Developmental changes of brain rhythms to naturalistic Social and Non-Social stimuli in infants: an MEG study

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Introduction

During the first two years of life, the infant social brain develops rapidly to prepare for social activity (e.g., joint attention activity, social referencing). To better understand the development of neural network activity to the emerging social behaviors early in life, the present study examined resting-state social brain rhythms in infants and toddlers aged 3-24 months using Magnetoencephalography (MEG). **The goals of the study are to evaluate: (1) resting-state brain rhythms when processing Social versus Non-Social videos; (2) developmental changes of the dominant peak frequency in infants 0-24 months old; (3) associations between social-specific brain rhythms and social behaviors.**

Methods

Subjects: Sixty-one typically developing (TD) infants aged 3 to 24 months (41 males, mean age 277 days ± 165 days).

Task: Participants viewed videos with Social (women singing nursery rhymes) and Non-Social (dynamic toys) content. Each condition lasted 90s, with each video presented a maximum of 2 times, so infants received a total of 3 minutes per condition.

Figure 1. Social and Non-Social resting-state task

Developmental Measures: Social behavior measures were obtained from Vineland Adaptive Behaviors Scale-III (VABS). Cognitive measures are obtained from Mullen Scales of Early Learning–3rd Edition (MSEL) or Bayley Scales of Infant Development–3rd Edition (BSID).

MEG data acquisition and analyses: Resting-state Social and Non-Social MEG data were recorded using an infant MEG system (Artemis 123TM; Fig. 2), designed for children 0 to 42 months old. MEG raw signals were filtered with a 0.3 - 55Hz band pass and a 60Hz notch filter. Subject's heartbeat artifact was removed via independent component analyses (ICA), and data with other artifacts (e.g., movement, environmental noise) were manually removed. MEG data were co-registered to a 1-year-old template. Dynamical Statistical Parametric Mapping (dSPM) estimated resting-state activity while watching Social and Non-Social videos throughout the brain. Average power of delta (1-3Hz), theta (3-6Hz), and and alpha (6-9Hz) were estimated by computing power spectrum density (PSD) on the dSPM maps for Social and Non-Social resting periods, with a 4s window and 50% overlap.

Figure 2. Customized infant MEG system (123-channels gradiometers).

Results

(1) Social and Non-Social resting-state delta, theta, and alpha dSPM maps between younger and older infants

