Influencing Visual Target Detection with Oscillatory Phase-Specific Stimulus Presentation

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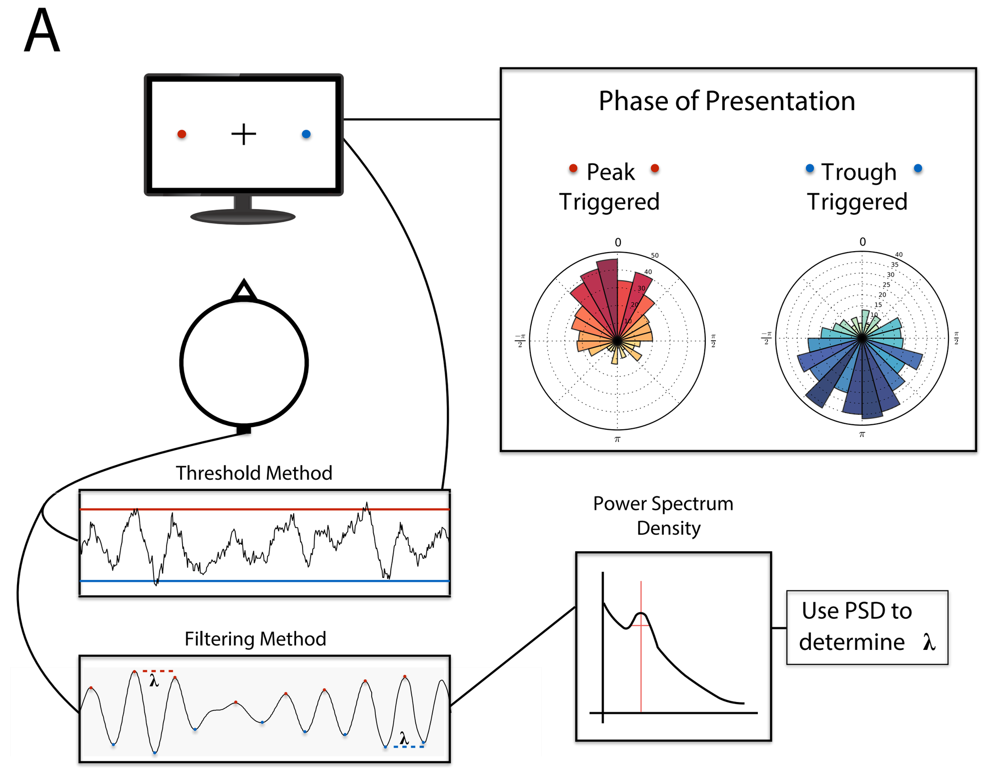
Abstract

Can we influence the detection of a visual target by presenting it at an optimal phase of an endogenous oscillation?

- The instantaneous phase of cortical oscillations relates to behaviour, e.g. there is an optimal posterior alpha phase for visual detection tasks and in other modalities (Busch & VanRullen, 2011).
- Methods for selectively presenting stimuli have been demonstrated before, using online methods using either a filtering approach (Varela et al., 1981) or a threshold approach (Kruglikov & Schiff, 2003), but these methods have never been used in an attempt to influence behavior.
- Here, we implement the two methods for selectively presesnting stimuli at specified phases of ongoing oscillations, comparing the methods, and investigate if selective presentation can bias behavioral performance in a visual detection task.

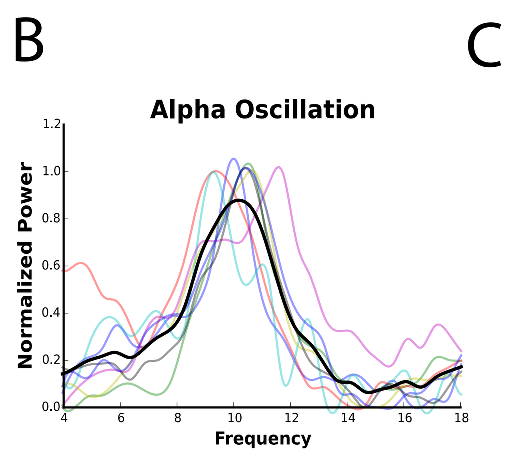
Outline of the Phase Selective Presentation Methods



A) Outline of the online system. EEG was used online to estimate and predict oscillatory phase using two methods:

Threshmethod - the raw voltage trace is thresholded to identify peaks and troughs of the dominant oscillation such that future phases can be predicted

Filt method - data are bandpass filtered, and used to extrapolate future phases by identifying peaks and troughs. λ is wavelength (peak to peak distance).



