SSVEP captures predictive feature-based attentional tuning for point-light biological walker detection in unattended spatial location

VISUAL PERCEPTION AND NEUROIMAGING LAB

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Background

Biological motion perception & Feature-based Attention

Biologicial motion detection and recognition benefits from feature-based attention directed towards diagnostic features (Thurman & Grossman, 2008)

Feature-based attention boosts the gain of neurons to task-relevant features, even in unattended locations (Treue & Martínez-Trujillo, 1999)

Question: Can we find evidence of feature-tuning in attentive filtering when searching for biological motion in clutter?

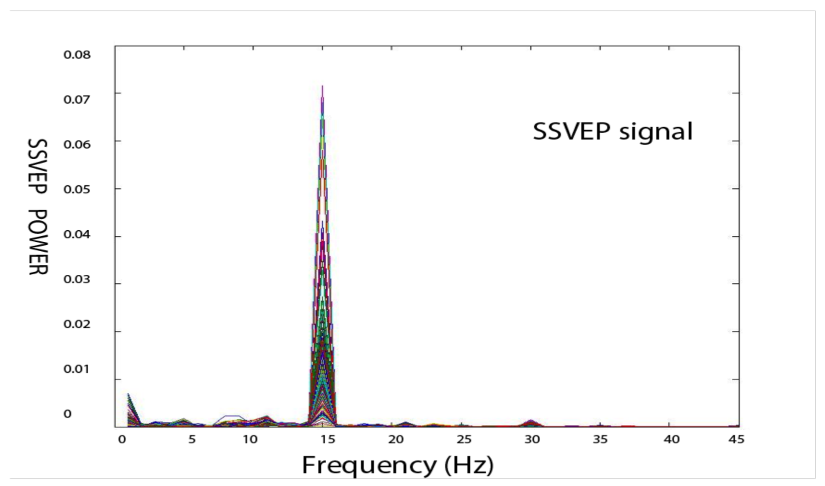
Method

SSVEP

Steady-state visually evoked potentials (SSVEP) entrain brain networks through visual flicker, tagging locations and features of the visual scene with frequency-specific flicker.

The SSVEP amplitude reveals feature-based attentive filtering, in both attended and unattended locations (Ding, Sperling, & Srinivasan, 2006; Morgan, Hansen, & Hillyard, 1996; Bridwell et al.,2012,2013; Painter et al.,2014)

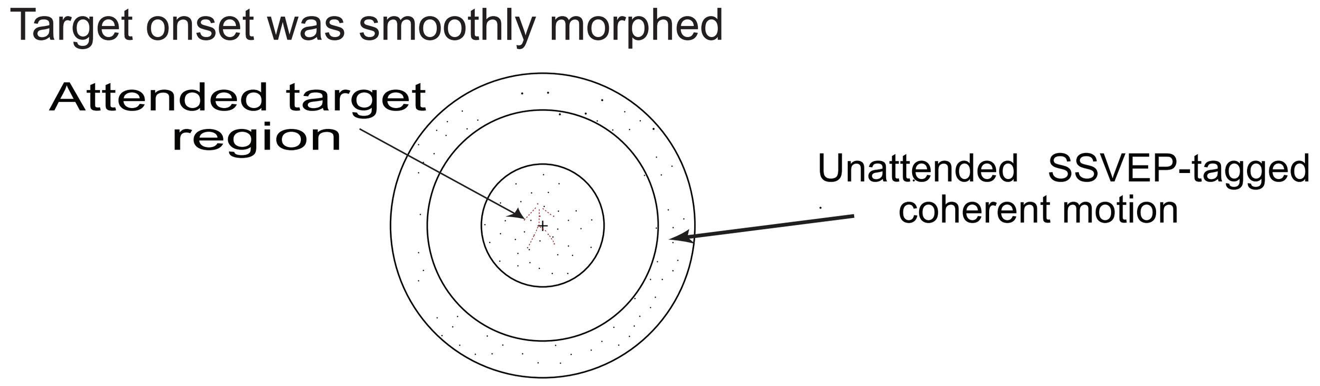
Example of 15 Hz SSVEP when participant viewing a visual stimulus flickering at 15 Hz

