Revealing the cortical dynamics of letter string perception.

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Introduction

Magnetoencephalography (MEG) is particularly well suited to measuring evoked response components of visual word recognition. However, little is known about the nature of fundamental components relative to the cortical surface. Thus, typical methods of distributed source analysis may overgeneralise the spatial extent of these responses by combining the actual sources with source localisation "bleed" into neighbouring cortices.

We conducted a replication of Tarkiainen et al.'s (1999) experiment, which reported robust effects for two response components of interest: the Type I / M100 effect, indexed by greater activity with increased visual noise, and the Type II / M170 effect, indexed by a preference for visible over legible but noisier letter strings.

Tarkiainen et al. (ibid) employed single dipole modelling, which orients activity with respect to the head coordinate system. We used distributed source analysis of these responses by reconstructing sources of activity with respect to the cortical surface. We aim to distinguish accurate sources from reconstruction "bleed" into neighbouring cortices, and test whether response components are generated by cortical currents orientated into, as opposed to out of the cortex.

Aims

1) **Are Tarkiainen et al.'s results replicated when using a cortically constrained distributed source analysis?**

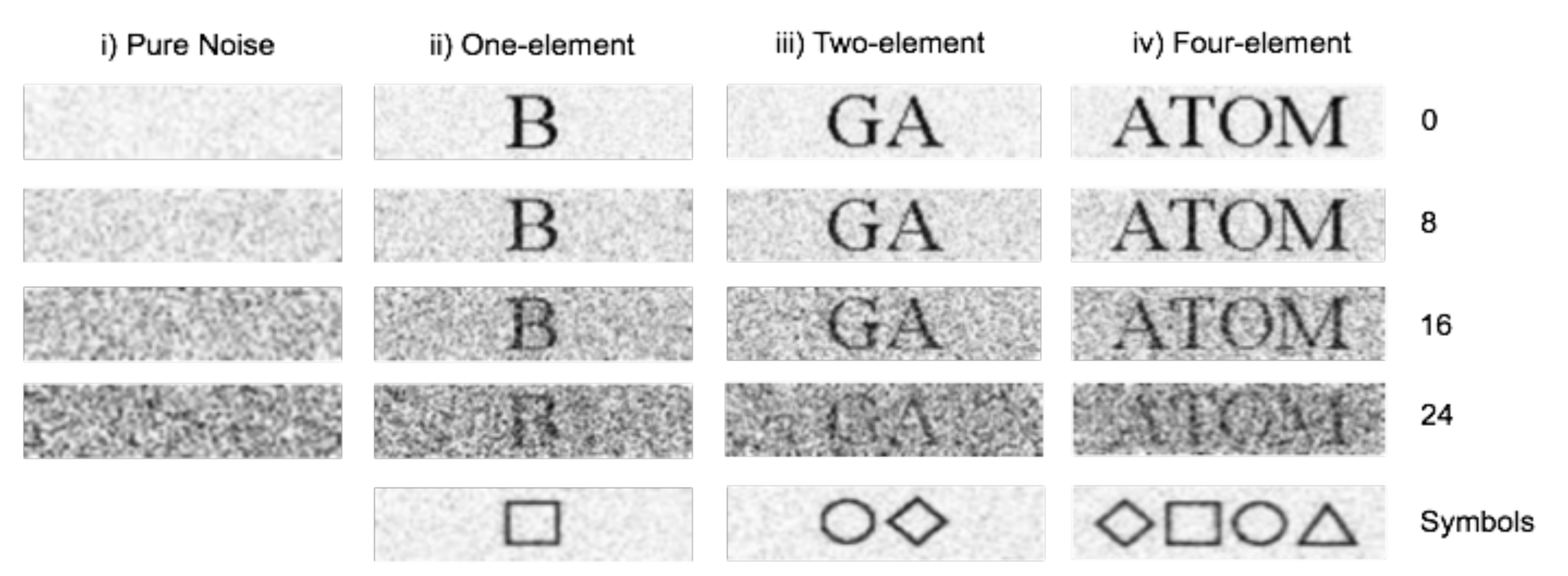
2) **What is the directionality of Type I and Type II responses with respect to the cortex?**

