IMPROVING SPEECH PERCEPTION WITH COLLABORATIVE BRAIN-COMPUTER INTERFACES

Davide Valeriani, Caterina Cinel and Riccardo Poli

Brain Computer Interfaces and Neural Engineering Laboratory – University of Essex (UK)

1. Introduction

- Brain-Computer Interfaces (BCIs) convert neural signals into commands [1]
- Collaborative BCIs have shown potential for improving group decisions in *visual search* [2, 3]
- **IDEA:** Can collaborative BCIs be used to improve group performance in *speech perception*?

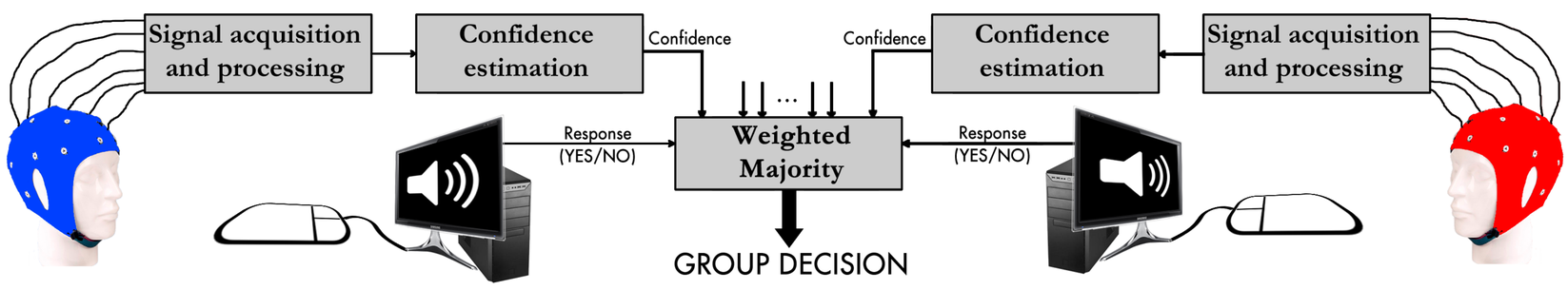
2. Experiment

- Ten healthy participants (all native English speakers) listened to 320 **spoken sentences affected by noise** and had to decide whether one of the following target words was uttered:

  route, *check*, *grid*, *lookout*, *side*, *trucks*, *village*
- Target words were present in 50% of the trials

3. Try it

4. Collaborative BCI for Decision Making



5. Data Acquisition and Processing

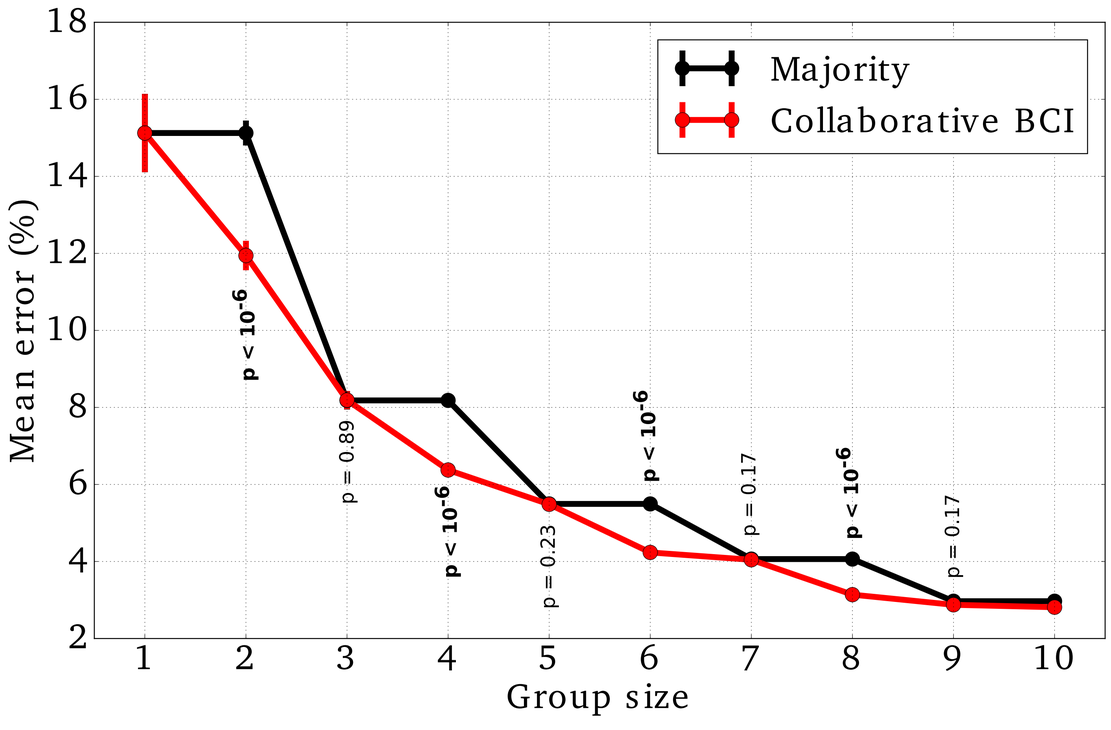
- EEG signals recorded from 64 electrode sites with a Biosemi ActiveTwo and preprocessed
- Neural signals from the **left temporal lobe** locations C5, TP7, T7, FC5 and CP5 segmented in **response-locked epochs** starting 1 s before the user's response and lasting 1.5 s
- Neural features extracted from the EEG epochs using **common spatial pattern**
- Response times minus the length of the audio recording used as an additional behavioural feature

6. Making Group Decisions

- **Assumption**: *correct decision are associated with higher confidence than incorrect ones*
- Correctness in the decision used as a label for the training trials
- **Least Angle Regression** (LARS) used to predict the decision confidence from the feature vector
- Group decisions made using **weighted majority**, the weights being the outputs of LARS passed through a squashing function [2]
- 10-fold cross-validation used to reduce the risk of overfitting

7. Results

- Mean decision errors (in %) achieved by groups of different sizes using the standard majority (black) and the proposed collaborative BCI (red).
- Wilcoxon signed-rank test used to compare the two error distributions (*p*-values reported).



8. Conclusions and Future Work

- **BCI-assisted groups make significantly better decisions** than both single non-BCI users and equally-sized even-sized groups of non-BCI users
- The collaborative BCI improves group performance by correctly **breaking the ties** occurring with even-sized groups more often than not
- Collaborative BCIs can augment group decision making even with **complex speech perception tasks**
- Plan for the future: test the cBCI with an **online experiment** and **interacting participants**

References

[1] J. R. Wolpaw, N. Birbaumer, D. J. McFarland, G. Pfurtscheller, T. M. Vaughan, "Brain-computer interfaces for communication and control," *Clinical Neurophysiology*," 113:767–791, pp. 767–791, 2002.

[2] R. Poli, D. Valeriani, C. Cinel, "Collaborative brain-computer interface for aiding decision-making," *PLoS ONE*," 9(7), 2014.

[3] D. Valeriani, R. Poli, C. Cinel, "Enhancement of Group Perception via a Collaborative Brain-Computer Interface," *IEEE Transactions on Biomedical Engineering*, 2016.

This research is funded by the UK's MoD through DSTL and received MoD and University of Essex ethical approval in July 2014.
Contacts: dvaler@essex.ac.uk — www.essexbcis.uk.