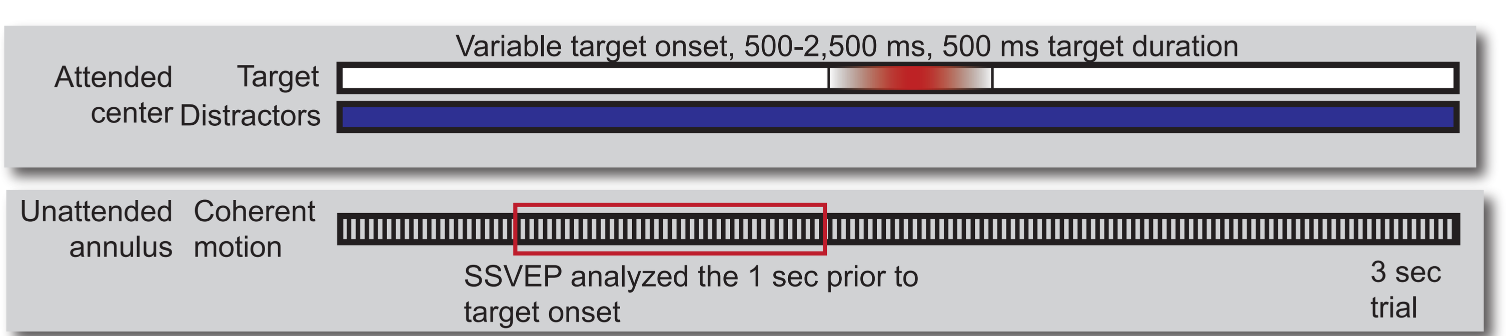


Stimulus & Task

Central attended region:

- Subjects monitored for the presence of point-light biological walker embedded in motion-matched noise
- Masking noise preceeded target onset by 500-2500 milliseconds
- Target onset was smoothly morphed





Unattended region in peripheral annulus flickered at 15 Hz

100% coherent noise moving *congruent*, *incongruent*, *orthogonal* or *diagonal* relative to facing direction of the walker

Only analyzing the SSVEP signal originating from the unattended region during the mointoring period (the 1 sec preceeding the onset of the "biowalker" target)