Materials and Methods

- 16 right-handed native English speakers
- Continuous MEG data acquired during experimental session
- 208 sensor array
- 50 trials per condition (per cell in design below)

- **Task**: English-adapted stimuli from Tarkiainen et al., 1999

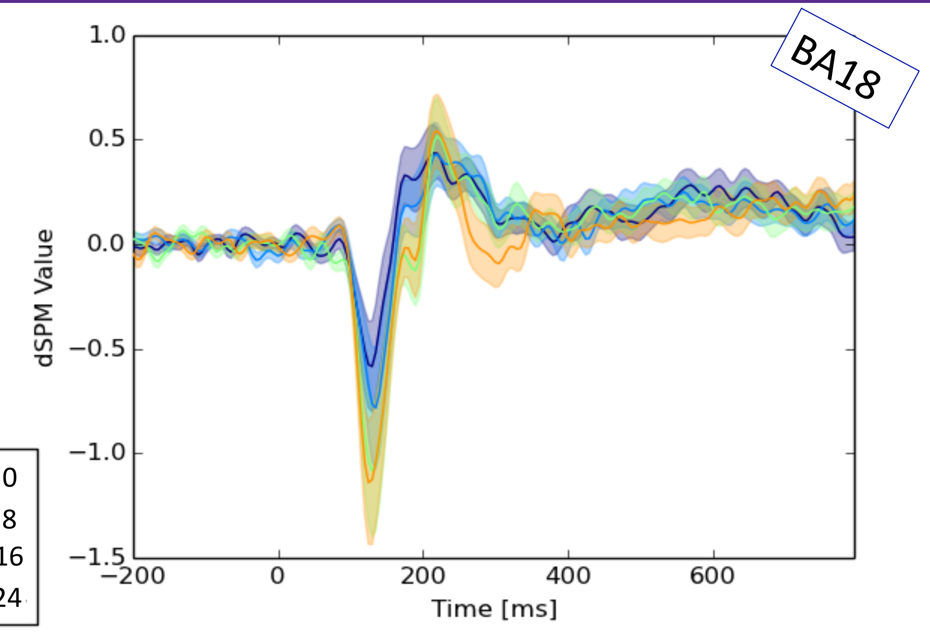
  Focus on stimuli and name aloud when presented with "?"

