Successful Classification of Attentional Tasks by Power Modulations in the Alpha Frequency Bandwidth

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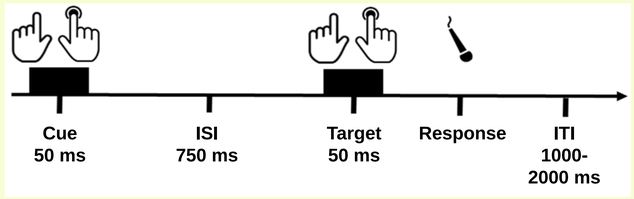
Highlights

- **Three attentional tasks known to modulate alpha oscillations used**
- **Random forest classifier trained on alpha modulations**
- **EEG data given to the machine is during the cue-target interval only**
- **Amplitude modulations in the alpha frequency contain sufficient information to successfully categorise the attentional task.**
- **Information in the 300-400ms interval provides most successfully categorises tasks.**
- **Alpha information facilitates classification in the early time window.**

Background

- Oscillations in the alpha frequency range (8-14Hz), measured using EEG, have been shown to have a functional role in cognition, attention in particular.
- Several different tasks have been used in order to generate and measure alpha oscillations.
- Voluntarily shifting attention and orienting attention in response to stimuli to one side of space leads to a differential change in alpha activity over the lateral somatosensory hemispheres (Haegens et al., 2011).
- We examined data already published exploring ERP correlates or attentional processes in touch (Jones & Forster, 2014).
- We sought to ask whether alpha power measured at electrodes over the somatosensory cortex contained sufficient information to categorise the attentional processes engaged in by the participant.

Design and Procedure



The experiment consisted of 13 blocks; 5 endogenous predictive, 5 endogenous counter-predictive and 3 exogenous. Each block consisted of 112 trials. 8 trials (~7%) contained no target (catch trials) and 4 trials (~4%) contained a short ISI (< 500ms; fast-fillers).

Endogenous tasks
In each block, 80 trials (~71%) the cue was predictive of the target location (expected trials) 20 (~18%) trials the cue did not predict the target (unexpected trials).

- **Endogenous predictive task:** the cue informed the participant that the target would appear in the same location as the cue.
- **Endogenous counter predictive task:** the cue informed the participant that the target would appear in the opposite location to the cue.

Exogenous task
In each block, for 50 trials the cue and target appeared at the same location and for 50 trials the cue and target appeared in opposite locations.

Participants
12 paid participants (10 – right handed)

EEG recording & data analysis

Recording & pre-processing

- 32 Electrodes + 2 HEOG.
- 500 Hz Sampling rate
- Filter 0.1-40Hz
- Artefact rejected (±80μV)
- Eye movements rejected (±40μV)

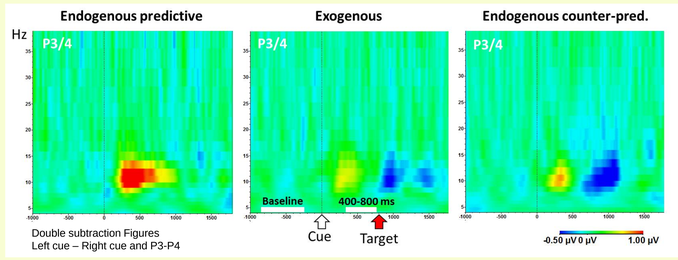
Wavelet Analysis

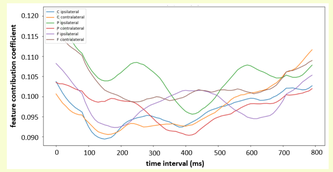
- Analysis based on -1000 to 2000ms long segments based on cue onset (0 ms).
- Wavelets (Morelet Complex, c=5) 4-40Hz, 20 log. spaced steps. Baseline corrected -760-240 ms
- Alpha layer extracted: 8.4-12.7Hz with a central frequency of 10.6Hz for each trial for cue target interval in 100 ms intervals.

Random Forest Classification

- Data were divided into 100 ms chunks in the cue target interval.
- For each interval, data were randomly split into training (90%) and test (10%).

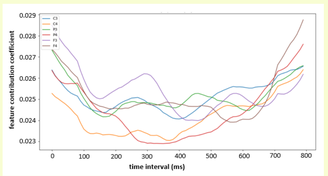
Results & Conclusions

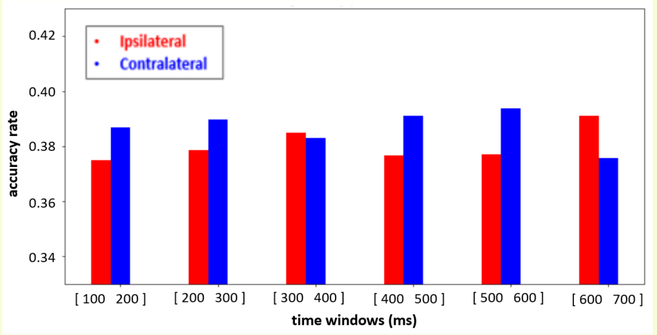


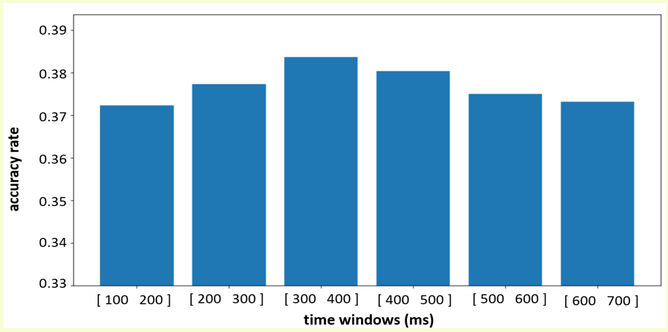


The contribution of each feature in the ML model as a function of time for ***lateralised modulations***

The contribution of each feature in the ML model as a function of time for each ***electrode***

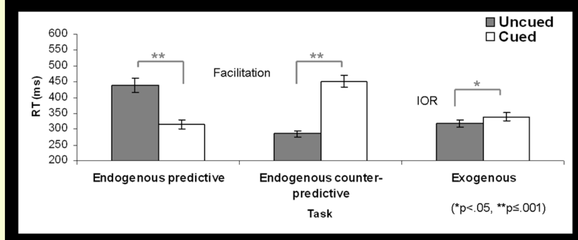






Behavioural performance

Participants showed facilitation of attended targets in the endogenous task and inhibition or return in the exogenous task.



- Behavioural data robustly replicates facilitation with endogenous tasks and inhibition of return for exogenous tasks.
- Alpha power changes in the cue-target interval is sufficient to classify one of three perceptually identical tasks.
- The classification of tasks was highest in the 300-400 ms window, suggesting attentional processes are reflected in the alpha changes in this time window, more than others.
- Alpha information contralateral to the attended side better informed classification in most time intervals with the exception of the very latest time interval (600-700 ms).

References:
Haegens, S., Händel, B. F., & Jensen, O. (2011). Top-down controlled alpha band activity in somatosensory areas determines behavioral performance in a discrimination task. *Journal of Neuroscience*, *31*(14), 5197-5204
Jones, A., & Forster, B. (2014). Neural correlates of endogenous attention, exogenous attention and inhibition of return in touch. European Journal of Neuroscience, 40(2), 2389-2398.

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