SSVEP Results

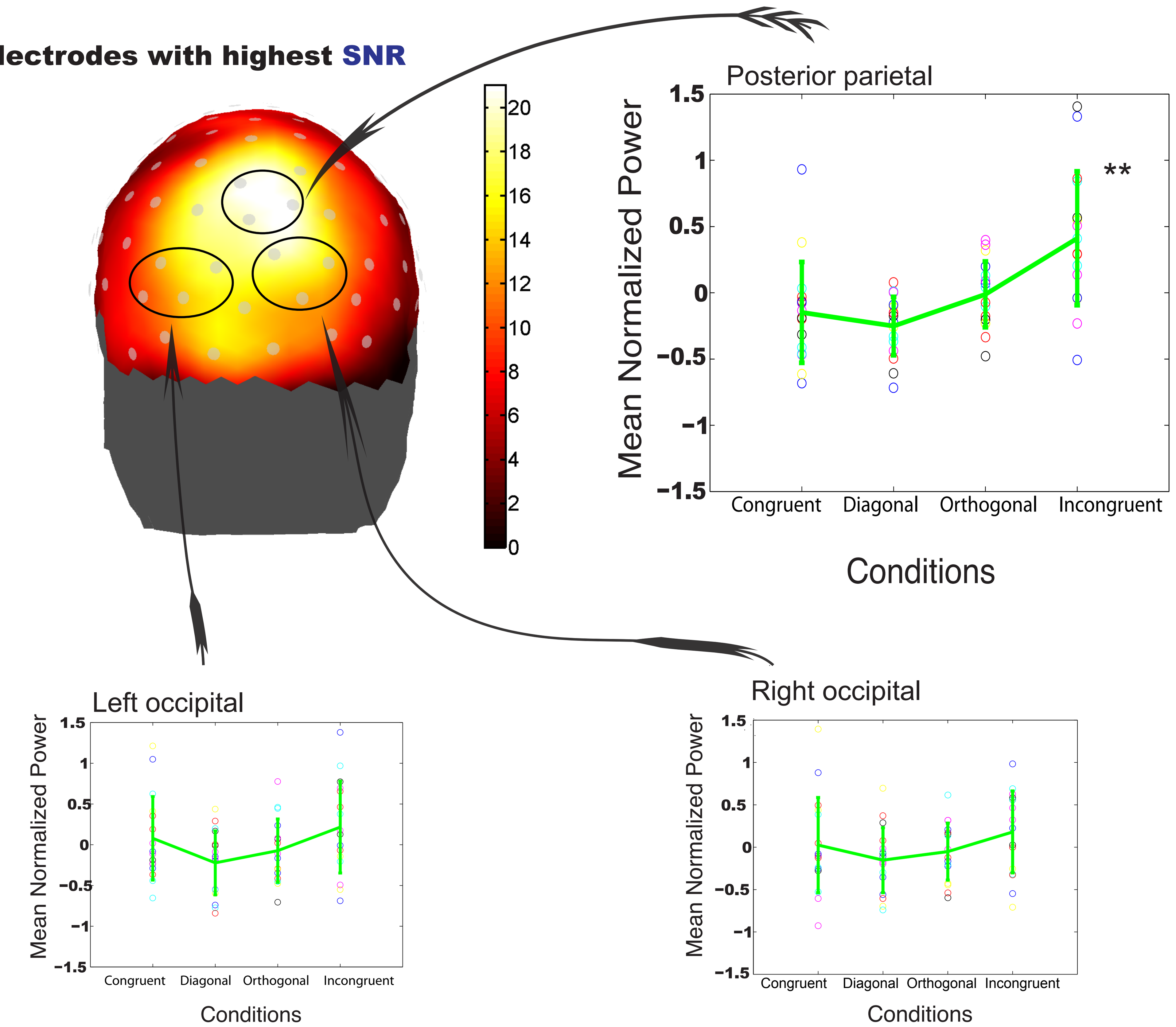
EEG analysis preparation

- Clean using ICA
- Transform to frequency space and isolate 15Hz SSVEP
- Remove electrodes with signal-to-noise (SNR) lower than 3x power at adjacent frequencies

Analysis

- Electrode selection: Selected those electrodes with highest SNR power, all conditions
- Tuning functions: SSVEP power, for each condition
- Significance (p< .001) assessed with 1-way repeated measures anova