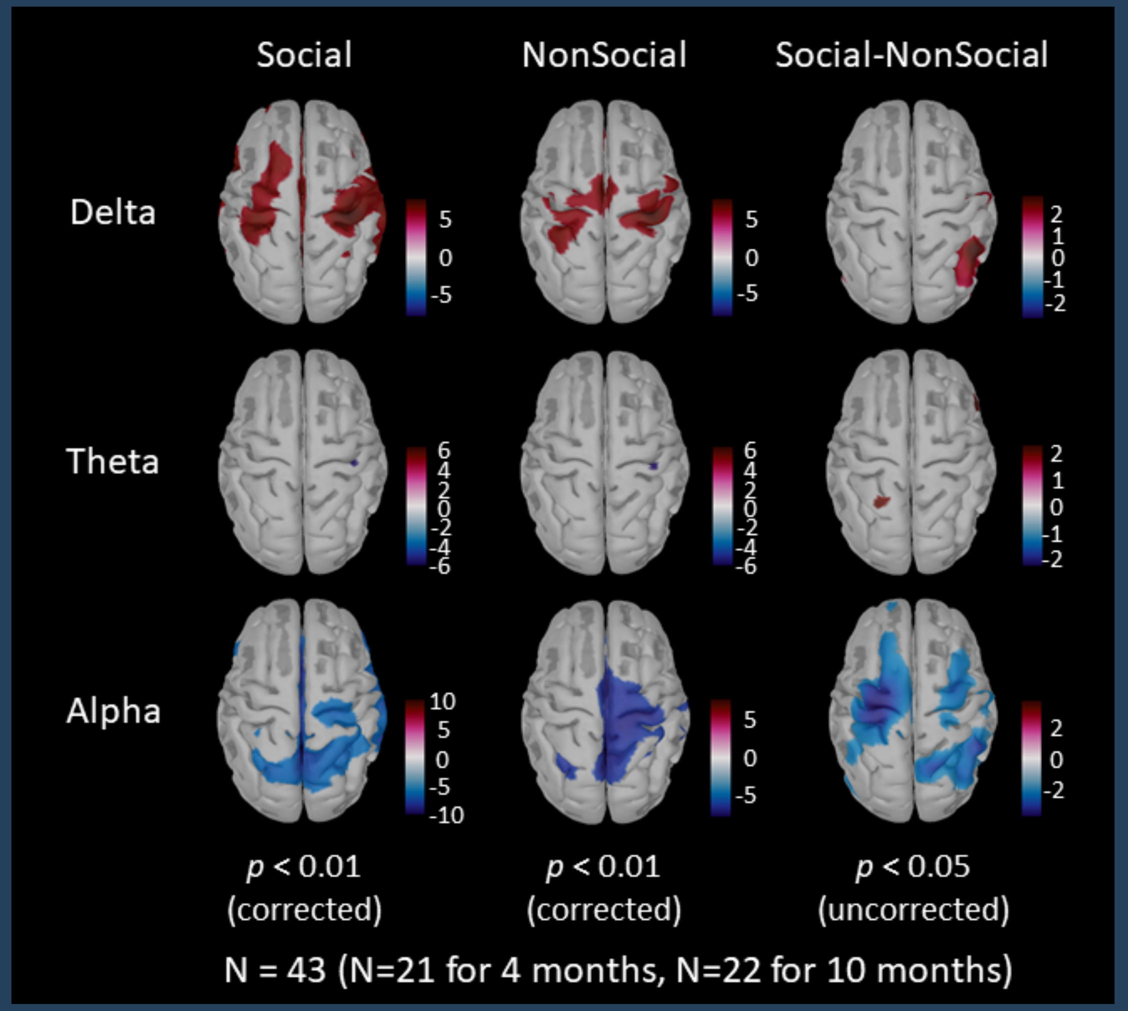
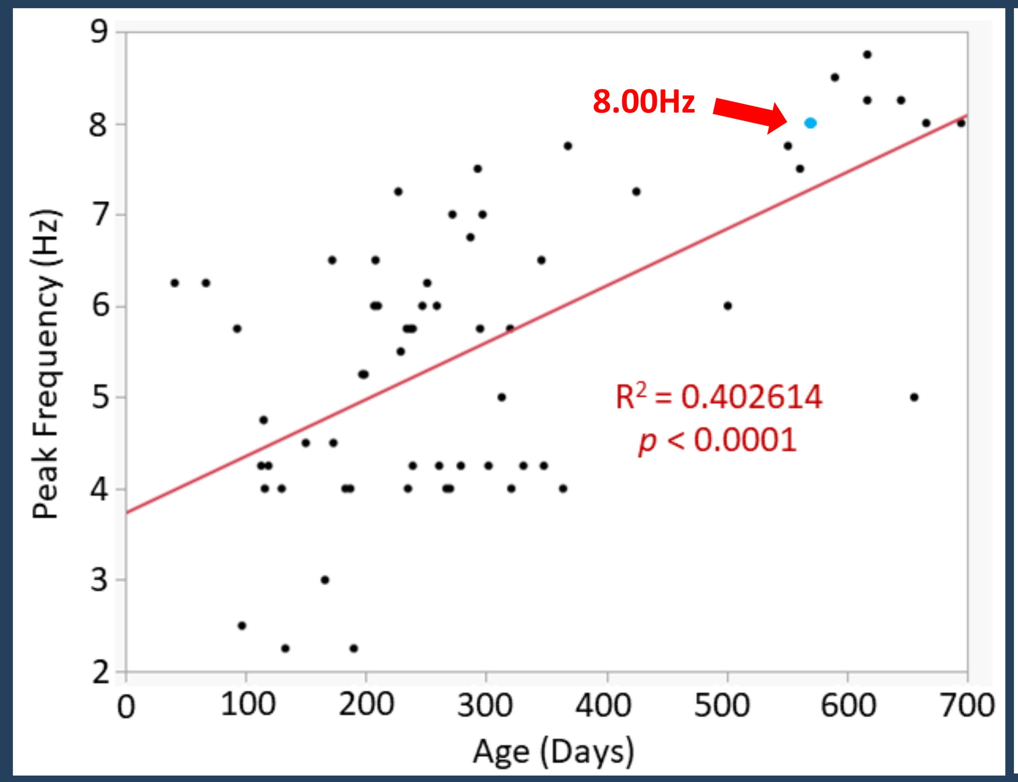


Figure 3. T-test maps comparing Social, Non-Social, and differences of Social – Non-Social between younger (4 months) vs. older (10 months) infants. For both the Social and Non-Social resting period, older infants showed weaker parietal delta and stronger parietal and temporal alpha power than younger infants. T-test of Social – Non-Social contrast maps between younger and older infants showed that compared to younger infants, older infants showed smaller differences in temporal delta and parietal theta power, and larger parietal and temporal alpha activity in the Social vs. Non-Social contrast maps.

