Neural correlates of stimulus expectations in somatosensory perception

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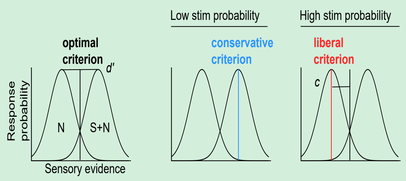
Introduction

- according to Bayesian integration theory, perception is a combination of prior beliefs and sensory signals [1]

- signal detection theory [2] defines two parameters for perceptual decision making:
  *the ability to distinguish signal from noise (d')
  *the threshold to respond to either signal or noise (c)



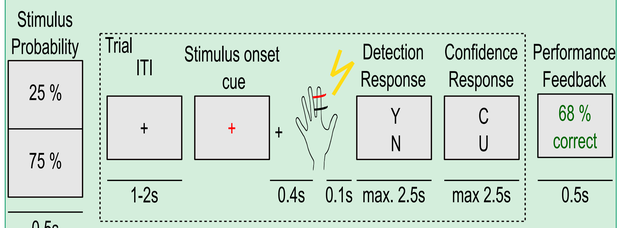
- a previous study could show that participants adjust their threshold to respond, as well as their confidence ratings in a visual detection task according to cued stimulus probabilities [3]

- alpha power in the prestimulus window correlates with the response criterion [4]

- only two studies have experimentally induced a criterion change and shown divergent results in prestimulus alpha power [5, 6]

- whether the different ways of manipulating response criteria (priming vs. reward contingencies) accounts for this divergence, and whether this is a general principle applicable to other sensory systems remains unknown

Paradigm



Hypotheses

- participants use a more conservative response criterion in the low stimulus expectation condition

- participants give higher confidence ratings in trials where the response matches the expectation
  (e.g. higher confidence in high stimulus probability trial for yes response)

- lower prestimulus power in the prestimulus window in the high stimulus probability condition

- the prestimulus power change to correlate with the criterion

Methods

- 43 participants (21 female), 720 trials in 5 blocks (360 signal trials), 64 channel EEG, ECG, respiration, experimental conditions: high/low stimulus probability, IV: intensity, condition, DV: response, confidence, response time

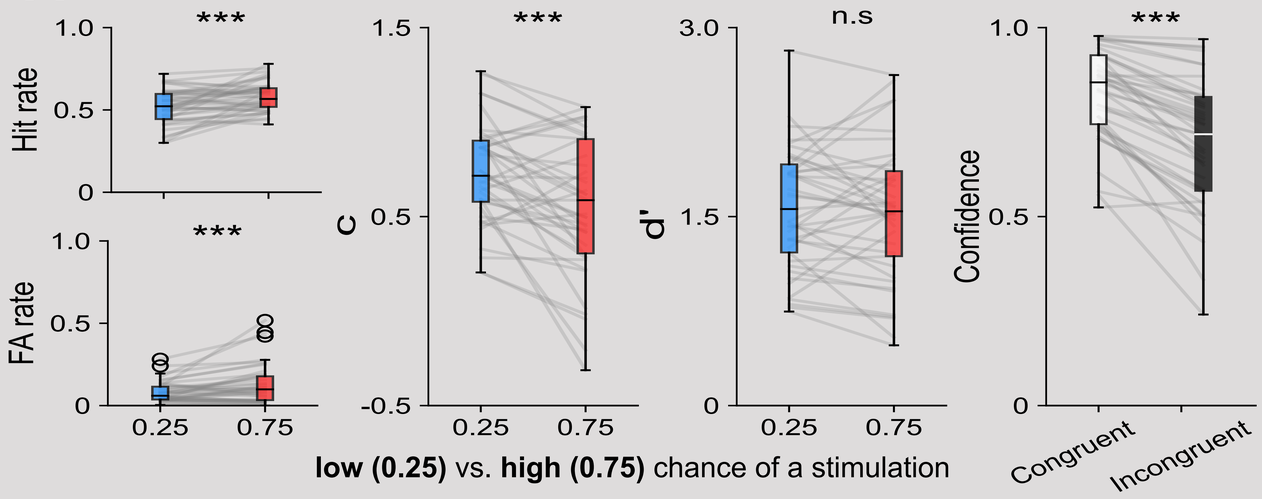
- EEG data preprocessing and analysis: mne python [10.5281/zenodo.7226631] preprocessing pipeline: epoching, bandpass filter 1-40Hz, downsample to 250Hz, Ransac package to detected bad channels, interpolation, fastica to discard EOG and cardiac artifacts, rereferencing to average

- evoked analysis: laplace filter, equalize number of epochs between conditions, define somatosensory channels based on signal - noise contrast around P50, average over conditions and channels or run spatio-temporal cluster test

