviors in a social context. Future research with larger and more diverse samples may be needed to further validate the method and investigate its potential applications in other areas of infant development. This research has the potential to provide a more comprehensive understanding of the neural significance of early everyday attention experiences.

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