Neural Correlates of Accuracy and Confidence during Realistic Decision-Making

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Background

- Every decision we make is accompanied by a degree of **confidence** (i.e., probability of correct decision)
- Neural markers of confidence are present in EEG signals [1] and could be used with machine learning to augment individual and group decision-making [2] in *controlled* environments

Aim – Decoding decision confidence from EEG signals in a realistic environment

Methods – EEG-fMRI study of decision-making in pandemic scenarios

Task: decide what region was most in danger during a pandemic

- 180 trials split into 6 blocks of 30 trials

Simultaneous EEG-fMRI data acquired on eight participants

- 128 EEG electrodes (EGI GES 400)
- fMRI data (3T) not analyzed in this study

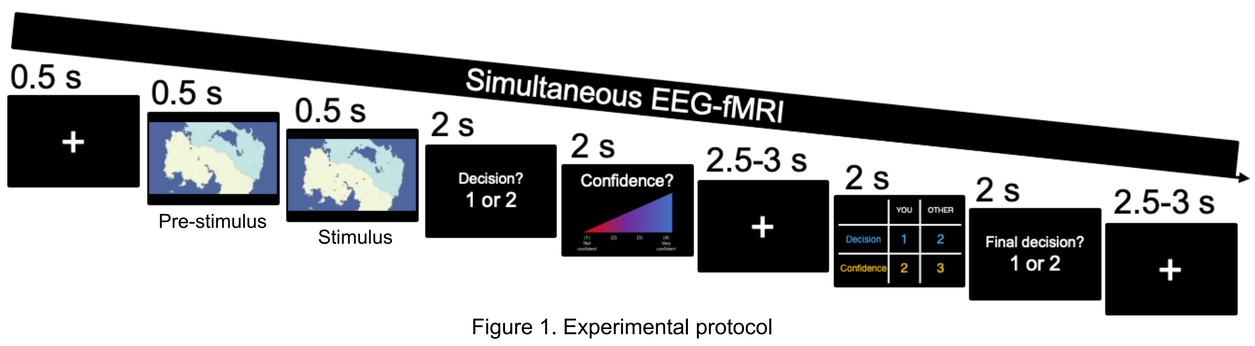

Figure 1. Experimental protocol

EEG data processing

- Removed gradient artifacts using template subtraction
- Ballistocardiographic artifacts removed with optimal basis sets [3]
- Data band-pass filtered (0.5-40 Hz) and segmented into stimulus-locked epochs of 1 second
- Epochs grouped by accuracy (correct vs. incorrect response) and confidence (low vs. high confidence)

Statistical analysis

- Wilcoxon signed-rank test ($p < 0.05$) between subject averages in each group

Results – Distinct neural markers of accuracy and confidence in occipital region

Neural markers of **accuracy** (correct vs. incorrect responses) peak at 550 ms from the onset of the pre-stimulus in the **bilateral occipital cortex**

