Inverse oblique effect in EEG gamma orientation tuning

Introduction

Gamma frequencies have been proposed both as a neurophysiological correlate of visual perception1, and a channel for feedforward propagation of visual input2. However, to date little work exists on the human EEG gamma band response to simple stimulus features such as orientation. If the human EEG gamma band is capable of indexing complex visual stimulus features, it should also show sensitivity to simple feed-forward parameters such as grating orientation.

Experiments using BOLD-FMRI have demonstrated that although a preponderance of voxels prefer cardinal orientaions3, at broader spatial scales there is a distinct preference for oblique orientations in human V14. A preference for oblique orientations in human EEG gamma would suggest that the signal measured in human EEG gamma reflects low spatial frequencies of brain activity, and is analogous to the global gamma rhythm found in macaque5, suggesting EEG gamma can provide a surrogate for gamma local field potential measured averaged over multiple implant electrodes.

Methods

Gratings were constructed using 75% black pixels and 25% white pixels and were 3 cycles per degree masked by an 8 degree circular aperture. To test multiple orientations in a single session, gratings were slowly rotated through all orientations, 50% of trials rotated clockwise, the other 50%, counter-clockwise. A single 360deg rotation lasted 18 seconds, and 50 total rotations were completed per subject, for ~20 minutes of EEG acquisition when including baseline.

EEG signals were downsampled to 250Hz, high-pass filtered at 1Hz, and independent component analysis was used to isolate gamma-band (30-90Hz) components responding to the grating. All but one subject had a significant gamma band response to the grating (Figure 1A). Tuning was computed at each frequency as (power(max orientation) – power(min orientation)) / (0.5 \* (std(power(minorientation)) + std(power(maxorientation)))), where std was across trials.

Results:

The gamma range (30-90Hz) showed two distinct peaks in response to the rotating grating (Figure 2A), which matched the maximum tuning responses (Figure 2B). Averaging across these two gamma peaks (28-34Hz and 55-60Hz) (Figure 2C) revealed gamma power in response to oblique orientations (135,225,315) was significantly greater than that for cardinal orientations (90,180,270) (Figure 2D).

Conclusion:

The preference for oblique orientations observed here matches both MEG6 and FMRI results in human4. This “inverse oblique effect” has also been observed in psychophysical experiments, where sensitivity to global stimulus features such as Glass patterns7 was increased at oblique orientations8.

Taken together, these results suggest that EEG gamma activity measured in humans is analogous to the “Global LFP” measured invasively in macaques5, which is obtained by computing gamma power after averaging the signal across spatially distinct recording sites.

References:

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