Encoding- and decision-related brain activity during a motion judgment task

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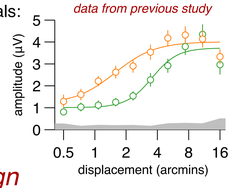
Background

here we recorded event-related EEG while participants performed a movement discrimination task, with 2 goals:

(1) assess the time course of interocular suppression measured in previous steady-state experiments[1]

(2) connect trial-wise variability in brain responses to behavioral variability in perception of movement



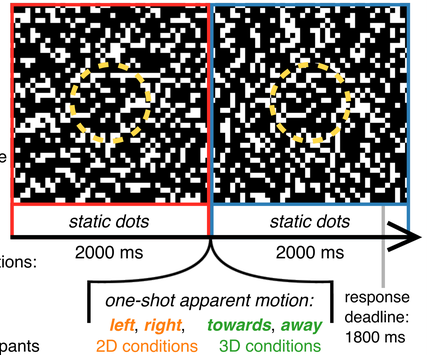
Experiment Design

random-dot patterns were presented stereoscopically such that a central disk region underwent one-shot apparent motion

dot displacement: 4 arcmin
disc radius: 2.5°/visual angle

interocular phase was manipulated to make the motion consistent with movement in one of 4 directions: left, right, towards or away from the observer

we recorded EEG as participants (n = 17) performed a 4AFC task judging the movement direction

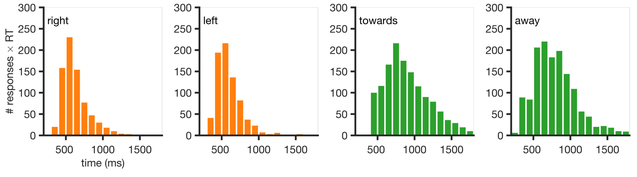


Behavioral Performance

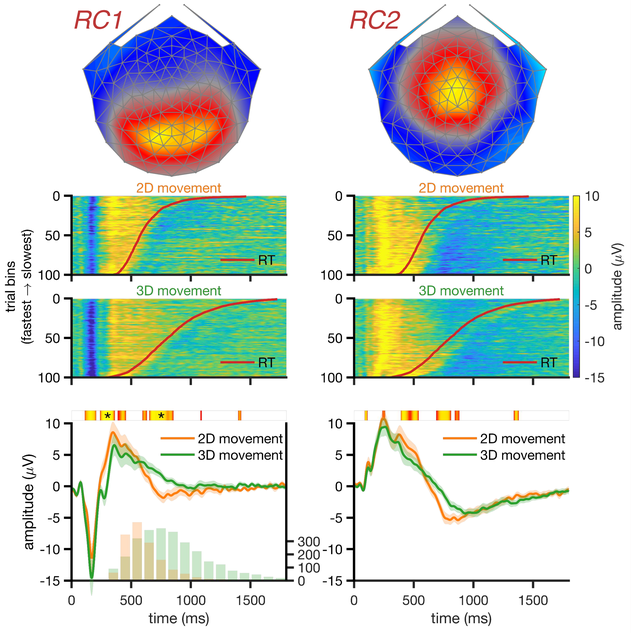
participants performed better for 2D compared to 3D, with the 3D conditions proving extremely difficult for some participants

4 of 17 participants were unable to do the 3D task, with accuracies < 60 % for the 3D conditions, and were excluded from further analysis

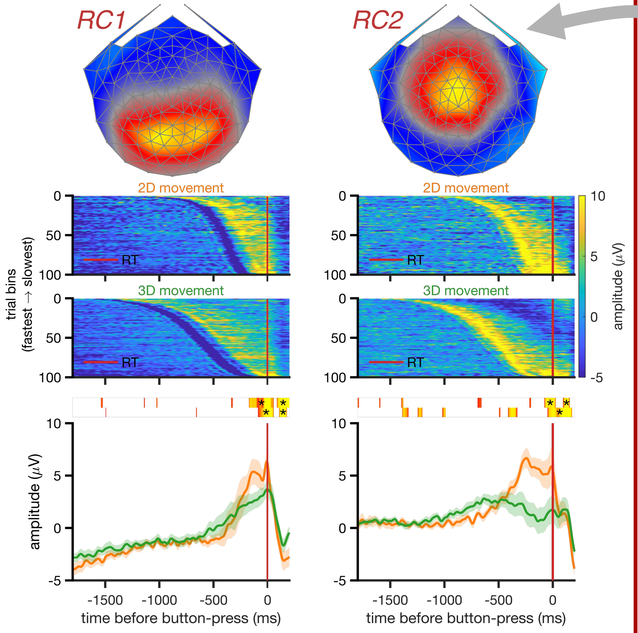
accuracies were lower for 3D, and RTs were longer and more variable



