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Entraining Brain Oscillations to Influence Facial Perception

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Introduction

- Brain oscillations are the result of neurons, perhaps in multiple regions of the brain, processing the same stimulus and consequently synchronizing to the same frequency (Hz) (Schnitzler, 2005).
- Using electroencephalography (EEG), brain oscillations have been associated with many different cognitive functions like visual and auditory perception, attention, and emotion processing (Thut & Miniussi, 2009).
- Periodic oscillating stimuli, like face images, can be used to entrain (synchronize) brain oscillations to a set frequency (Rossion & Boremanse, 2011).
- Entrainment influences perception of visual (Mathewson et al., 2012) and auditory (Will & Berg, 2007) stimuli.

Methods

Experimental Setup

- 20 participants were recruited from the University of Puget Sound.
- EEG was used to measure neural activity. For this, subjects were fitted with a 32-channel BioSemi active electrode system, referenced by left and right mastoid electrodes.

Task Specifics

- Face stimuli were obtained from the Radbound Faces Database (Langner et al., 2010). Faces were emotionally neutral, happy, or disgusted (Figure 1).
- Figure 1 depicts the procedure of each trial. Each example demonstrates a possible combination of variables (scramble vs. face, emotion, and timing) for the target image. Figure 2 outlines the possible variable combinations.
- After each trial, subjects indicated if the target image was a scramble or face and which emotion was expressed using the left and right arrow keys on a QWERTY keyboard.

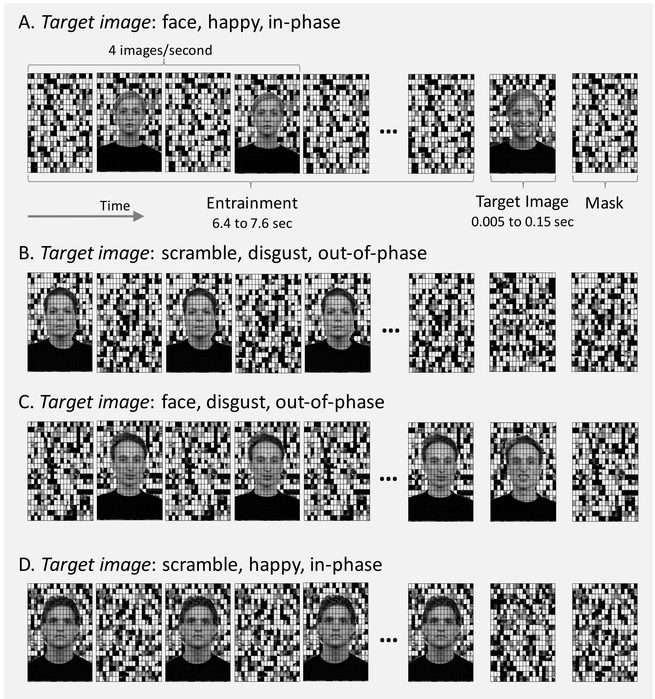


Figure 1. Example trials with possible target image variable combinations.

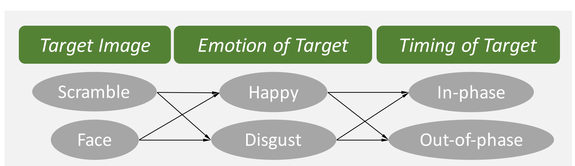


Figure 2. All possible target image variable combinations.

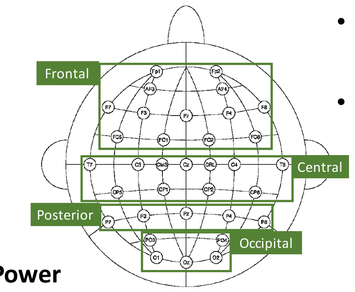
Data Analysis

- Behavioral effects were assessed by proportion of correct target identifications (face vs. scramble).
- Spectral density plots were generated from EEG data to determine oscillation power of the entrainment frequencies (4 Hz for all stimuli, 2 Hz for faces) across the scalp.
- Information from each electrode was grouped based on the region of the cortex (Figure 3) – occipital, posterior, central, or frontal regions of interest (ROIs) – and the frequencies at which the most power was expressed were identified.

