Improving Speech Perception with Collaborative Brain-Computer Interfaces

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***Abstract*— Collaborative brain-computer interfaces (cBCIs) have shown potential to improve group decisions with visual stimuli. This paper proposes a cBCI that assists and improves group decisions in a speech perception task. Neural features extracted from left-temporal-lobe EEG signals and response times were used to estimate the confidence of each individual in each decision and weigh that accordingly. The performance of the cBCI was compared with that of non-BCI groups using traditional majority voting. Results obtained with 10 participants showed that the cBCI acts as a tie-breaker and achieves significantly better decisions for all even group sizes.**

I. Introduction

Brain-computer interfaces (BCIs) convert neural data into commands, allowing users to control devices without using muscles [1]. Recently, collaborative BCIs (cBCIs) have been used for human augmentation, in particular for improving group performance in *visual perception* tasks [2][3].

Here we investigate the possibility of using a cBCI to improve *speech perception* in a task where participants listen to spoken sentences affected by noise and decide whether or not specific target words were uttered within each sentence. Group decisions were made by using a confidence estimated by the cBCI using neural signals and response times (RTs).

II. Methods

Ten native English speakers healthy volunteers (aged 24.9 ± 4.9, 2 females) participated in the experiment after giving written consent. They were presented with a series of spoken sentences including between 4 and 20 words (mean = 9.3 ± 2.8 words) and were asked to decide whether or not one of the following target words was uttered: route, check, grid, lookout, side, trucks, village. Participants memorised the set of target words by performing a practice preliminary task.

In each trial, the participant was shown a fixation cross for 1 s followed by an audio recording affected by various types of noise. Then, the volunteer was asked to indicate whether a target word was present or not by clicking the left or the right mouse button, respectively. The mouse was controlled using the preferred hand. RTs measured from the stimulus onset were recorded. Sentences containing one of the target words were presented in 50% of the 320 trials performed in the experiment. The same sequence of audio tracks was used in the experiment for all participants in order to be able to simulate offline concurrent group decisions.

A Biosemi ActiveTwo EEG system was used to record neural signals from 64 electrode sites sampled at 2048 Hz. The data were referenced to the mean of the electrodes placed on the earlobes, band-pass filtered between 0.15 and 40 Hz, low-pass filtered at 6 Hz and down-sampled to 32 Hz. Neural features were obtained by applying common spatial patterns to the epochs starting 1 s before the user's response and lasting 1.5 s extracted from EEG data recorded at locations C5, TP7, T7, FC5 and CP5. RT features were obtained by subtracting from RTs the length of the audio recording used in the trials. Group decisions were made as in [3].

III. Results and Conclusions

The mean error rates obtained by cBCI-assisted and traditional groups of different sizes are shown in Figure 1. These results clearly show that the proposed cBCI is able to achieve significantly better performance than non-BCI groups for sizes 2, 4, 6, 8, while it is on par for the other group sizes. This is due to the cBCI's ability of correctly break the ties occurring with even-sized groups.

We conclude that cBCI-based human augmentation also works with auditory tasks, despite them being perceptually very different from the visual search task previously used.

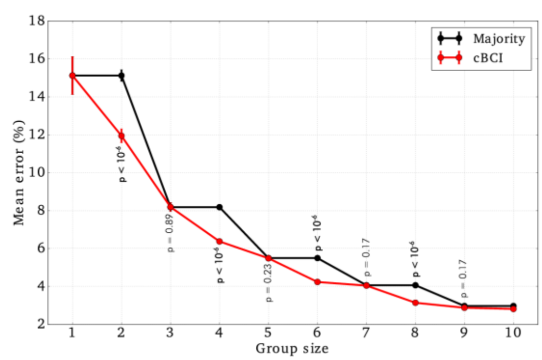

Figure 1. Mean decision errors (in %) achieved by groups of different sizes using the standard majority and the cBCI. The *p*-values of the one-tailed Wilcoxon signed-rank test comparing the two methods are also indicated.

*This research was supported by the Defence and Security PhD programme through DSTL and received MoD and University of Essex ethical approval in July 2014.

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