# HYBRID COLLABORATIVE BRAIN-COMPUTER INTERFACES TO AUGMENT GROUP DECISION MAKING

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**Aims**

In the recent years, collaborative Brain-Computer Interfaces (cBCIs) have shown the potential to be used in the context of neuroergonomics to augment human performance, for example in decision making.[1,2] *This study proposes an innovative hybrid cBCI to augment group performance in decision making.*

**Methods**

The proposed hybrid cBCI records the explicit decisions of groups of isolated users exposed to identical situations. Brain activity (recorded via EEG) produced during decision-making is then used to estimate the confidence of each user in each decision. Decision confidence is estimated by least angle regression (LAR) using two EEG common spatial patterns and the response times (RTs) as features. LAR is trained using the assumption that correct decisions are associated to high level of confidence and vice versa. The cBCI uses individual confidence estimates to weigh the decisions of each user and build group decisions via weighted majority voting. Groups of increasing size are formed off-line[1] to evaluate the group performance.

This approach has been tested with two experiments (10 participants each), one involving a visual search task with realistic stimuli (i.e., finding a polar bear in a scene full of penguins – see Figure 1(left))[3] and the other involving a speech perception task where participants listen to a series of spoken sentences (of 4—20 words) affected by noise and have to decide whether a target word was uttered – see Figure 2(right) where the target word is in bold.

**Results**

The mean error rates obtained with 10-fold cross-validation by all possible groups of increasing sizes formed with the 10 participants in the two experiments are shown in Figure 1. In both cases, cBCI performance is compared with traditional groups making decisions using the standard majority rule. Results show that cBCI-assisted groups are significantly superior to non-BCI ones for all even group sizes (Wilcoxon signed-rank test $p < 0.05$).

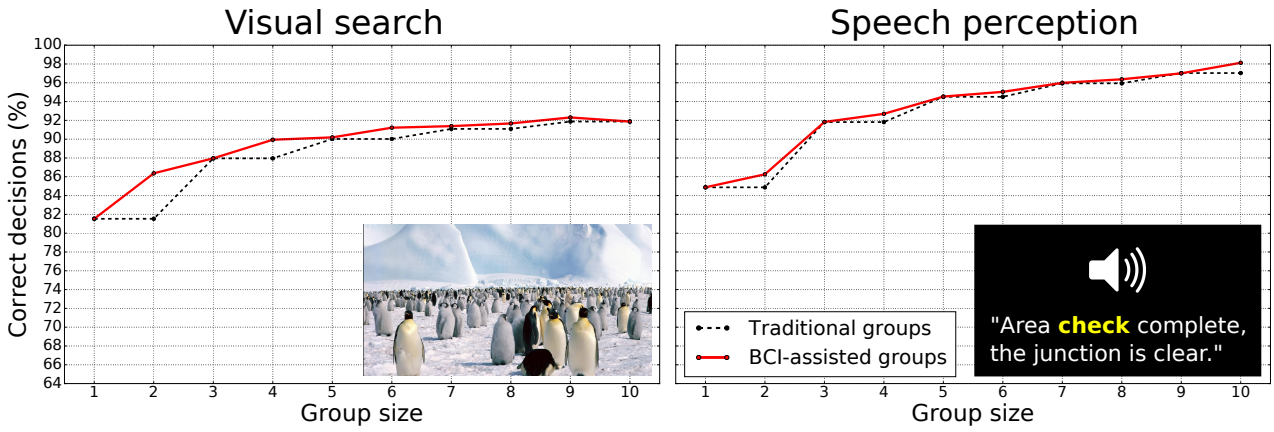


*Figure 1. Percentage of correct decisions achieved by groups of different sizes using standard majority (black dotted line) and the proposed cBCI (red solid line) in the two experiments conducted. An example of the stimuli used in each experiment is also shown in the bottom right corner of each plot.*

**Conclusions**

The proposed hybrid cBCI allows groups to make better decisions than both individuals and equally-sized non-BCI groups using the majority rule with tasks involving visual and auditory stimuli.

**References**

1. Poli R, Valeriani D, Cinel C. Collaborative brain-computer interface for aiding decision-making. *PLoS ONE*. 2014; 9(7):e102693. doi:10.1371/journal.pone.0102693.
2. Wang Y, Jung T-P, Gao X, Gao S. A collaborative brain-computer interface. *2011 4th International Conference on Biomedical Engineering and Informatics (BMEI)*. October 2011. doi:10.1109/bmei.2011.6098286.
3. Valeriani D, Poli R, Cinel C. A collaborative brain-computer interface for improving group detection of visual targets in complex natural environments. 2015 7th International IEEE/EMBS Conference on Neural Engineering (NER). April 2015. doi:10.1109/ner.2015.7146551.

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