- induced time-frequency analysis: subtract evoked response, power calculation using Morlet wavelets with 4 cycles / frequency and a 1 Hz resolution, cluster permutation over time and frequencies in prestimulus time window, single trial prestimulus power extraction in the alpha [7-13] and beta [15-30] band
- permutation tests with 10000 permutations and p < .05

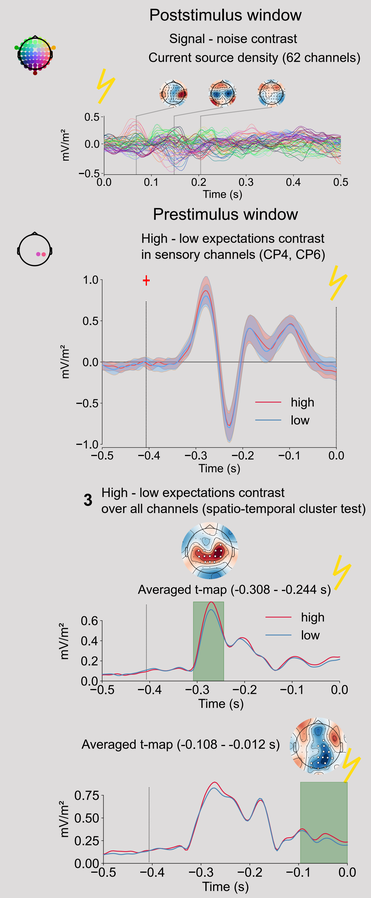
Analysis scripts available at https://github.com/CarinaFo

A Behavioral results



Neural results

B Evoked potentials

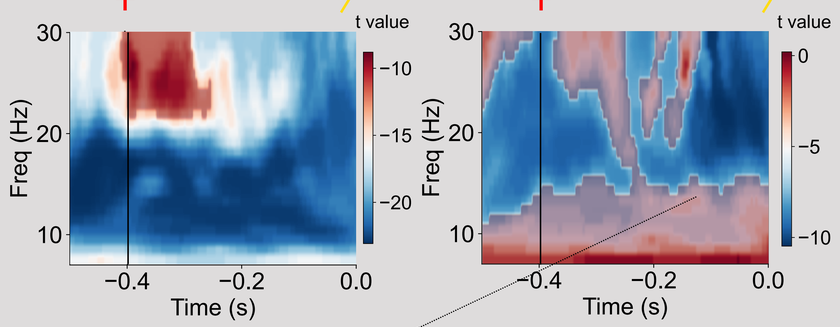


C Induced time frequency representation

Detected - undetected trials

High - low expectation trials

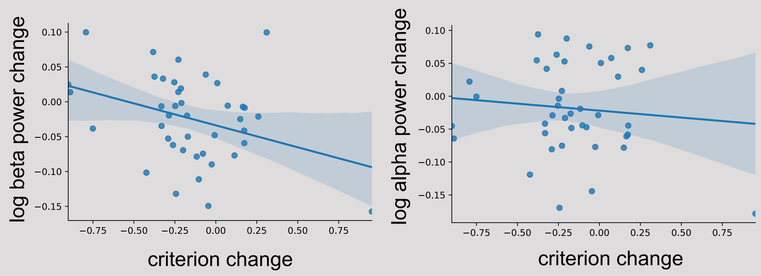
cluster permutation test with cluster-free threshold enhancement



D Brain-behavior

criterion change and prestimulus beta power correlation: pearson *r* -0.34, *p* = 0.03

criterion change and prestimulus alpha power correlation: pearson *r* -0.1, *p* = 0.51



Discussion

A Behavioral results

Human observers adjust their decision criterion and confidence ratings depending on stimulus probabilites.
While the majority of participants (31) change their decision criterion according to stimulus base rates, the extent of the change is variable.
Stimulus probabilities have a stronger effect on confidence ratings.

B Neural results - evoked potentials

Cue evoked potentials in sensory channels do not differ between high and low stimulus expectations.
A cluster permutation test over all channels and prestimulus timepoints (-0.5s to stimulus onset) reveals
two significant cluster:
- a cluster from 200 to 300 ms post stimulus onset cue in central electrodes
- a cluster from 100 ms to stimulus onset in right posterior electrodes

C Neural results - induced TFR

A time-frequency cluster permutation test over the contrast of detected-undetected trials in sensory channels reveals a significant cluster in the alpha/ beta range over the whole prestimulus window, with lower power in detected trials.
Contrasting high with low stimulus expectation trials, shows decreased beta power in the high expectation condition around stimulation cue onset as well as close to stimulation onset.

D Brain-behavior

The change in criterion correlates negatively with the change in prestimulus beta power (15-30 Hz, 100 ms before stimulation onset).
We found no significant correlation between alpha power and criterion change.

Open questions

- does modelling single trial power with a SDT linear mixed effects model yield stronger effects on criterion?
- does beta power depend on the previous trials choice?
- does beta power also predict confidence on a single trial level?
- what is the behavioral relevance of the cue evoked potential differences in central and posterior areas?

References

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