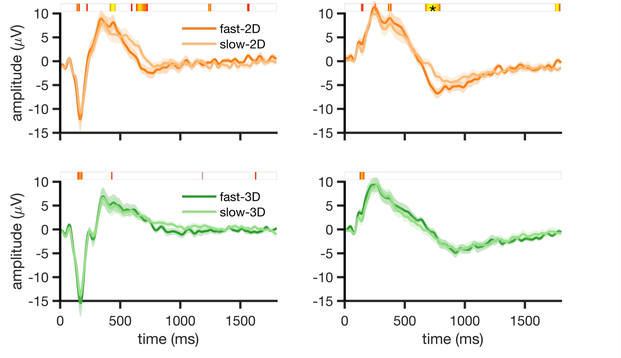
Stimulus-locked analysis



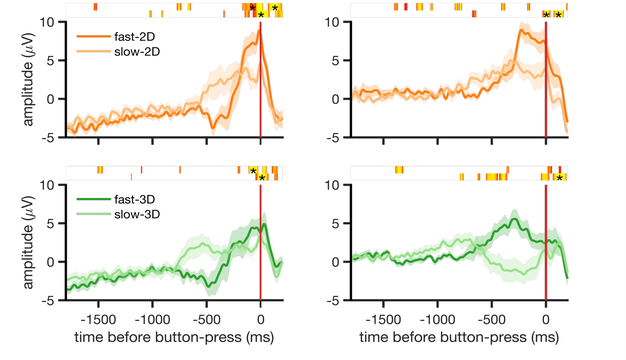
Response-locked analysis



Splitting by Response Timing

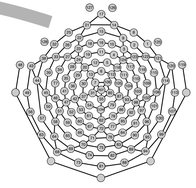


orange-yellow bars indicate significance of paired t-test comparing the two waveforms. Orange indicates $p < 0.05$, yellow indicates increasingly smaller p



orange-yellow bars indicate significance of paired t-test comparing each waveform to a waveform generated from the same data, but with shuffled RTs

Reliable Components Analysis



A method of spatial dimensionality-reduction[2] that maximizes between-trial covariance and produces physiologically plausible spatial filters.

Trained on stimulus-locked data from the first 500 ms after the one-shot apparent motion.

Here we focus on the first two components, which explain ~40% of the variance in the data

Results Summary

RC1

Early, transient responses (at ~160 ms) are enhanced for 3D conditions

Later, more sustained suppression of 3D conditions from ~250-450 ms, consistent with prior results[1]

Slower return to baseline for 3D than 2D (possibly RT-related)

Decision-related activity can be observed at least as early as 175ms before button-press for 2D and 90 ms before button-press for 3D

RC2

Evidence of both suppression of 3D movement and RT-related slower return to baseline

Decision-related activity mostly observed at or after the button-press

Conclusions

Our results suggest that the interocular suppression previously measured using steady-state experiments[1] can be replicated under the open-loop conditions present in the current event-related experiment

Prior results indicate that suppression depends on second-order processes, including extraction of relative motion and disparity[1], consistent with the relatively late onset of suppression observed here

RT-related variability occurred later than suppression, and mainly for 2D condition

Response-locked analyses revealed decision-related activity that clearly preceeded the button-press for 2D, while the effects were more ambigiuous for 3D.

The results provide a first step towards a time-resolved electrophysiological analogue to psychophysical data showing that temporal integration underlying decision making is sub-optimal for movement in depth[3]

References

[1]Kohler PJ, Meredith WJ, Norcia AM (2018) Revisiting the functional significance of binocular cues for perceiving motion-in-depth. *Nature communications* 9:3511.

[2]Dmochowski JP, Greaves AS, Norcia AM (2015) Maximally reliable spatial filtering of steady state visual evoked potentials. *NeuroImage* 109:63-72.

[3]Katz LN, Hennig JA, Cormack LK, Huk AC (2015) A Distinct Mechanism of Temporal Integration for Motion through Depth. *The Journal of Neuroscience* 35:10212-10216.