Pre-Surgical Mapping for Brain Tumor Patients Using Magnetoencephalography (MEG)

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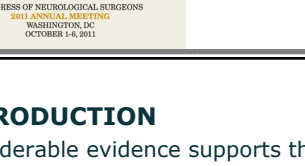
INTRODUCTION

Considerable evidence supports that magnetoencephalography (MEG) can be a valuable noninvasive tool for presurgical mapping eloquent brain areas. In this study we present the UPMC Brain Mapping Center's initial experiences with presurgical brain mapping using MEG.

METHODS

Between September 2010 and August 2011, twenty patients with brain pathologies underwent presurgical mapping using MEG (17 tumors, 1 arteriovenous malformation, 2 epilepsy). Sensory (median nerve stimulation), motor (index finger lift or hand curl), aurally-presented language, and visually-presented language paradigms were used for almost all patients. Single dipoles were chosen to represent each identified average MEG peak, which were then projected on the coregistered MRI.

HOW TO READ THESE PICTURES

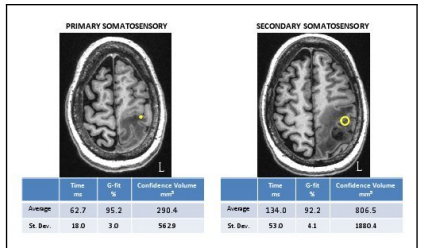


GOODNESS OF FIT : An indicator of what percentage of the data at this single time point is explained by this single dipole. If many regions are active simultaneously this percentage will decrease.

CONFIDENCE VOLUME : We are 95% sure that the dipole origin is located somewhere within this volume. Larger volumes indicate less precision of dipole placement.

Somatosensory

16 out of 20 patients underwent electrical stimulation of the median nerve contralateral to the brain hemisphere affected by their brain tumor. In all 16 patients, a primary somatosensory area was able to be detected. The localization most commonly occurred on the contralateral Post-Central Sulcus (n=11), but was also found in some patients to be on the posterior edge of the Central Sulcus (n=5).

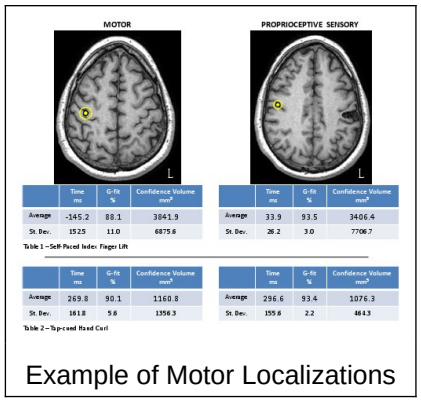


Example of Somatosensory Localizations

Additionally, some patients also yielded a second localization about 70 ms later associated with continued somatosensory processing (n=12). The anatomical location varied from the contralateral Post-Central (n=5), posterior edge of Central (n=5), and Insula (n=2).

Motor

18 out of 20 patients underwent one of two motor paragims, either a self-paced index finger lift or a tap-cued hand curl, contralateral to the brain hemisphere affected by their brain tumor. In 11 patients, a possible motor area was able to be detected with mixed success (7/12 finger lift, 4/6 hand curl). The localization most commonly occurred on either the Pre-Central Sulcus (n=4) or the anterior edge of the Central Sulcus (n=6), while one appeared to localize to a portion of a Post-Central Sulcus physically distorted by the tumor.



Example of Motor Localizations

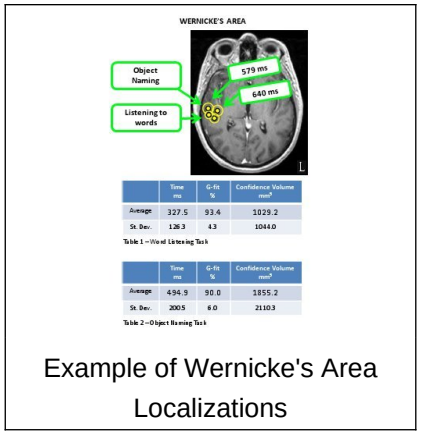
Furthermore, some patients also yielded a second localization associated with proprioceptive somatosensory processing of the motor action (n=10). The anatomical location was predominantly Post-Central (n=8), but a couple were also on the posterior edge of Central (n=2).

Language

18 out of 20 patients completed either a word listening task or a object naming task, some both. Patients were highly variable in the number of localizations that were possible, ranging from 1 to 7 total localizations (mean=3.2, stdev=2.1). In 11 patients these localizations were found in the left hemisphere only, while in 2 they were found in the right hemisphere only. 5 patients exhibited bilateral activities. The localizations can be broken down in to Wernicke's Area and Broca's Area, although precise localizations within these regions varied greatly by patient.

Wernicke's Area

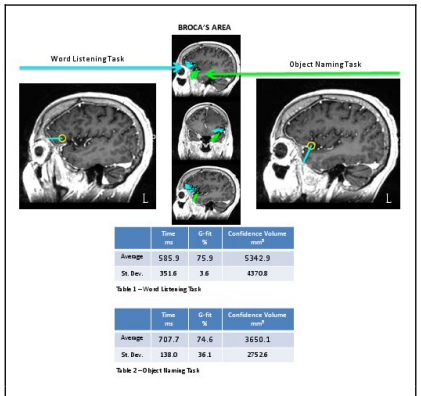
Out of 54 total localizations across 18 participants, 48 localizations were found to be in a Wernicke's type Area. Of these, 29 were localized to some posterior portion of the Superior Temporal Sulcus, while the remaining 19 localized to some posterior temporal lobe facing edge of the Sylvian Fissure.



Example of Wernicke's Area Localizations

Broca's Area

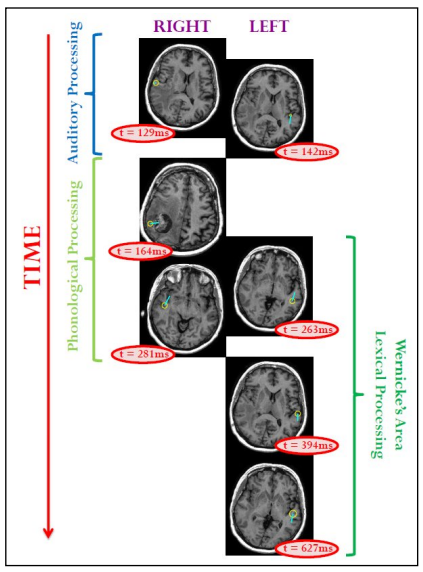
Out of 54 total localizations across 18 participants, only 8 localizations were found in a Broca's type Area, in the inferior frontal region. Localizations were found in both the pars Opercularis and pars Triangularis sub-regions.



Example of Broca's Area Localizations

Time Course and Distribution

Not all language functions are handled by only Wernicke's and Broca's Areas. Rather, natural language processing is network based and unfolds over thousands of milliseconds. For some patients, we are able to determine a fuller time course and distribution of language.



CLINICAL APPLICATION

Neurosurgeons can download the MEG analysis overlaid on MRI sets into their stereotactic system for use in the OR. Thus MEG data can be used for intraoperative guidance.

CONCLUSIONS

While somatosensory responses are robust and repeatable, motor and language localizations are more challenging and require investigating alternative analyses. The results presented represent the successes and pitfalls of our initial experience with pre-surgical planning using MEG.