Patterns of pre-cue alpha power predict the decision about where to attend in willed attention

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Introduction

- In the classical cued visual spatial attention paradigms, each trial starts with a cue, which instructs the subjects to focus attention on a spatial location in order to process an impending stimulus.
- Attention can also be allocated by purely internal decisions, such as when subjects are asked to spontaneously decide where to attend (willed attention).
- fMRI studies have shown that the decision about where to attend activates a frontoparietal control network consisting of regions such as dorsal ACC, anterior insula, dorsal lateral PFC and inferior parietal lobule.
- Bengson et al. (2014) further reported that lateralized EEG alpha power over occipital-parietal cortex immediately before the decision predicted the decision about where to attend.
- In this study, we examined the underlying neural mechanisms by analyzing data recorded at two institutions using the same paradigm (UF and UCD).

Methods

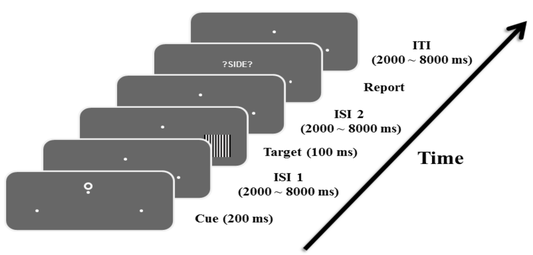

Fig.1. Experimental paradigm

- Each trial started with a visual cue. Instructional cues directed the subjects to covertly pay attention to either the left or right visual field, while choice cues, 33% of all trials, prompted the subjects to choose the side of the visual field to attend.
- EEG data were recorded in two different locations: UF (N=13) and UC Davis (N=19).
- fMRI data were recorded with EEG simultaneously at UF.
- EEG data were pre-processed with EEGLAB. fMRI data were pre-processed using SPM.
- Linear support vector machines (SVM) were used to perform MVPA to decode the attended spatial location (attend left versus attend right).
- The main focus was on whether multielectrode patterns of alpha power in the time period of -500 ms to 0 ms predicted the decision to attend. Other frequencies between 5 Hz and 25 Hz were also considered. Here 0 ms denoted cue onset.
- We also computed the decoding accuracy from -2000 ms to 0 ms as a function of time using patterns of alpha power (moving window size = 500 ms, step size = 20 ms) to examine the time course of predicting the decision about where to attend.
- In addition, we divided the subjects into two groups: low pre-cue alpha decoding accuracy group and high pre-cue alpha decoding group, and compared the BOLD activation evoked by the choice cue in the frontoparietal control network.

Results

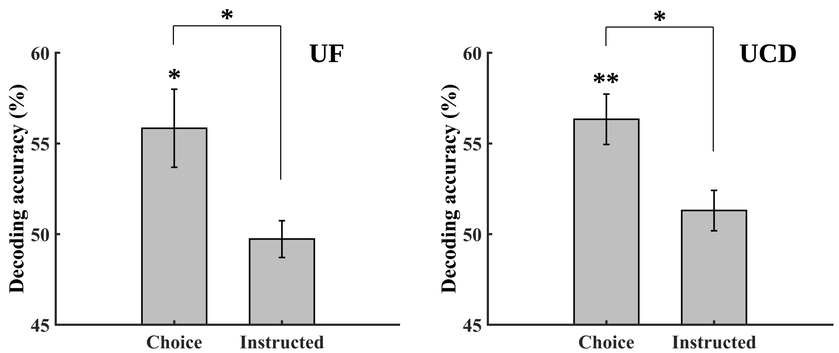

Fig. 2. Alpha power decoding accuracy over interval -500 ms to 0 ms. Left: UF data. Right: UCD data. *: $p < 0.05$, **: $p < 0.01$.

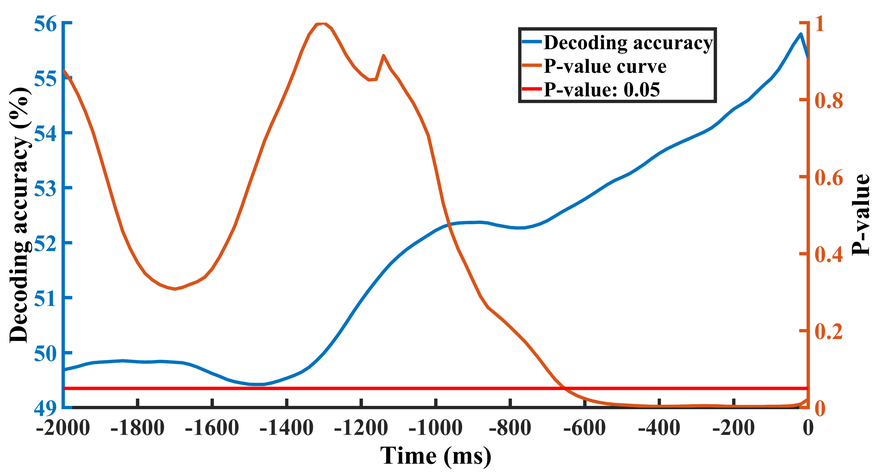

Fig. 3. Alpha power decoding accuracy as a function of time from -2000 ms to 0 ms. Here UF data and UCD data were combined via meta-analysis.

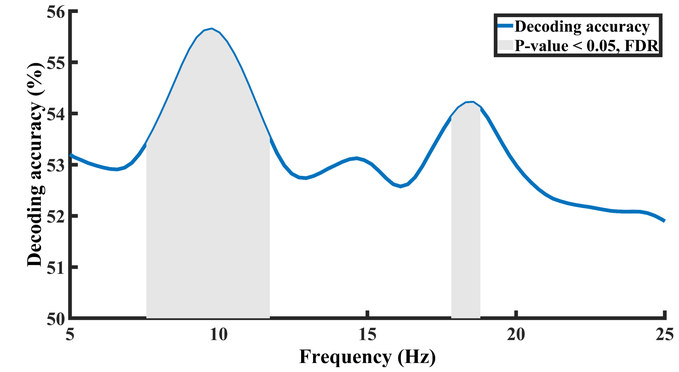

Fig. 4. Decoding accuracy spectrum in (-500 ms, 0 ms). UF data and UCD data were combined via meta-analysis. Frequencies where decoding accuracy is above chance (FDR corrected) are shaded.

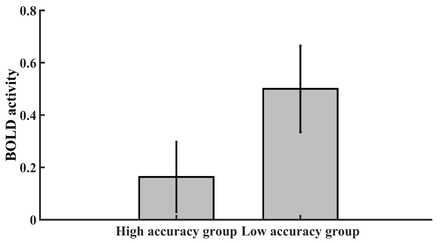

Fig. 5. Frontoparietal BOLD activation evoked by choice cue in two groups of subjects. Left: subjects with high pre-cue alpha decoding accuracy. Right: subjects with low pre-cue alpha decoding accuracy. Groups were determined via median split in alpha decoding accuracy over -500 ms to 0 ms.

Summary and Discussion

1. Consistent across two datasets, multichannel patterns of EEG alpha power in the interval -500 ms to 0 ms prior to the onset of choice cue predicted the decision about where to attend, substantiating Bengson et al. (2014) finding obtained with a different approach.
2. BOLD activity in the frontoparietal willed attention control network evoked by the choice cue was lower for subjects with higher pre-cue alpha decoding accuracy.
3. These results demonstrate that (1) independent of goal-directed or bottom-up sensory factors, spontaneous brain states influence how humans focus attention and (2) pre-cue brain states and cue-evoked brain activity interact to bring about the decision about where to attend.

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