Results

Neural

- All regions of interest (ROIs) showed entrainment (Figure 3).
- Non-occipital ROIs were significantly more entrained to 2 Hz than 4 Hz ($p < 0.01$).
- The occipital ROI was significantly more entrained to 4 Hz than 2 Hz ($p = 0.035$).



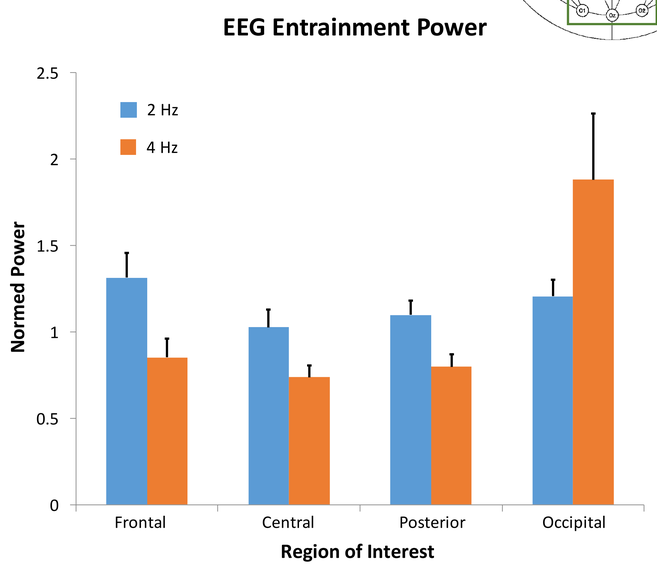


Figure 3. *Top*: BioSemi 32-channel electrode layout grouped to form each region of interest. *Bottom*: Normed power for each region of interest at 2 Hz and 4 Hz.

Behavioral

- Correct identification of faces shown in-phase was significantly higher than correct identification of those shown out-of-phase ($p = 0.02$) (Figure 4).
- Phase timing had no significant effect on accuracy in identifying a scramble image.
- Proportion correct for scramble targets was significantly higher than for face targets.

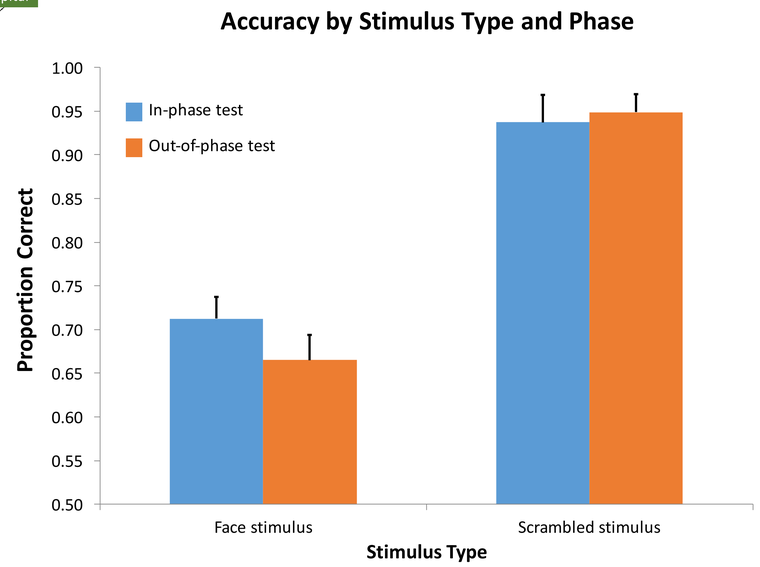


Figure 4. Proportion of target images correctly identified as a face or scramble when in- or out-of-phase.

Conclusions

- Separate entrainment of the occipital ROI and posterior, central, and frontal ROIs can be achieved with face stimuli.
- Entraining with face stimuli influences the ability of a subject to accurately identify faces shown in-phase versus out-of-phase.
- Subjects were biased towards identifying the target image as a scramble when less certain if the target was a face or a scramble.

Future Directions

- Explore the effect of target emotion on the ability of a subject to discriminate between a face and a scramble.
- Compare correct identification of target emotion (happy vs disgust) between in-phase and out-of-phase target faces.
- Evaluate event-related potentials resulting from in-phase versus out-of-phase target images to better associate changes in neural activity with entrainment and the observed behavioral effects.

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Acknowledgments

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