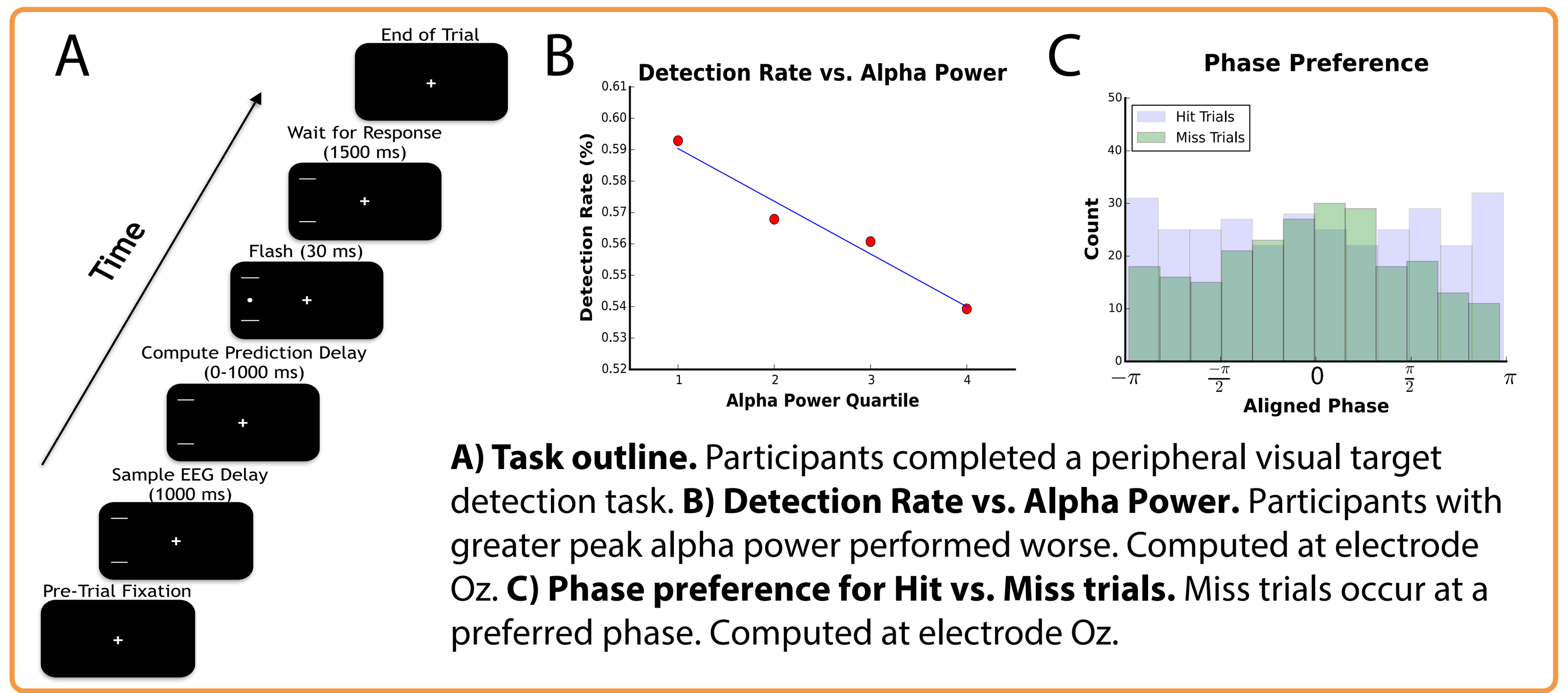
C

Electrode	Oz
Reference	FCz
Sampling Rate	5000 Hz
Online Sample Time	1000 ms
Online Filter	Individual Alpha +/- 3 Hz
Threshold Percentile Values	[0.5, 99.5]

B) Alpha oscillations. Normalized alpha oscillations for each subject. Online peak alpha frequency estimated from 60 second rest baseline period.