(2) Resting-state peak frequency (across entire recording) increased as infants aged

(a) ***Peak Frequency vs. Age***



(b) ***Individual's average power spectrum***

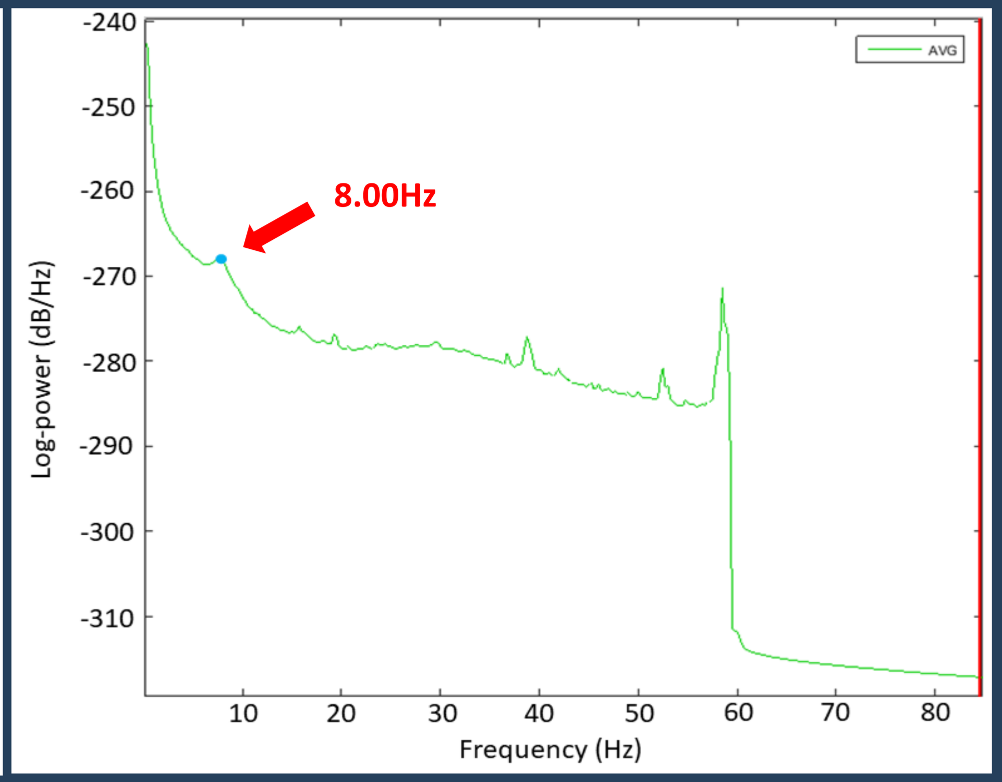
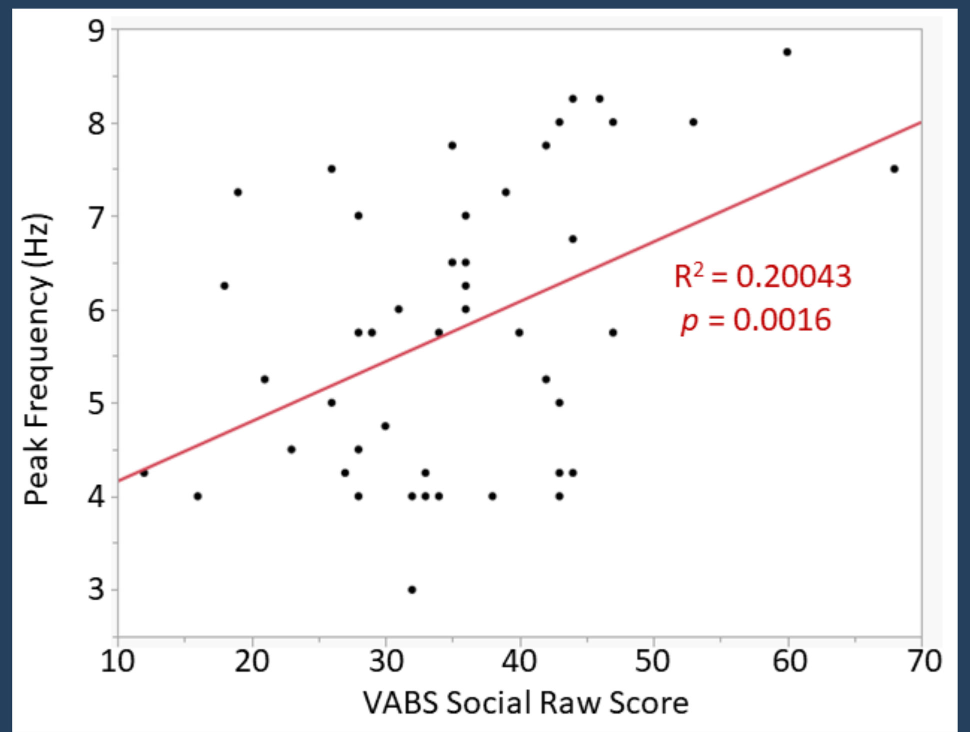


