

Modulation of Single-Trial Visual Evoked Response by Alpha-Band Oscillation

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Abstract

It has been suggested that alpha-band oscillation may play a functional role in sensory processing. Applying blind source separation to MEG data collected during visual stimulation, we found that neuronal sources located within the occipito-parietal cortex show both visually evoked responses and ongoing alpha-band oscillation, and that detected single-trial response onset times were modulated by the phase of the alpha rhythm. To study how this rhythmic activity influences sensory processing, we constructed a model in which an ongoing alpha-band oscillation and a fixed sensory response are superimposed. This model shows the same modulation of detected single-trial response onset by alpha phase that is observed in the actual MEG data.

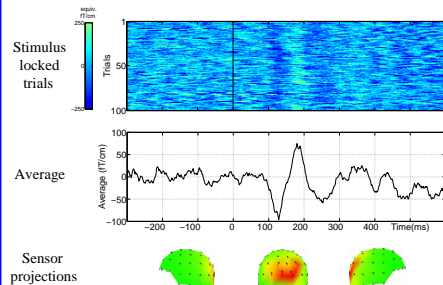
Methods

1. Data

MEG datasets were collected during 100 trials of visual stimulation from each of five subjects at a sampling rate of 600 Hz using a Neuromag-122 neuroradiometer.

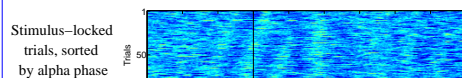
2. Source Separation and Localization

A blind source separation algorithm (SOBI, for Second Order Blind Identification) was applied to the raw data. This algorithm produces a set of sources, each consisting of a time series and a vector of attenuations to the sensors. Each source's sensor projection vector gives information about its spatial location. We selected one occipito-parietal source from each subject for use in subsequent analysis.



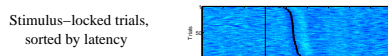
3. Sorting by Alpha Phase

Trials were sorted by alpha phase measured prior to the response onset. Phase was calculated from the 10 Hz coefficient of a short-time Fourier transform, using a Hanning window of 668 ms.

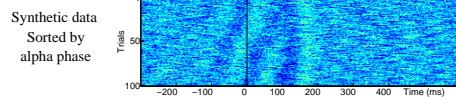
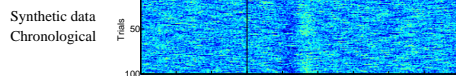
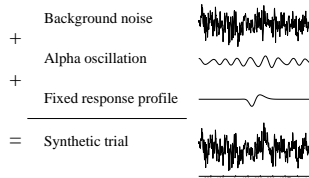


4. Response Detection

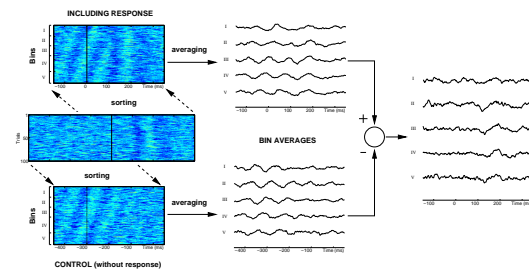
The stimulus-triggered average was used as a response template. For each trial we slid this template to find the best match.



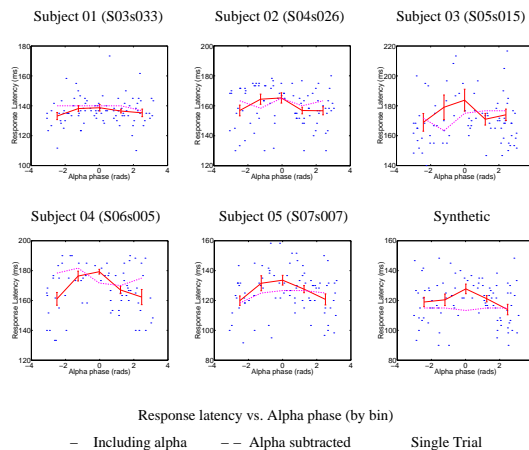
5. Synthetic Data



6. Subtracting Background Alpha



Results



Discussion

- Both phase-sorted stimulus-locked images and latency vs. alpha phase plots show an apparent modulation of latency by alpha phase.
- Subtracting estimated background alpha from real data reduced the variability of detected latencies.
- Synthetic data with an alpha oscillation superimposed on a constant response profile also leads to a modulation of detected latency by alpha phase.

Conclusions

- Apparent alpha phase modulation of the evoked response is insufficient to reject a noninteracting superposition model.
- This data is therefore consistent with three hypotheses:
 - MEG measures synaptic activity, so we might expect alpha phase to modulate the response latency in the next region downstream, and not in the same region.
 - The processes generating the alpha rhythm and the sensory response are physically collocated but do not interact at the short time scale.
 - Our blind source separation algorithm fails to separate the non-interacting alpha signal from the sensory response, even though they are not collocated.

Acknowledgements

This research was supported by NSF CAREER award 97-02-311 and the National Foundation for Functional Brain Imaging.