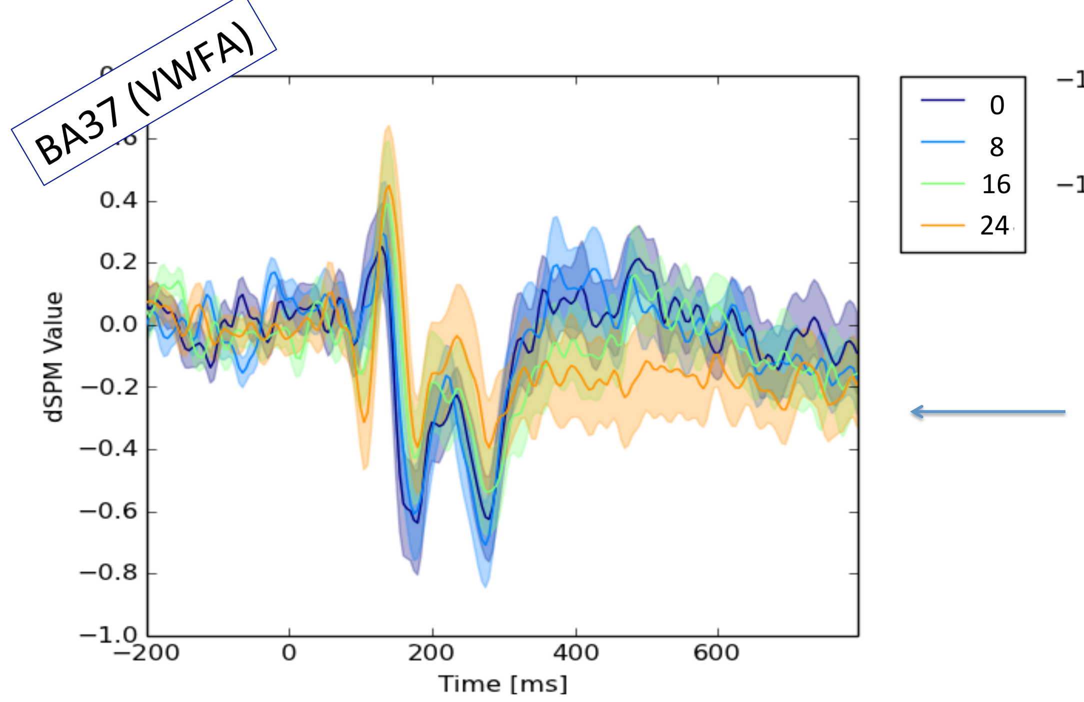


Replication

Type I:

Greater activity for high noise(24) than low noise(0), peaking ~ 100ms





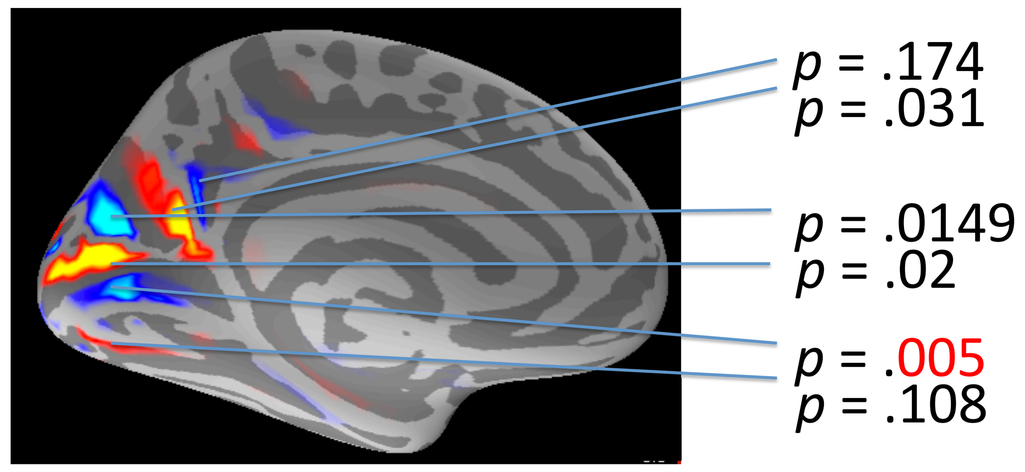
Type II:

Greater activity for low noise(0) than high noise(24), peaking ~ 150ms

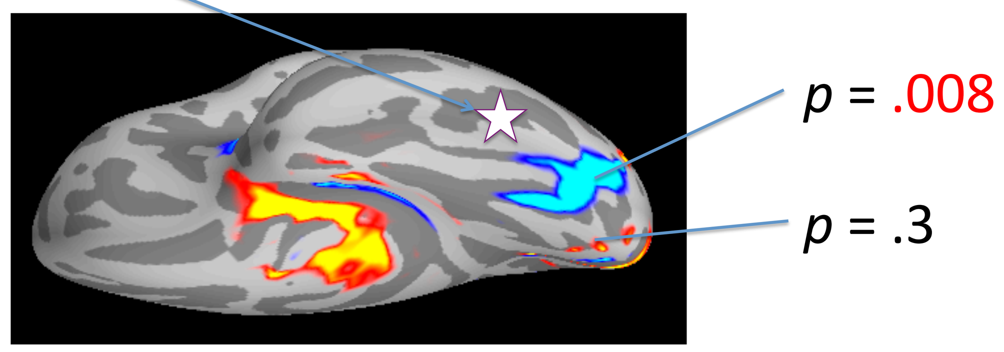
- Data processed in mne-python using "fixed" orientation (signed respect to cortex)
- Anatomical ROI's (above) selected from Tarkiainen et al.'s results