Figure 4. Scatterplots of (a) Associations between resting-state peak frequency and age; (b) Power spectrum across all channels from one representative subject (569 days old).

(3) Higher peak frequency was associated with better social ability and cognitive development

(a) ***Peak Frequency vs. Social Ability***



(b) ***Peak Frequency vs. Cognition***

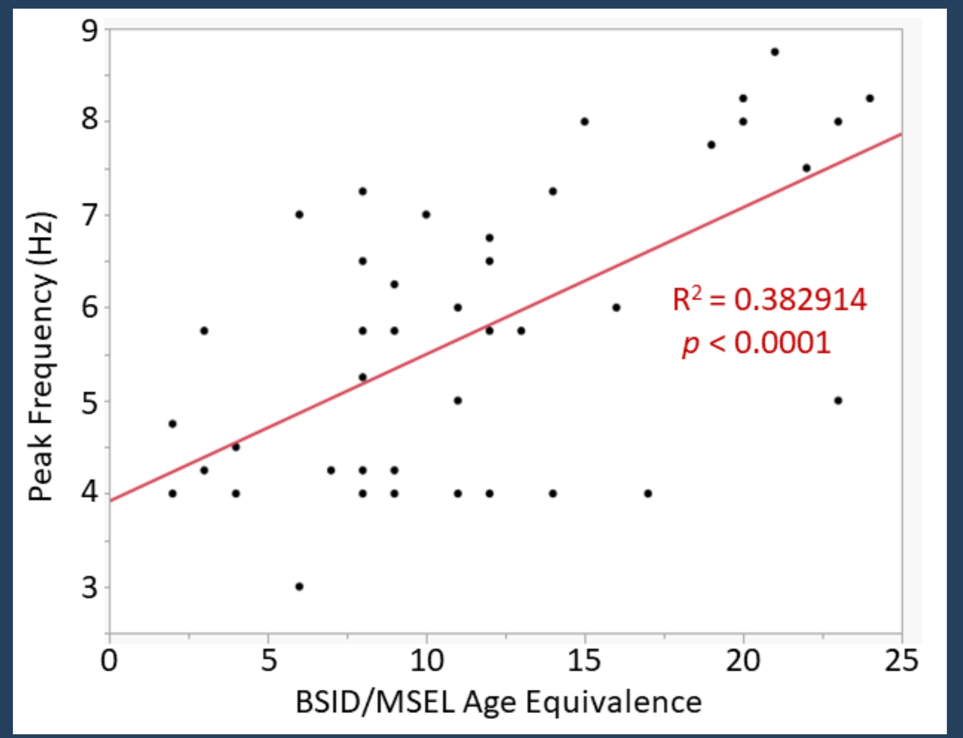


Figure 5. Scatterplots of (a) Associations between resting-state peak frequency and social ability taken from the VABS; (b) Associations between resting-state peak frequency and cognition taken from either the MSEL or BSID

Discussion / Conclusion

- **Across Social and Non-Social resting periods, older infants showed stronger temporo-parietal alpha and weaker parietal delta power than younger infants. Differences in parietal and temporal alpha between Social and Non-Social stimuli became more pronounced and wide spread as a function of age.**
- **Resting-state dominant peak frequency increased as children aged, suggesting that social processing emerges during the first year of life and then continue to mature.**
- **Higher peak frequency is associated with more mature social and cognitive development, demonstrating the possibility of resting-state peak frequency as a potential predictor of socio-cognitive ability in young children.**
- **In our longitudinal cohorts, ongoing analyses will evaluate the maturation trajectories of Social and Non-Social resting-state brain rhythms across 4 years.**

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