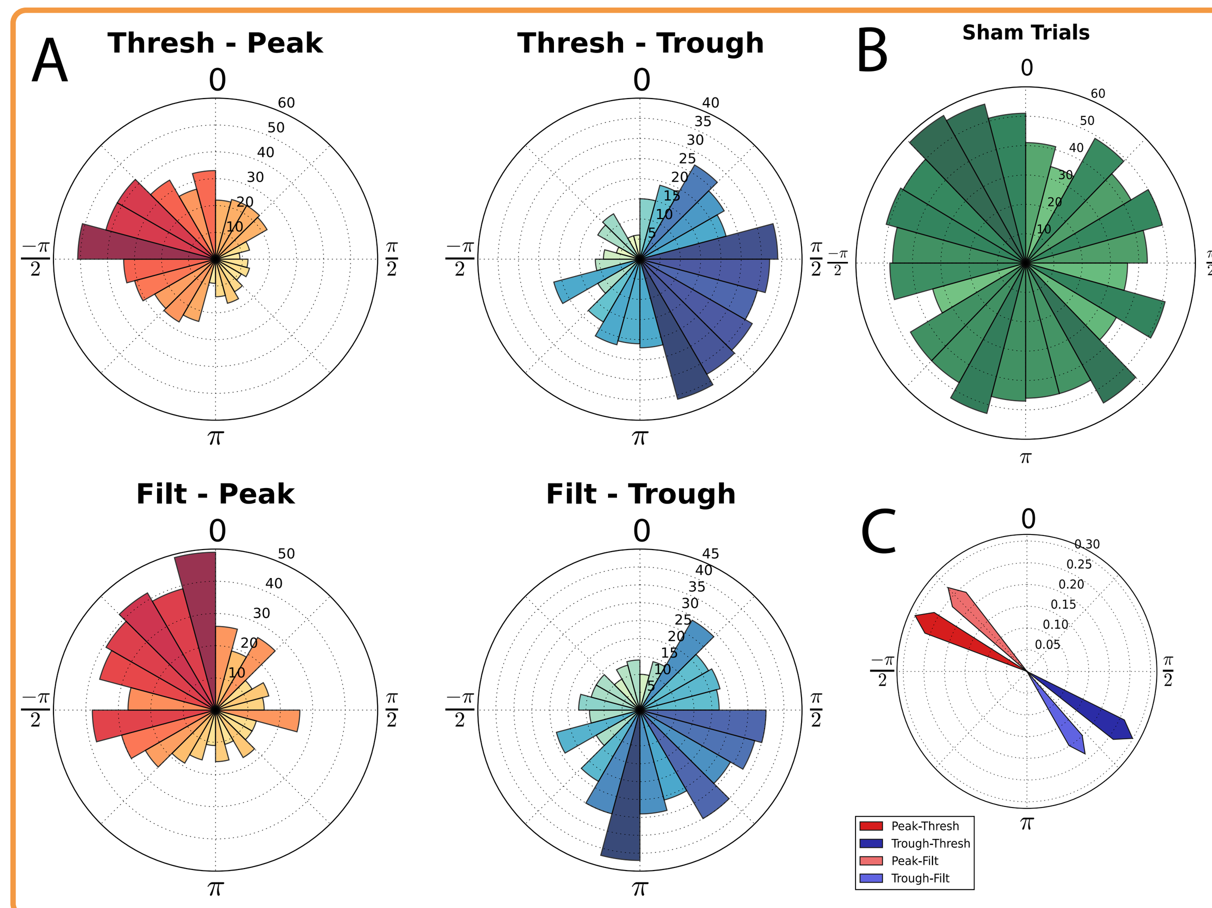
C) Parameters used in the online system.