Functional ROI Comparison

- **Type I**: robust effect in lingual gyrus



- **Type II**: robust effect in fusiform gyrus (VFWA coordinates: Cohen et al., (2000)



- Results gathered from 2 x 3, noise vs. stimulus-type ANOVA

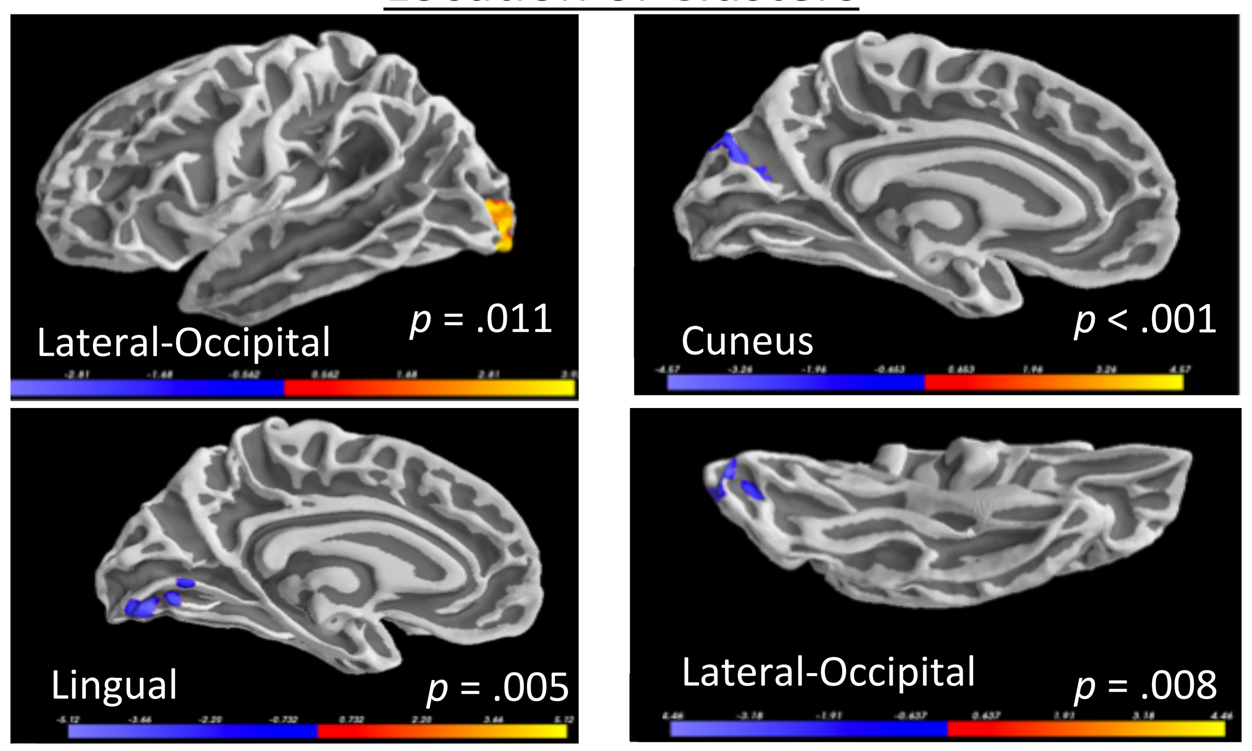
Cluster Permutation Analyses

- Nonparametric statistical testing (see Maris and Oostenveld, 2007)
- Calculated over time and space, corrected for multiple comparisons
- Cluster formation restricted to the visual cortex for Type I and temporal lobe for Type II
- Minimum size of clusters = 10 sources
- Threshold for forming clusters, $p < 0.1$

Blue clusters refer to negative activity, i.e., current oriented into the cortex

Type I:

