6-9 Hz EEG Synchronization during Cognitive Processing at 8 Months and 4 Years

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Introduction

Recent developmental research has revealed that 6-9 Hz synchronization is associated with cognitive processing during infancy. That is, EEG power values are higher during a spatial working memory / inhibitory control task than at baseline (Bell, 2002, 2001). Infants show a similar pattern of increase in EEG power values from baseline to task during sustained attention (Stroganova, Orekhova, & Posikera, 1999) and cortical inhibition tasks (Orekhova, Stroganova, & Posikera, 1999). These increases in EEG power values are evident at frontal as well as posterior scalp locations.

No research to date has examined this specific relation in the early childhood years – a time when many advances are being made in working memory and inhibitory control abilities (Gerstadt, Hong, and Diamond, 1994; Luciana & Nelson, 1998.) 6-9 Hz remains a prominent frequency band in 4-year-old children (Marshall & Fox, 2002).

Of interest to the current study was whether the 6-9 Hz synchronization pattern would be associated with cognitive processing during early childhood as well. If so, would this increase be evident at all scalp locations, as during infancy, or specific to frontal locations, as suggested by recent fMRI work with 7 year olds during a working memory / inhibitory control task (Casey et al, 1997).

Participants


Infants --- There were 50 healthy, full-term 8-month-old infants born to parents with at least a high school education; 68% had college educations. Parents had placed birth announcements in local newspapers.

Children --- By age 4 there were 27 of these same children living in the local area. 25 parents agreed to participate in a follow up study of cognitive development. Children were tested at age 4½, just prior to entering kindergarten.

Methods


EEG --- At each age, recordings were made from 16 scalp locations (referenced to Cz) during baseline and cognitive task. Data were later transformed to average reference.

Working Memory / inhibitory Control tasks --- At each age, participants were assessed on a developmentally appropriate task associated with frontal lobe functioning. Each task required the participant to hold information in memory and inhibit a naturally occurring response.

Infants: looking A-not-B task (Bell & Adams, 1999), where a toy is hidden in one of two locations. Complete EEG and behavioral data were available for 43 infants.

Children: day/night Stroop-like task (Gerstadt et al, 1994) and the yes/no task, created in our lab. Complete EEG and behavioral data were available for 20 children.

EEG Power Results

Infants --- *Figure 1*. Multivariate analyses revealed a Condition (base vs. task) by Region interaction (Wilks'=.479, F(7,36)=5.59, p<.001). Follow-up analyses at each region (i.e., using homologous pairs) revealed a main effect for Condition at every region except central (C3,C4). Thus, power increased from baseline to task at frontal and posterior regions.

Children --- *Figure 2*. Multivariate analyses revealed a Condition by Region interaction (Wilks'=.163, F(7,13)=9.52, p<.001). Follow up analyses at each region revealed a main effect for Condition only at medial frontal (F3,F4). Thus, power increases were specific to this frontal scalp location.

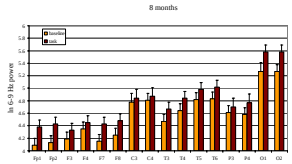

Figure 1

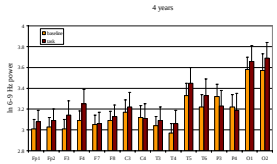

Figure 2

EEG Coherence Results

Infants --- *Figure 3*. Multivariate analyses revealed a Condition (base vs. task) by Pair interaction (Wilks'=.780, F(7,40)=3.76, p=.018). Follow-up analyses of each electrode pair (i.e., using Fp1/F3, F3/F7, F3/P3, F3/O1 and homologous right hemi pairs) revealed a main effect for Condition at Frontal Pole/Medial Frontal and Medial Frontal/Lateral Frontal pairs. Thus, coherence decreased from baseline to task at frontal coherence pairs.

Children --- *Figure 4*. Multivariate analyses revealed no Condition by Pair interaction (p=.14).

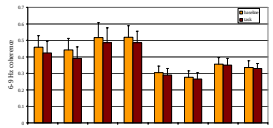

Figure 3

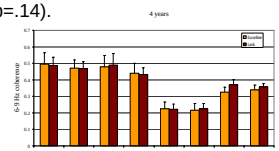

Figure 4

Conclusions

These EEG power data suggest that brain electrical activity is diffuse during infant cognitive processing and that it becomes more localized during early childhood. The EEG coherence data, however, suggest that a pattern of frontal-to-frontal coherence communications may underlie the diffuse infant power patterns. These findings may yield insight into qualitative changes in cortical functioning from the infant to the early childhood time periods, adjustments that may be indicative of developmental changes in brain specialization.

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