Neurotechnologies for Optimal Human-Machine Collaboration in Decision-Making

Davide Valeriani

***Abstract*— The scope of Brain-Computer Interfaces (BCIs) has expanded in the past few years from assistive technologies to neurotechnologies for human augmentation in decision-making. When paired with autonomous machine learning agents, BCIs could help groups achieve optimal collaboration and more accurate performance in critical face recognition tasks.**

I. Introduction

Recent research has shown that Brain-Computer Interfaces (BCIs) could be used in collaborative settings to enhance group decision making [1]. Neural signals recorded with electroencephalography (EEG) were used with machine learning to estimate the decision confidence of each person. These estimates were then used to weigh individual decisions and obtain group decisions that were significantly more accurate than decisions made by non-BCI groups.

While collaborative BCIs have the potential of improving our decision-making, the advances in artificial intelligence have allowed to develop autonomous agents able to make automatic decisions. In many critical domains, such as face recognition, these autonomous agents outperforms humans [2]. However, the *wisdom of crowds* seems to happen even when groups are made of a combination of human and algorithmic agents [3].

Here we explored the possibility of combining BCIs and a residual neural network (ResNet) to enhance the performance of groups in face recognition [4].

II. Methods

Ten healthy participants undertook a face recognition experiment composed of 288 trials, while their EEG activity was recorded using a 64-electrode Biosemi EEG system. In each trial, participants were presented with a picture of an indoor, crowded environment for 300 ms, and then asked to decide whether a target person was present or not in the image. For each participant, an individual BCI based on common spatial pattern filters and logistic regression was trained to decode the confidence in each decision, i.e., the probability of that decision to be correct. The same images used as stimuli were also fed to a publicly-available residual neural network (https://github.com/ageitgey/face_recognition), trained on about 3 million faces derived from a number of datasets. The ResNet estimated its confidence by computing the difference between the encoding of each face in the image and the encoding of the target face [4].

We simulated groups of different sizes and membership by combining the 10 participants and the ResNet in all possible ways and computing the group decisions using a weighted majority rule. This research received UK Ministry of Defence Research Ethics Committee and University of Essex ethical approval in July 2014 (ref. 520/MODREC/14).

III. Results

As found in previous research [1], BCI-assisted groups were significantly more accurate than traditional non-BCI groups of equal size (Fig. 1). Groups of BCI-assisted humans and the ResNet were significantly more accurate than BCI-assisted groups of only humans. Also, hybrid groups including at least 5 humans were more accurate than the ResNet alone.

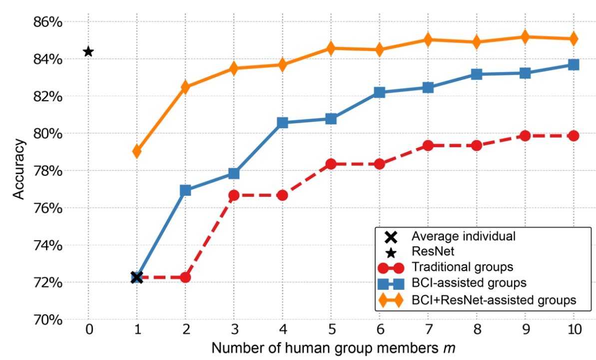

Fig. 1. Average accuracy of individuals, ResNet, and groups of increasing size using different combinations of neurotechnologies.

IV. Conclusions

BCIs and other neurotechnologies could be used to enable optimal human-machine collaboration, leading to improved group performance in critical decision-making.

References

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D. V. is with the Department of Otolaryngology, Head and Neck Surgery, Massachusetts Eye and Ear, Boston MA 02114 USA (phone: 617-573-6029; fax: 617-573-6024; e-mail: davide.valeriani@gmail.com).