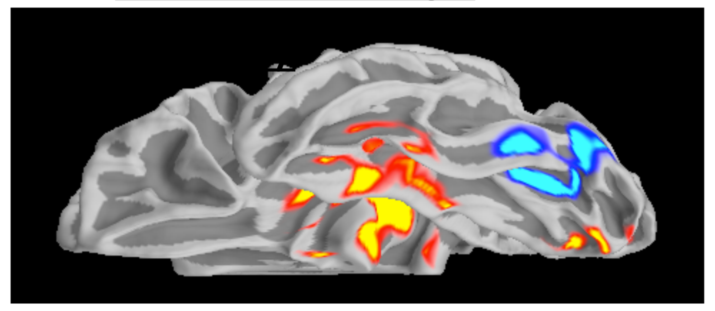
Location of Clusters



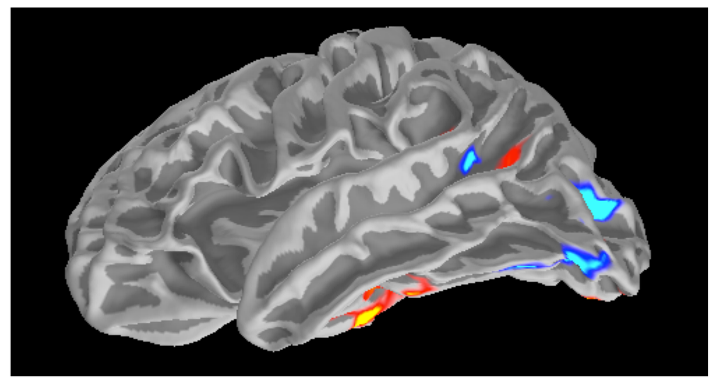
- T-Test: Word[24] vs. Word[0]
- Time window 80:130ms

Type II:

Grand Average

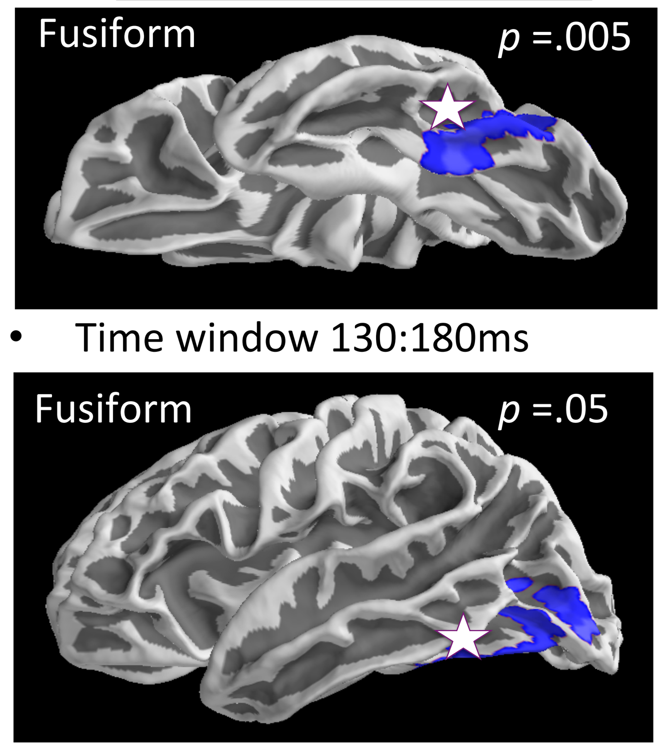


- T-Test: Word[0] vs. Word[24]



- T-Test: Word[0] vs. Symbols[0]

Location of Clusters



- Time window 130:180ms
- Time window 130:180ms

Conclusions

- Distributed source analysis replicated Tarkiainen et al.'s results
- Cortical currents appear to be oriented *into* the cortex (negative)
- Results motivate using source reconstructions that fix direction of sources orthogonal to the surface and analysing only *negative* sources for estimates of these responses

References:

Tarkiainen, A., Helenius, P., Hansen, P. C., Cornelissen, P. L., & Salmelin, R. (1999). Brain, 122(11), 2119-2132.
Cohen, L., Dehaene, S., Naccache, L., Lehéricy, S., Dehaene-Lambertz, G., Hénaff, M. A., & Michel, F. (2000) Brain, 123(2), 291-307.
Maris, E., & Oostenveld, R. (2007). Journal of neuroscience methods, 164(1), 177-190.

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