I - Visual Detection is Alpha Power & Phase Dependent



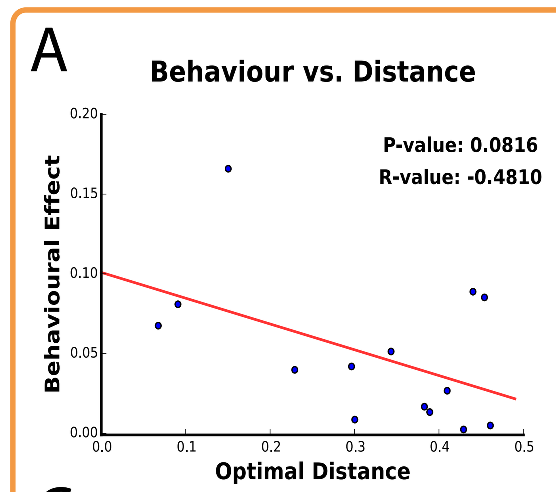
A) Task outline. Participants completed a peripheral visual target detection task. **B) Detection Rate vs. Alpha Power.** Participants with greater peak alpha power performed worse. Computed at electrode Oz. **C) Phase preference for Hit vs. Miss trials.** Miss trials occur at a preferred phase. Computed at electrode Oz.

II - Phase-Selective Presentation Is Successful



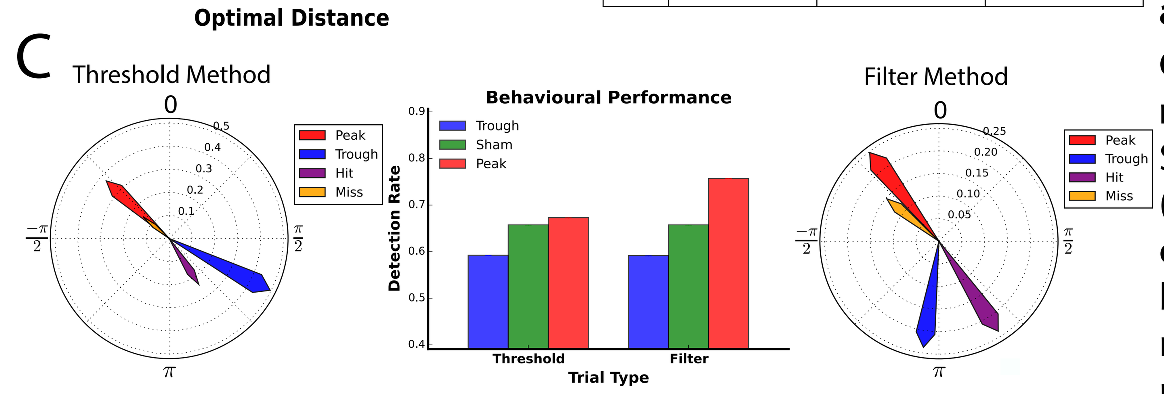
A) Phase of stimulus presentation in online trials. Compares Filt and Thresh methods to offline Sham. Data filtered +/-2 Hz around individual alpha, Hilbert transformed, phase angle was computed at time of stimulus presentation. **B) Stimulation phase angle for sham online trials.** Demonstrates no manipulation in sham. **C) Mean vectors for online methods.**