Electrodes with highest SNR

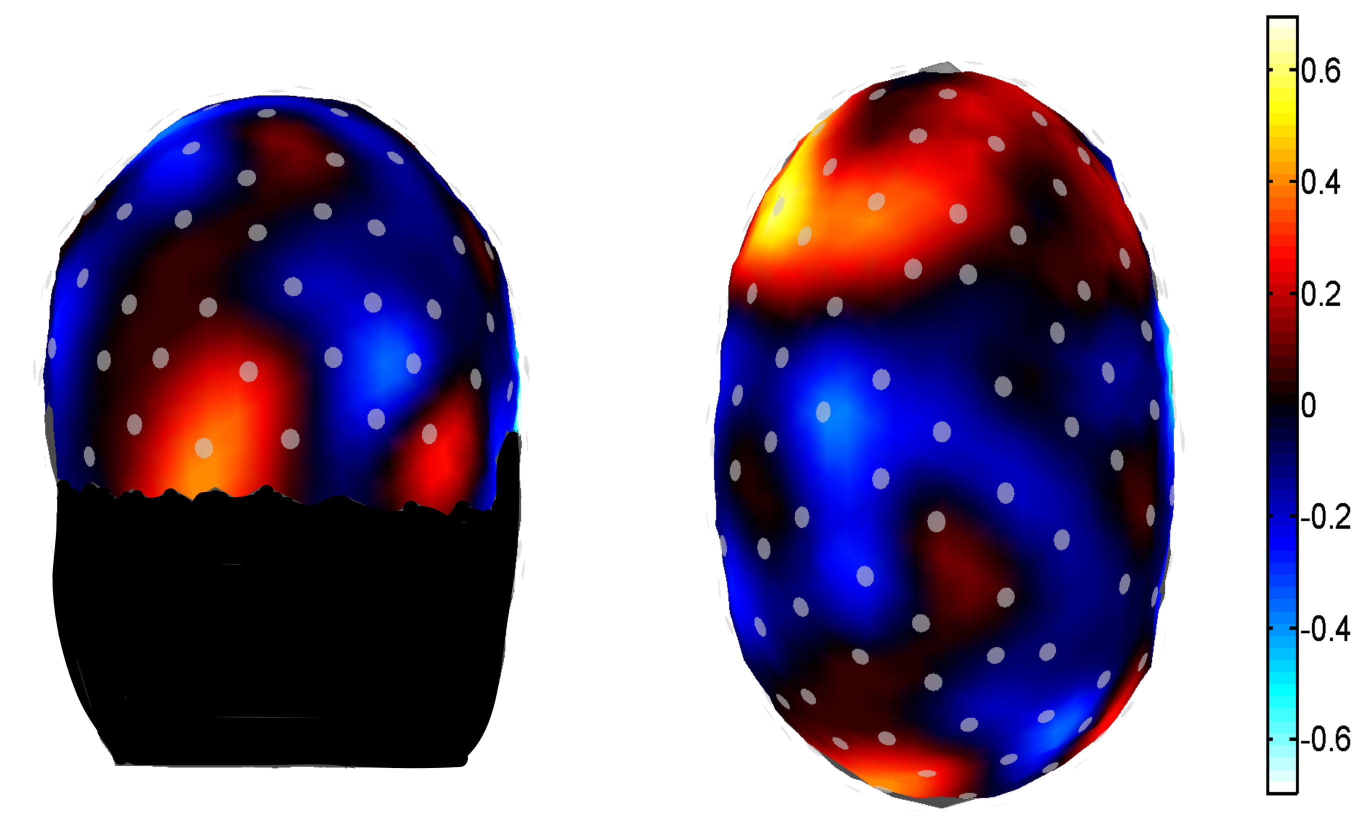


Predictive Model Fitting

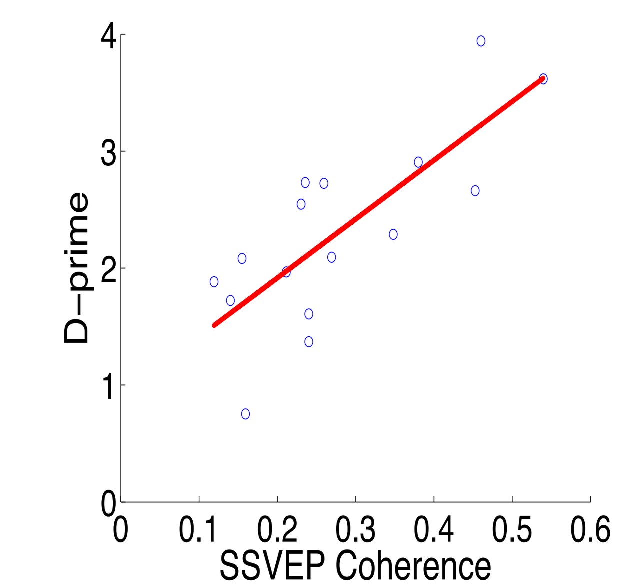
Used Partial least Square (PLS) regression method to predict d-prime values (perceptual sensitivity) from SSVEP coherence with respect to high SNR posterior parietal cortex.

Coherence reflects the consistency of phase-locking between two sources (network connectivity).

Regression Coefficients from PLS regression analysis



For "Incongruent" condition only, EEG coherence between PPC and ventrolateral pefrontal cortex (VLPFC) and occipital cortex successfully predicted individual subject d-prime sensitivity.



Individuals with higher SSVEP phase-locking between PPC and VLPFC had higher d-prime values, and vice versa.

Conclusions

Posterior parietal cortex has information of the attended features when monitoring for biological motion.

SSVEP tuning suggests observers are monitoring for features with motion opposite that of the facing direction of the walker, such as the backstroke of the feet.

Attention to that feature, as revealed by the strength of coherence between PPC and VLPFC, predicts subsequent perceptual sensitivity.

Our results also demonstrate a novel method to analyze the properties of attentional filtering when monitoring for specific visual features in complex objects.

References

Thurman, S. M., & Grossman, E. D. (2008). Temporal "Bubbles" reveal key features for point-light biological motion perception. Journal of Vision, 8(3), 28.1–11. http://doi.org/10.1167/8.3.28

Treue, S., & Martínez Trujillo, J. C. (1999). Feature-based attention influences motion processing gain in macaque visual cortex. Nature, 399(6736), 575–9. http://doi.org/10.1038/21176

Bridwell, D. a, & Srinivasan, R. (2012). Distinct attention networks for feature enhancement and suppression in vision. Psychological Science, 23(10), 1151–8. http://doi.org/10.1177/0956797612440099

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