WALKING IMPROVES THE PERFORMANCE OF A BRAIN-COMPUTER INTERFACE FOR GROUP DECISION MAKING

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ABSTRACT: We show that walking on a treadmill improves the performance of an EEG-based collaborative brain-computer interface (cBCI) for assisting group decision making.

INTRODUCTION

Collaborative brain-computer interfaces (cBCIs) have been used to improve group decision making thanks to their ability to estimate the decision confidence of individuals from their brain signals and response time (RT) [1-3]. However, previous studies used the cBCI in controlled lab conditions, where users performed limited muscular activity while making decisions. Here, we developed and tested a cBCI in situations where users perform decision-making tasks while walking on a treadmill.

METHODS

Ten participants were presented with video sequences (frame rate = 4 Hz) of a dynamic environment representing the viewpoint of a user walking at a constant pace along a corridor, where characters could appear from side doorways for one frame (Fig. 1 (left)). In each trial, the participants had to decide whether the character was wearing a helmet or a cap within 2.5 s. After reporting their decisions, participants had to indicate their degree of confidence using an 11-point scale (from 0=not confident, to 100=very confident) within 2 s. The experiment was composed of 12 blocks of 42 trials: six blocks where the participant was walking on a treadmill in a leisurely manner (2 km/h), and six blocks where he/she was sitting on a comfortable chair, in a counterbalanced order. A Biosemi ActiveTwo EEG system was used to record the neural signals from 64 electrode sites following the 10-20 international system. The EEG data were sampled at 2048 Hz, referenced to the mean of the electrodes placed on the earlobes, and band-pass filtered between 0.15 to 40 Hz to reduce electrical noise. Decision confidence was estimated by logistic regression using the RT and two neural features, extracted by applying Common Spatial Patterns filters to low-pass filtered (16 Hz) response-locked EEG epochs starting 1 s before the response and lasting 1.5 s. The data collected from the participants were then combined off-line to form all possible groups of increasing size.

RESULTS

Fig. 1 (right) shows the mean accuracies for group sizes one to five using either standard majority (black) or a weighted majority using the confidence reported by the participant after each decision (blue) or the confidence estimated by the cBCI (red), for the walking (solid lines) and sitting (dashed lines) conditions. This shows that cBCI and reported confidence produce similar results, but walking improves the group performance statistically significantly ($p < 0.03$ for Wilcoxon signed-rank tests) for reported confidence and cBCI when compared to the corresponding sitting conditions.

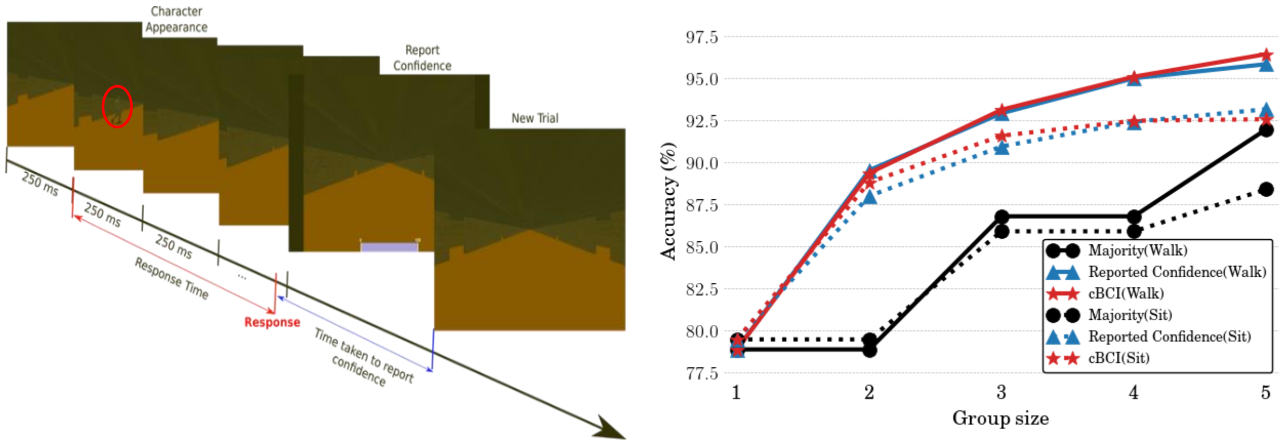

Figure 1. Example of sequence of stimuli used in one trial of the experiment. Average group accuracies for groups of size 1 to 5 using standard majority (in black), reported confidence (in blue), and cBCI (in red) while sitting (dashed lines) and walking (solid lines).

CONCLUSIONS

While muscular artefacts caused by walking on a treadmill could be expected to produce negative effects on the ability of the cBCI to decode the decision confidence of users, the similarity between the cBCI and reported confidence performance in both the walking and sitting conditions indicates otherwise. Instead, we found that walking improves group performance in the task considered in this paper, which is likely due to increased level of alertness, leading to overall better performance, in the walking conditions. This suggests that the cBCI may work well on a wider range of operating environment than just a lab.

REFERENCES

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