Brain-Computer Interfaces for Optimal Human-Machine Collaboration

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Background

- BCIs can be used to improve group decision-making in human and human-machine teams [1-3]
- Receiving advice from others could be beneficial [4] or detrimental [1] to decision-making performance

Aim – Neural correlates of openness to advice in realistic decision-making

Methods – Team decision-making in pandemic scenarios

Task: decide what geographic region was most in danger during a pandemic (6 blocks of 30 trials, Fig. 1)
Feedback: after each decision, participants saw the decision and confidence of an artificial agent on that trial (Fig. 1)
Neural data acquired from 128 EEG electrodes (EGI GES 400) on 14 participants (7 females, age = 42.7 ± 12.6 years)

- *Preprocessing*: band-pass filter (1-40 Hz), subsampling (50 Hz), artifact rejection (discard trials with amplitudes > 5 mV)
- Epochs extracted from the feedback display and lasting 1000 ms; baseline correction with mean voltage 100 ms before feedback

Openness to advice: epochs grouped by whether users changed their decision ("trust") or not ("distrust") after seeing a disagreeing opinion from the artificial agent
Statistical analysis: Wilcoxon signed-rank test ($p < 0.05$) between subject averages in each group

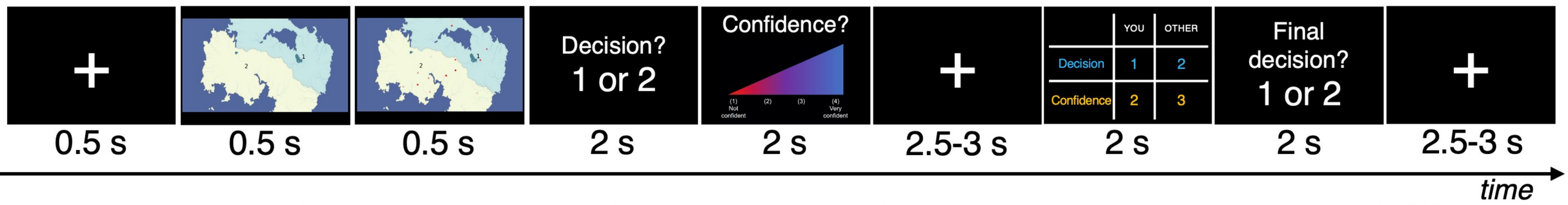

Figure 1. Experimental protocol. Participants were presented a fictional geographical map of two regions with dots representing endemic cases for 500 ms. They were asked to decide which region was most in danger and estimate their confidence level in their decision using a keypad. They then received a feedback about the decision and confidence of an artificial agent on the same task, and finally had the chance to change their response or confirm it.

Results – Neural correlates of openness to advice

- Differences between trust and distrust trials **peak between 150 ms and 350 ms** after receiving feedback (Fig. 2A)
- **Left parietal and occipital electrodes** (P7, P3, O1) correlated with openness to advice (Fig. 2B)

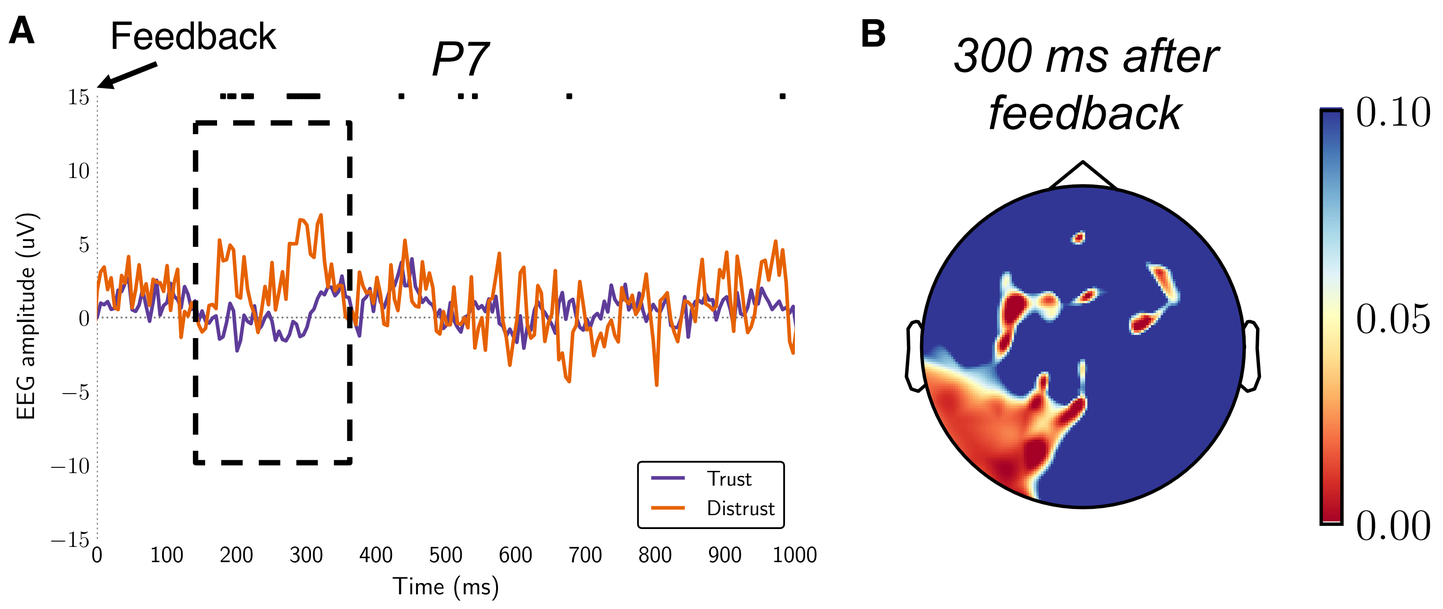

Figure 2. Neural correlates of openness to advice. (A) Grand average EEG epochs comparing trust (openness to advice) and distrust (refusal of changing mind) trials. Black dots on top show when the two grand averages are significantly different ($p < 0.05$). Dashed rectangle highlights the range 150-350 ms. (B) Scalp maps representing the p value of the Wilcoxon signed-rank test comparing trust vs. distrust trials at 300 ms after receiving feedback

Conclusions and Future Work

- Neural correlates of openness to advice (feedback) are localized to the left parietal and occipital regions
- These results could inform whether receiving advice would be beneficial in decision making, and enable the development of brain-computer interfaces for **optimally-collaborating machines** [3]

[1] Valeriani, D., Cinel, C., & Poli, R. (2017). Group augmentation in realistic visual-search decisions via a hybrid brain-computer interface. Scientific reports, 7(1), 1-12.
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