III - Selective Presentation can Bias Behaviour



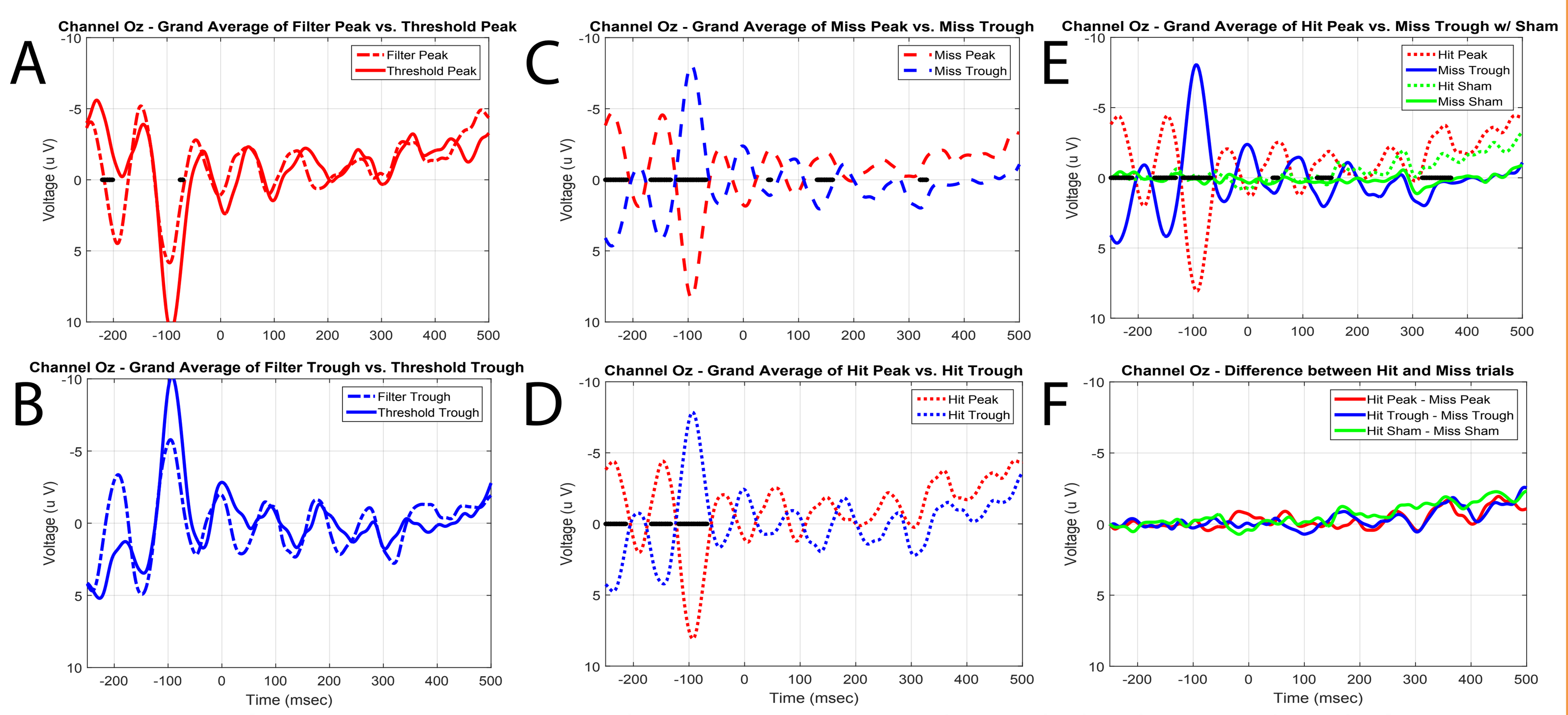
B

S#	Peak Detection	Trough Detection	Δ Detection
1	19.23%	21.05%	1.82%
2	71.97%	59.12%	12.85% **
3	50.00%	44.44%	5.56%
4	73.33%	70.73%	2.60%
5	46.75%	46.00%	0.74%
6	80.00%	81.48%	1.48%
7	58.16%	55.47%	2.69%
8	72.26%	69.06%	3.20%



