Cortical Sources of ERP during Procaccade and Antisaccade Eye Movements with Realistic Source Models

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Abstract

The cortical sources of event-related-potentials (ERP) using realistic source models were examined in a prosaccade and antisaccade procedure. College-age participants were presented with a preparatory interval and a target that indicated the direction of the eye movement that was to be made. In some blocks a cue was given in the peripheral location where the target was to be presented and in other blocks no cue was given. In Experiment 1 the prosaccade and antisaccade trials were presented randomly within a block; in Experiment 2 procedures were compared in which either prosaccade and antisaccade trials were mixed in the same block, or trials were presented in separate blocks with only one type of eye movement. There was a central negative slow wave occurring prior to the target, a slow positive wave over the parietal scalp prior to the saccade, and a parietal spike potential immediately prior to saccade onset. Cortical source analysis of these ERP components showed a common set of sources in the ventral anterior cingulate and orbital frontal gyrus for the presaccadic positive slow wave and the spike potential. In Experiment 2 the same cued- and non-cued blocks were used, but prosaccade and antisaccade trials were presented in separate blocks. This resulted in a smaller difference in reaction time between prosaccade and antisaccade trials. Unlike the first experiment, the central negative slow wave was larger on antisaccade than on prosaccade trials, and this effect on the ERP component had its cortical source primarily in the parietal and mid-central cortical areas contralateral to the direction of the eye movement. These results suggest that blocked prosaccade and antisaccade trials results in preparatory or set effects that decreases reaction time, eliminates some cueing effects, and is based on contralateral parietal-central brain areas.

Participants

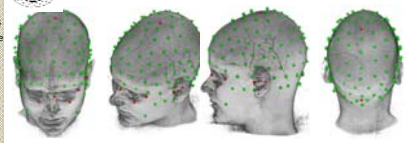
- Experiment 1: 19 young adults (20 to 41, mean age 25 years)
- Experiment 2: 11 young adults (19 to 34, mean=25 years)
- All participants had 3.0T structural MRI (3D, T1-weighted, 1.0 mm slices, 256 x 159 x 256 FoV
- Electrode placement maps for the EGI GSN 128-Channel SensorNet; placed individualized fiducial points on 3-D rendered scalp from MRI; did Coherent-Point-Drift coregistration of indivdual fiducials and average electrode placement map.
- Segmenting of structural MRI, including GM, WM, CSF, bone (skull), scalp, eyes, muscles, nasal cavity
- Individual stereotaxic atlases, based on "Hammers", LONI Probablilistic Brain Atlas, Harvard-Oxford, and lobar atlases; defined ROIs theoretically important for eye movement control
- 3D "Finite Element Model" wireframes derived from segmented structural MRI; EMSE computer program to do inverse model for sLORETA

Questions

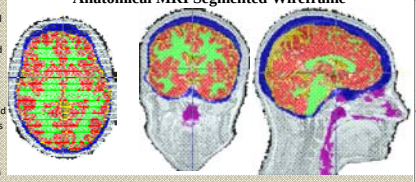
- What are the presaccadic ERP components occurring for prosaccade and antisaccade eye movements? What are the cortical sources of these components?
- What are the effects of "blocked" trials, compared with "mixed-choice" trials, on the ERP / cortical sources for these eye movements?
- How can ROI-based, realistic FEM head models, be used to assess cortical sources of eye movement control?

Methods

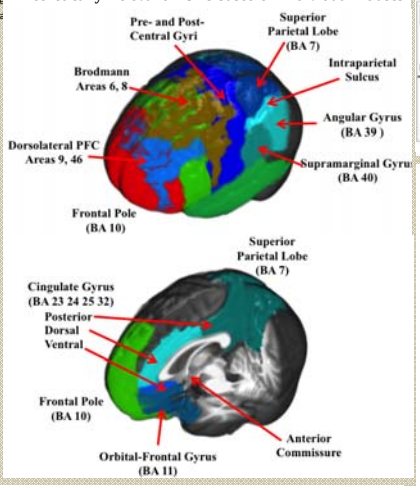
Individual Electrode Placement Map
EGI GSN-128 SensorNet



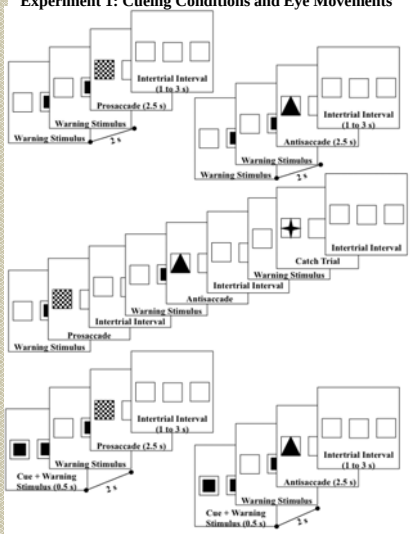
Anatomical MRI Segmented Wireframe



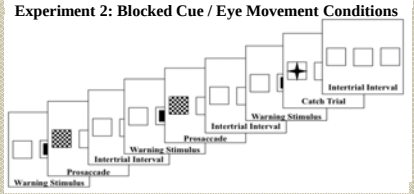
Theoretically Relevant ROI's based on Individual Atlases



