MR-FOCUSS Locations of Speech Onset Based on Significance Level Thresholds

Susan M. Bowyer PhD[1,2,3], John Moran PhD[1], Sandra Nagel PhD[4], and Norman Tepley PhD[1,2]

[1]Department of Neurology, Henry Ford Medical Group; [2]Physics Department, Oakland University; [3]Department of Neurology, Wayne State University; [4]Department of Psychology, Saginaw Valley University.

WEB site: http://www.megimaging.com

Objective: To determine if localization precision is enhanced by applying a significance level threshold to MR-FOCUSS images of the initial cortical locations of speech onset during word naming and color identification.

Background:

A fundamental challenge for the cognitive neuroscience of speech and language is to capture the spatio-temporal patterns of brain activity that underlie functional components of the language process. The unique property of MEG imaging is its ability to detect neuronal generators for speech within millisecond-time ranges instead of seconds as found in others imaging techniques such as fMRI, PET.

MEG data contains not only the signals of interest but also noise and artifacts from patient and environment, which affect the amplitude of imaged activity differently at each brain location. Statistical mapping is used widely with fMRI and PET data and compensates for location dependent noise by displaying imaging results as significance levels. The ability for MEG data to be displayed as a statistical map enables timing of cortical events to be determined uniformly for all brain locations.

Methods

Six normal control subjects were monitored with 148 MEG channels (4D Neuroimaging Magnes WH2500). None of these subjects had Dyslexia, ADHD or other learning disorders.

- Task 1 involved visual presentation of a colored block and asking the subject to name the color aloud.
- Task 2 involved visual presentation of a printed color name, e.g. "green", displayed in that color. Each subject was asked to say the word aloud.

- 40 epochs of data were averaged and filtered 1-50Hz. A data segment from -100 to +500 ms after stimulus onset was analyzed with MR-FOCUSS. Statistically significant regions of activation were identified by transforming the time sequence of MR-FOCUSS imaged activity to significance levels (figure 1) based on the distribution of maximal pre-stimulus imaged activation [Sekihara,et.al., NeuroImage 27 (2005) 368 - 376]. The locations and timing of imaged functional activity were determined using a significance threshold and co-registered to a normal MRI scan. Red colors on MRI scans have amplitudes with a significance level of greater than $\alpha = 0.20$.

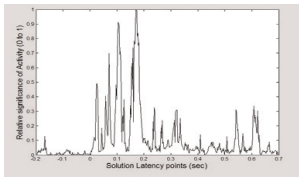

Figure 1. Graph of the Relative levels of significant activity across time.

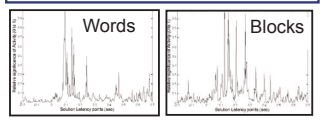

Figure 3 Graphs for Subject #1 during task 1 and task 2. Images seen in Figures 4-7

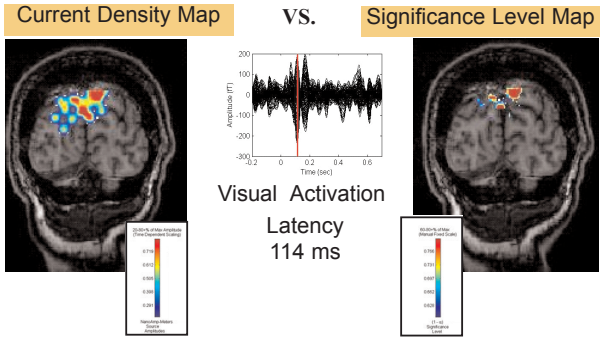

Figure 2. Visual evoked response at 114 ms. Current Density map is shown on the left for this latency and the Statistical Significance map is shown at the right for the same latency. Graph of Significance is figure 1

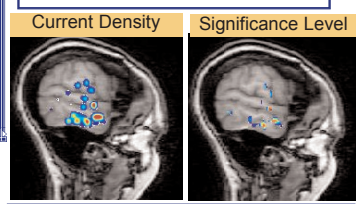

Figure 4 Left temporal activation during Task 2 (word) at 229ms.

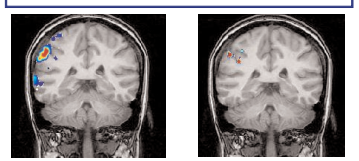

Figure 5 Right temporal activation during Task 1(block)at 230ms.

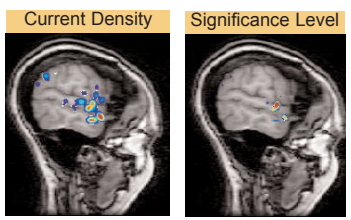

Figure 6 Left Broca's area activation during the Word condition 285ms

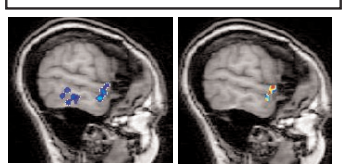

Figure 7 Left Broca's area activation during the Block condition 378ms

Statistical method

We used the method proposed by Sekihara, where MEG data baseline, prior to the stimulus, is treated as a random sample of artifact and noise that occurs throughout the MEG data. This random artifact data is resampled 50 times [4] to determine the statistical distribution of imaged noise and artifact. From these imaging results significance levels are individually set for each source location.

Results

During Task 1, initial statistically significant cortical activation was seen at 114 ± 12 ms in the occipital region in all 6 subjects (figure 2). This area of initial activations was also seen at the same latency in Task 2. This was followed by significant (figure3) activation in the right angular gyrus at 245 ± 23 ms for Task 1 (figure 4). For Task 2, however, activation was seen in the left superior temporal region at 234 ± 21 ms (Figure 5). Activation in the Left inferior frontal gyrus (Broca's areas) was seen at 400 ± 31 ms in both Tasks for all 6 subjects (figures 6 and 7).

Conclusion

Cortical location differences of speech onset between reading words and naming colored blocks were easily identified from both Current Density and Significance Level maps. Significance Level maps overlap with Current Density areas of high intensity. Onset of activation in different regions can be compared in Significance Level maps as sensitivity had been normalized across the brain. Statistical maps of MEG can more easily be compared to fMRI and PET images.

References

Acknowledgements: Research supported by NIH/NINDS Grant RO1-NS30914.

1. Sekihara k, Sahani M, Nagarajan S. A simple nonparametric statistical thresholding for MEG spatial-filter source reconstruction images. NeuroImage 27 (2005) 368 - 376
2. Moran JE, Bowyer SM, and Tepley N. Multi-Resolution FOCUSS: A source imaging technique applied to MEG data. Brain Topography 18 (2005) 1-17.
3. Moran JE. MR-FOCUSS. MEG_Tools user manual. Available for download from: http://www.megimaging.com
4. Darvas F, Rautiainen M, Pantazis D, Baillet S, Benali H, Mosher JC, Garnero L, Leahy RM Investigations of dipole localization accuracy in MEG using the bootstrap. Neuroimage 25 (2005) 355-368 .