Realistic Head Models for Cortical Source Analysis in Infant Participants

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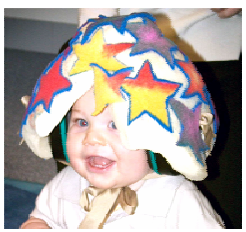
Background

Cortical source analysis can identify cortical areas that are active during infant cognitive processing. This analysis uses high-density EEG recording and quantitative models that identify dipole sources inside the head to account for the EEG data. These sources can be related to the EEG activity in the time domain, to the experimental procedures, and to the cognitive processes occurring during the task. Cortical source analysis with infant participants has used adult models for the electrical and spatial characteristics of the head. The current poster will overview a method for using infant MRIs to develop realistic head models for infant participants for cortical source analysis.

Infant Anatomical MRI

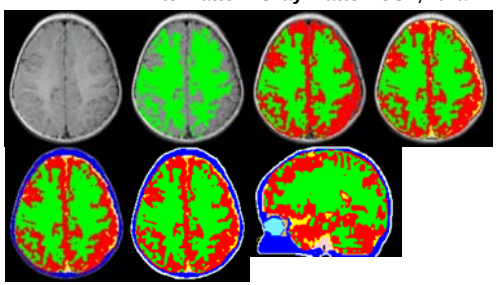
Infant anatomical MRI must be obtained. This could come from a database of infant MRIs, e.g., NIH MRI study of normal brain development, 1.5 T T1W – PD/T2W, 0, 3, 6, 9, 12, Evans 2006. Use a single MRI selected on basis of age and head size, or use normalized MRI for age. OR, do MRI of individual infant participant (e.g., 3.0T of normal, unsedate infants; Gilmore, 2004; Richards, proposed; Paterson et al, ISIS 2004).



Head Media Segmentation

The head must be segmented into its constituent parts, including scalp, skull, CSF, gray matter, white matter, eyes, muscle, nasal cavity, dura…

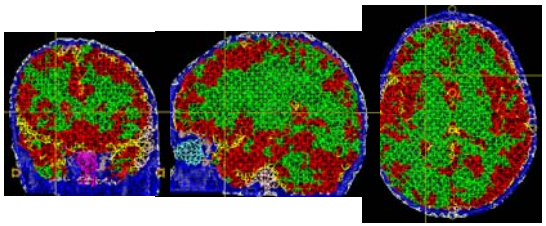
MRI White Matter Gray Matter CSF,Dura



Skull Scalp Saggital View

Semented "Wireframe" File

The segmented MRI is made into a 3-D "wireframe". The wireframe has tetrahedral elements, each which has four vertices (corners) and an associated media type (skull, scalp, etc). The wireframe may be stored as a series of numbers for use with topographical and cortical source model programs. The conductivity of each tissue type may be incorporated into the wireframe or stored separately for different ages.

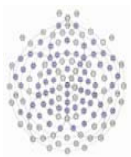


Number of electrodes

64 Channel EEG

128 Channel EEG

Layout of EEG Caps & Sensor Nets



1—an electrode placement map may be generated for the MRI. This identifies the location of the electrodes on the recorded MRI. If the individual with the MRI also participates in the experiment, this electrode placement map is used.

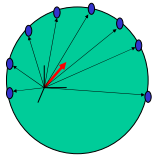
2—If a generic or selected MRI from another individual isused, the electrode placement map from the MRI is "warped" to the head size parameters of the infant in the experiment. The warped placement map is used for the participant's ERP analysis.

3--The locations may be translated into coordinates in the Talairach (Talairach & Tournoux, 1988) coordinate system.

Cortical Source Analysis

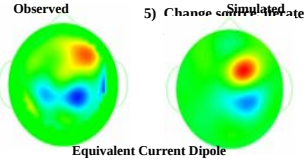
Cortical source analysis ("Brain electrical source analysis"; equivalent current dipole (ECD) analysis) is used to identify putative electrical source inside the head of electrical activity occurring on the scalp. Dipole source analysis hypothesizes a (a set of) dipole (s) that generates an electrical current on the scalp. This forward solution may be compared with the scalp EEG map, and the dipole location and magnitude is modified to minimize the difference between the generated map and the scalp electrical map.

Equivalent Current Dipole Analysis



1) Current flow on scalp (EEG / ERP)
2) Hypothesize cortical source
3) Calculate forward solution
4) Compare against scalp current
5) Change source (iterate 3)

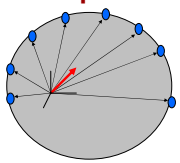
Observed Simulated



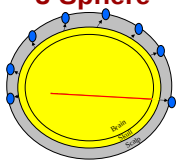
Equivalent Current Dipole

Sphere Models for Location and Conductivity

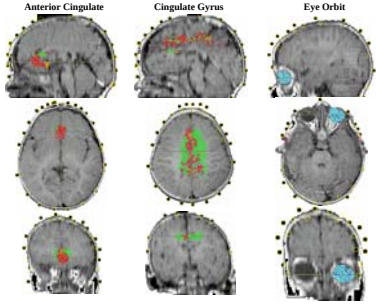
1-Sphere



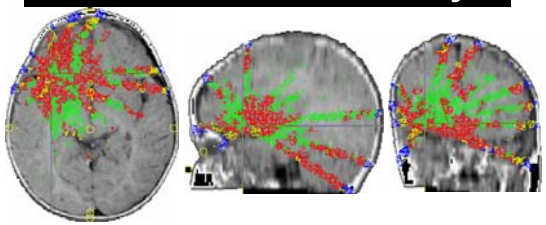
3-Sphere



Realistic Locations (e.g., Talairach Space)

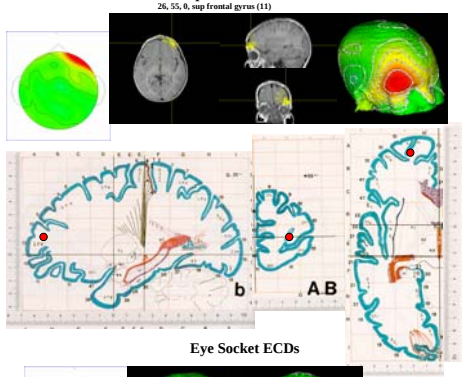


Realistic Current Pathways

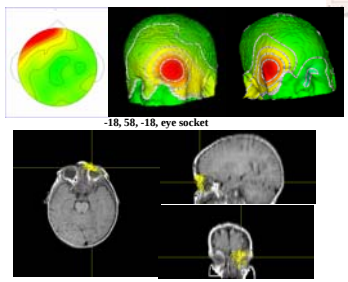


Richards, 2005 (3-Shell)

Lateral Frontal Component and Talairach Location



Eye Socket ECDs



Activations for Presaccade and Saccade