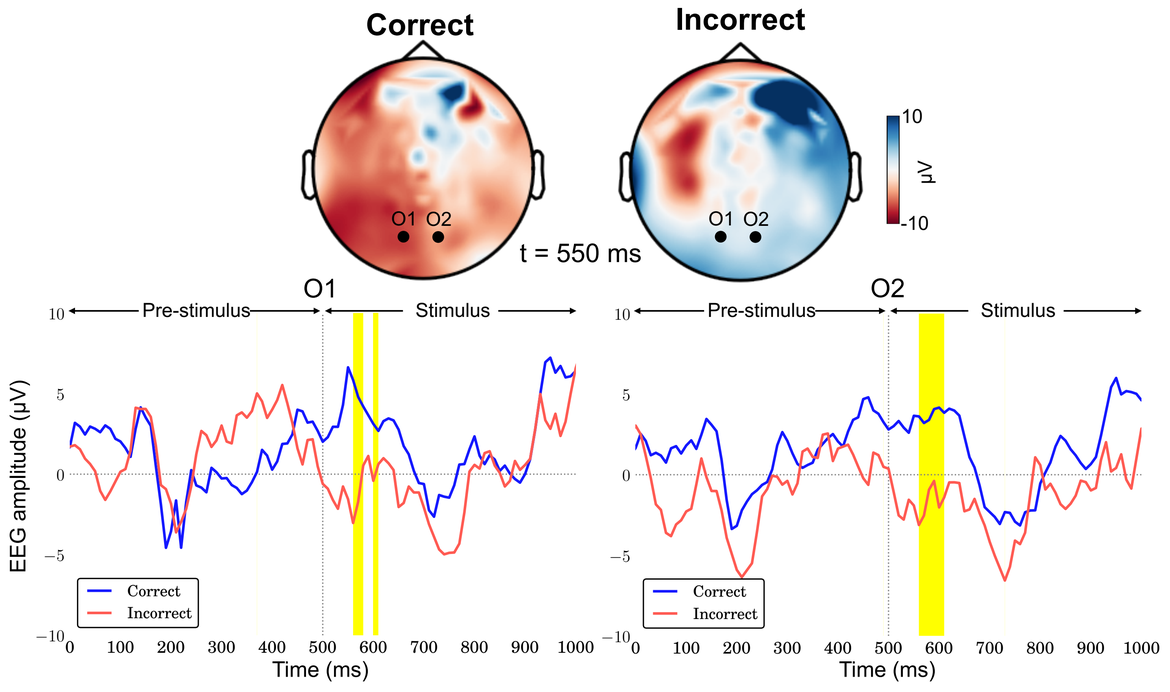

Figure 2. (Top) Scalp maps show the average voltage recorded in correct and incorrect trials across participants at different electrode locations. (Bottom) Grand average of EEG signals recorded at occipital locations O1 and O2. Yellow areas represent time samples where correct and incorrect averages were significantly different (p<0.05).

Neural markers of **confidence** (low vs. high) peak at 330 ms and 900 ms from the onset of the pre-stimulus in the **left occipital cortex**

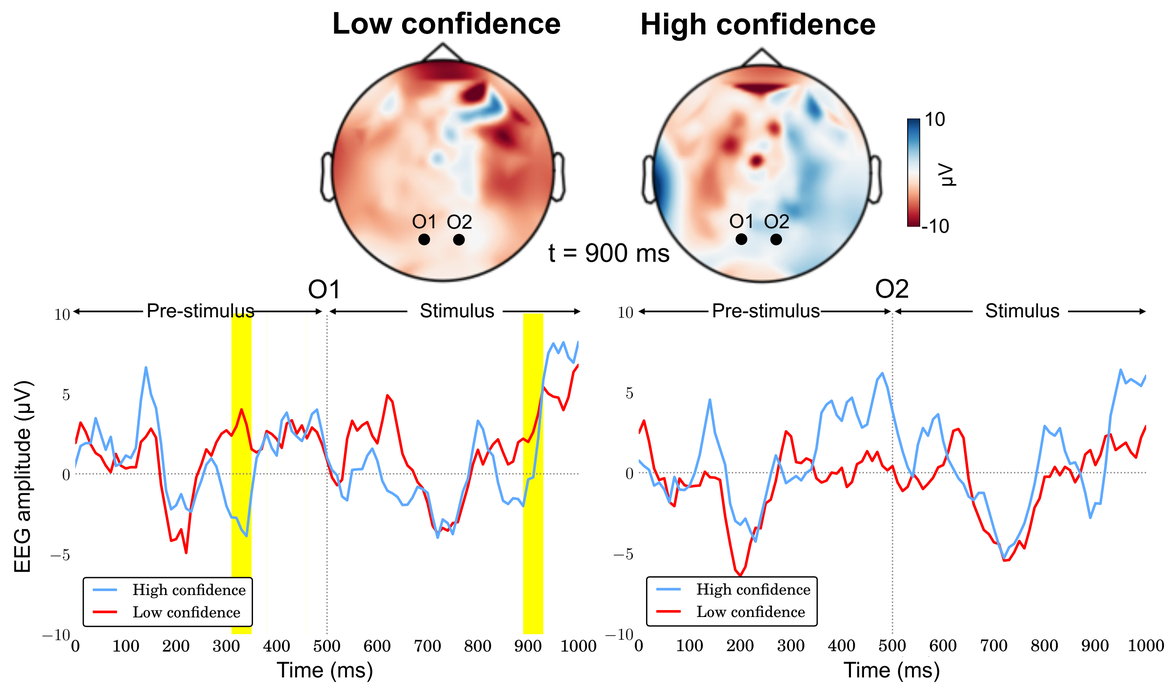

Figure 3. (Top) Scalp maps show the average voltage recorded in low confidence (1 or 2) and high confidence (3 or 4) trials across participants at different electrode locations. (Bottom) Grand average of EEG signals recorded at occipital locations O1 and O2. Yellow areas represent time samples where low and high confidence averages were significantly different (p<0.05).

Conclusions and Future Work

- Distinct neural patterns of accuracy and confidence found in the occipital region [4,5]
- Confidence and accuracy could be decoded even in realistic environments during critical decision-making tasks
- This work could enable the development of brain-computer interfaces for optimal decision-making [2]
- Future work: combine EEG and fMRI data for optimal accuracy and confidence decoding

References

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