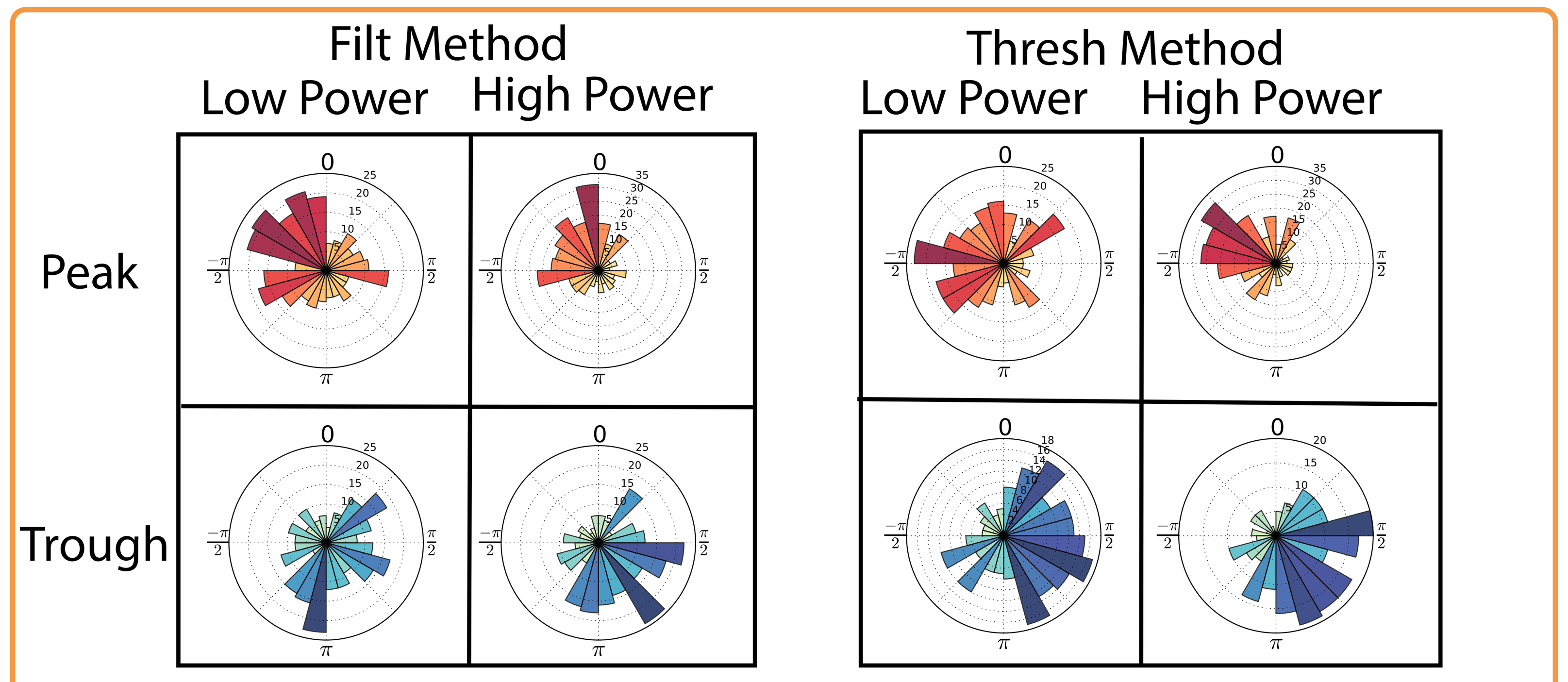
A) Behavioural performance depends on difference between online targeted and offline optimal mean phases. S7 excluded due to no preferred phase. **B) Behavioural data for all subjects. (**p<0.05) C) Subject 2 responded most to manipulation.** Subject 2's mean offline (Sham) optimal phases of Hit and Miss trials are best aligned with the mean Peak and Trough phases of online methods.

