10th Annual Meeting of the Organization for Human Brain Mapping

Abstract Number: 2271.471001 Submitted By: Karim N'Diaye
Last Modified: 15 Jan 04

Brain activity in duration discrimination: Topography and dynamics of its EEG and MEG correlates

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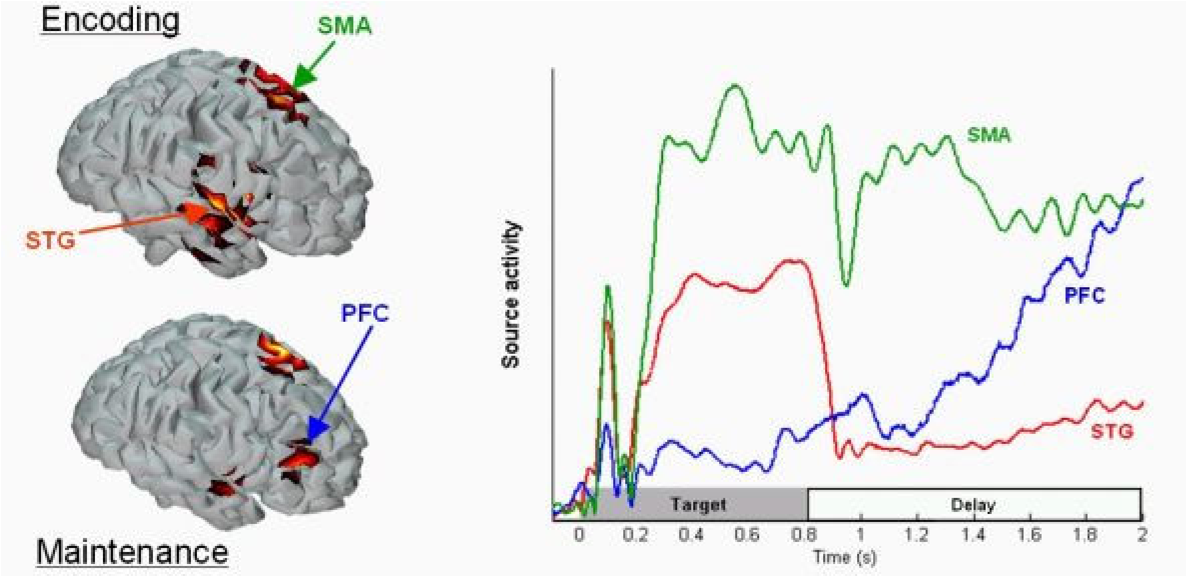
Introduction: Despite the growing number of studies using fMRI or EEG, the functional mechanisms and neural bases for time perception are relatively unknown. On one hand, most fMRI studies show a common network of distributed cortical areas devoted to time perception, but the role of each structure in the involved processes remains to be specified. On the other hand, electrical scalp recordings have identified components of cerebral activity related to various stages of time processing, but the neuroanatomy of their generators is largely undetermined. The present experiment is aimed at filling this gap by using the high spatiotemporal resolution of EEG-MEG source reconstruction to determine the neural substrates of human timing.

Methods: EEG alone and simultaneous EEG and whole head MEG were recorded from young adult human subjects performing a duration discrimination task. Stimuli used were two intervals marked by a pair of brief (20ms) tones. Subjects had to compare two intervals of this type to judge whether the second interval lasted longer or shorter than the first one, giving their answer with a button press. The first "target" interval was kept constant within each block, while the second "test" interval was pseudo-randomly chosen amongst longer and shorter durations according to a pre-programmed sequence. A first group of subjects was presented with two different target durations (either 600 or 800ms). Target durations were chosen consequently (respectively between 450 and 800ms, and between 600 and 1000ms). To assess the role of sensory processing in evoked scalp activity, these subjects also performed the same task using filled intervals, i.e. durations marked by a continuous tone instead of a pair of short beeps. A second group of subjects also performed a pitch discrimination task aimed at controlling for attentional and memory components. EEG and MEG data were analyzed with minimum-norm based source reconstruction using segmented individual MRI of the participants (when available) with the BrainStorm Toolbox.

Results & discussion: ERP analyses from the EEG data are presented in a companion poster. Within auditory cortex, short tones defining empty intervals trigger transient activity, while filled intervals lead to sustained activity returning close to baseline level only after the sound's offset. Sources activity within SMA region slowly increases during the encoding phase (as the duration is presented), persists during the delay period and finally resolves at then end of the comparison. This suggests SMA involvement at all stages of the duration discrimination. Sources within left and right prefrontal cortices show similar increasing activity during the maintenance but their respective time course differentiate during the comparison. Left frontal activity resolves even before the end of the test interval, whereas right-sided activity increases until the time of the decision. Left frontal activity would underlie retrieval of the target interval as right frontal activity would reflect attention towards the test duration. Additional subjects simultaneously recorded in EEG and MEG are currently being included. Preliminary analyses show consistent results with the one described above.



Source reconstruction of brain activity in duration discrimination of filled 0.8s-long intervals. Active regions are shown on a 3D-template brain during the encoding of the target duration (top) and during the maintenance throughout the delay (bottom) of this target duration. Colored arrows point at three regions of interest. Time course of activity in these regions is plotted on the graph on the right using the same color code: Supplementary Motor Area (SMA) in green, Superior Temporal Gyrus (STG) in red and Prefrontal Cortex (PFC) in blue.