Experiment 1: Cueing Conditions and Eye Movements

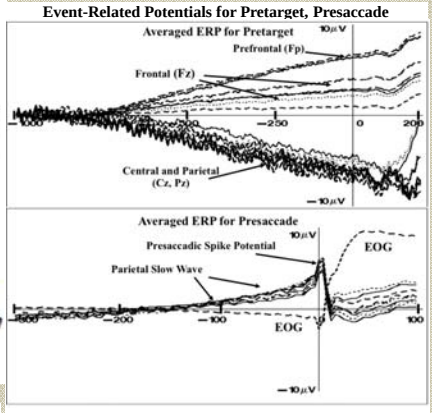


Experiment 2: Blocked Cue / Eye Movement Conditions

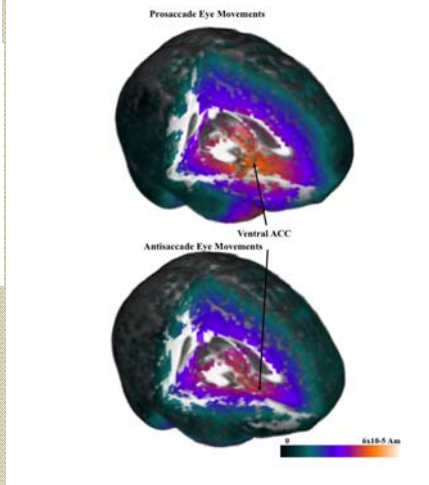


Results

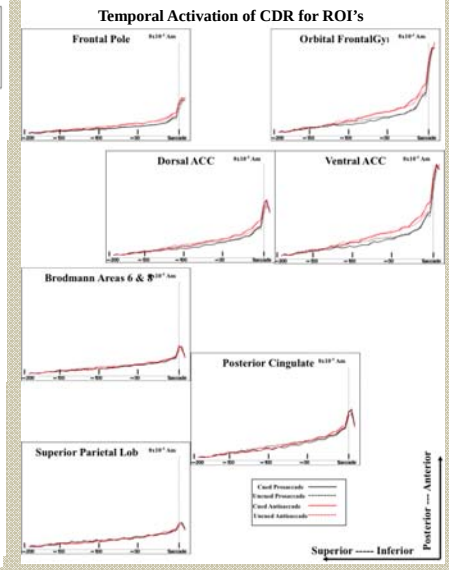
Event-Related Potentials for Pretarget, Presaccade



Current Density Reconstruction for Presaccadic SP

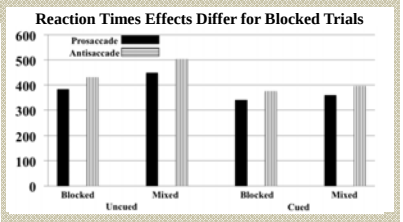


Temporal Activation of CDR for ROI's

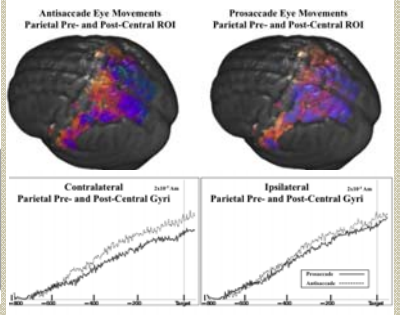


Results

Reaction Times Effects Differ for Blocked Trials



Lateralized Brain Activity for Blocked Trials
Antisaccade EM > Prosaccade EM



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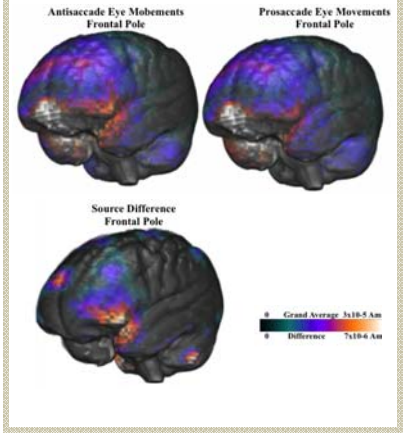

Discussion

- The presaccadic spike potential was localized to the orbitofrontal gryus and ventral anterior cingulate cortex. It was larger for cued eye movements. The presaccadic parietal slow wave was larger for antisaccade than for prosaccade eye movements
- Blocked trial presentations reduced the effect of cueing on the RT; i.e., seems to be a response set
- Negative slow wave is larger on blocked trials for antisaccade eye movements, and this effect is lateralized in parietal and central areas contralateral to the eye movement
- On blocked trials, there were larger cortical activity contralateral to the eye movement, preceding the the eye movement, in areas around the lateral frontal pole
- Many of the prosaccade / antisaccade eye movement brain activity found in prior studies, especially fMRI, is due to blocked trials presentations. The ERP evidence suggest there is a response set for blocked antisaccade trials (reduced cueing effects; enhancement of spatial orienting system contralateral to eye movements