IV - Effect of Phase on ERP's



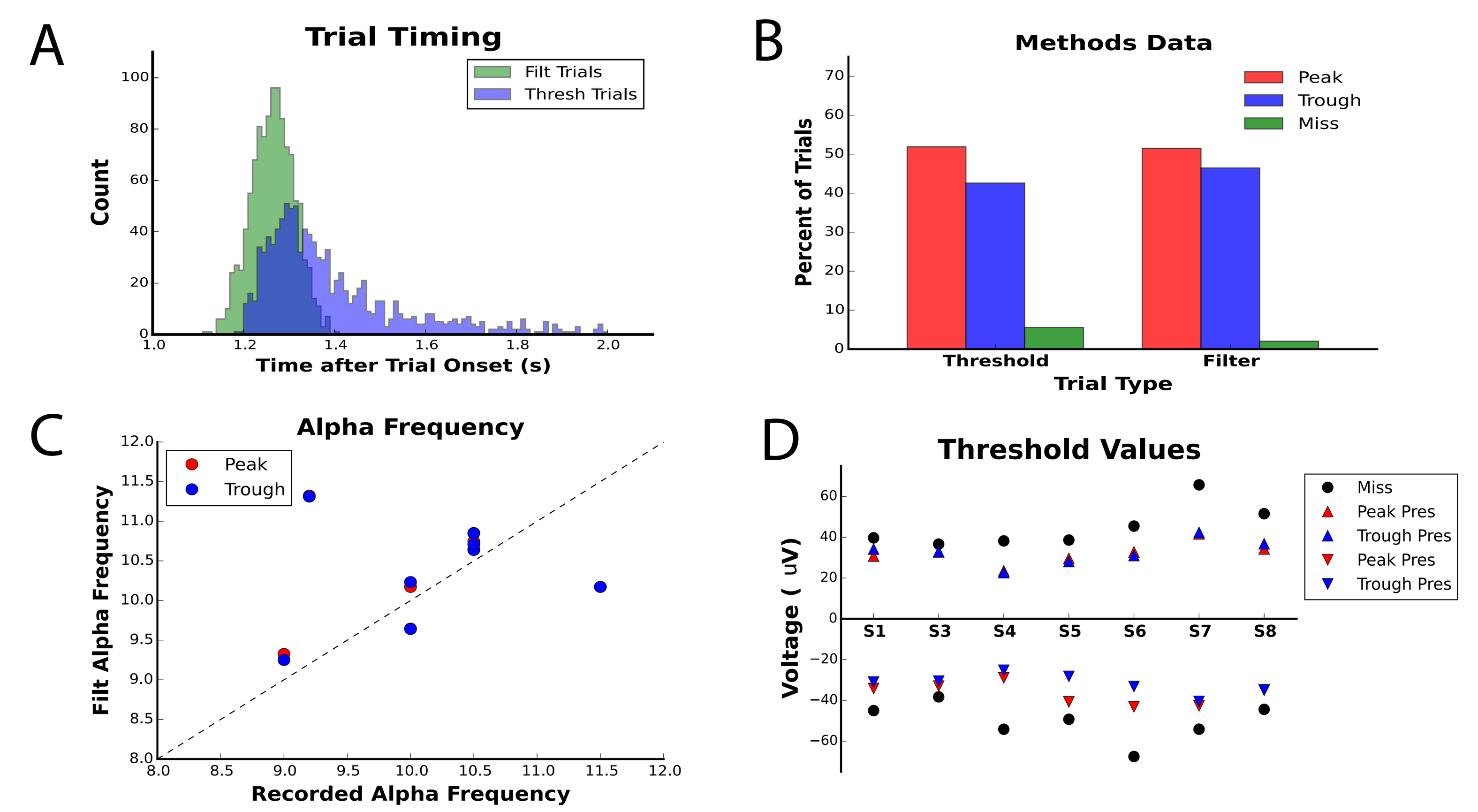
A&B) Comparing Filt and Thresh methods. The Filt and Thresh methods differed only slightly. **C&D) Effect of selective phase presentation within Hit or Miss trials.** Selective phase presentation may have more of a post-stimulus effect on Miss trials **E) Selective phase presentation compared to Sham trials.** Our manipulations may maximally differentiate Hit and Miss trials. Black axis indicates Hit Peak > Miss Trough (p<0.05). **F) Difference between Hit and Miss Trials.** Targeting both Peaks and Troughs has a trending impact on how Hit and Miss trials are differentiated via ERP amplitude.

V - Selective Presentation is Robust to Low Power



The effect of alpha power on selective presentation. We median split high and low power trials, and compared the Filt and Thresh methods in predicting a stable phase.

VI - Method Details



A) Trial durations. B) Peak, Trough, and Miss trial distributions for Filt and Thresh methods. Miss trials indicate when the method failed to detect a peak or trough. **C) Initial peak alpha identification.** We correctly identified peak alpha frequency from the recorded baseline period. **D) Subject specific threshold values for classifying Peak or Trough trials**

Conclusions

- Phase selective stimulus presentation is possible, with two distinct methods, at least for dominant oscillations such as posterior alpha.
- These methods are reasonably robust with regards to the power of the oscillation, and work in real time allowing for implementation with fast-paced behavioural tasks.
- These methods show promise for influencing behaviour (as hypothesized by work on phase effect of visual perception), however these methods may need to be adapted to allow presentation at specified phases, allowing for use of individually determined preferred phase.

Acknowledgements

Thanks to Professor Virginia DeSa for support on this project, and to Joshua Stivers, Will Fox, Torben Noto and Tammy Tran for help with data collection.

References

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Alfred P. Sloan Foundation