A two stage process for improving Brain-Computer Interface outcomes

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BACKGROUND
- Most types of Brain Computer Interfaces (BCI) for neurorehabilitation use Electroencephalography (EEG) to detect brain activation patterns deemed beneficial for recovery
- These systems take many [5-8] sessions before the BCI can be used effectively, as it needs to adapt to individual patterns of brain activity
- Using other brain derived signals such as Motor Evoked Potentials (MEPs), elicited by Transcranial Magnetic Stimulation (TMS) or Neurofeedback (TMS-NF) healthy participants can achieve control over the BCI within 2 days (Ruddy et al., 2018)
- The trained brain states were associated with distinct patterns of neural oscillations within the motor network (Ruddy et al., 2018)

Here we will test whether it is possible to use a pattern of brain activity learned during TMS-NF to feed into a two-staged BCI that can be used to pre-train participants before using a traditional EEG-BCI system, such that they would learn faster and with greater success.

EXPERIMENTAL GROUP

TMS-NF
1. Transcranial Magnetic Stimulation (TMS) evokes Motor Evoked Potential (MEP)
2. MEP is recorded by Electromyography
3. MEP amplitude is compared to baseline
4. Feedback is displayed to participant

TMS-NF control scheme

The experimental group will have two sessions of TMS-NF. The last session of TMS-NF will include record EEG recordings.

Using a Common Spatial Patterns (CSP) approach the state responsible for MEPS with high amplitudes will be determined and used to drive the EEG-BCI sessions for the experimental group.

CONTROL GROUP

EEG-BCI
1. Acquire EEG signals during rest
2. Differentiate electrophysiological patterns for these two states using CSP
3. Display feedback to participant in computer game to train them to achieve control of BCI

EEG-BCI control scheme

The control group will also use CSP, calibrated by two different mental states: resting EEG and Motor Imagery.

METHOD

34 Participants randomised
- 17 in EG: Experimental group
- 17 in CG: Control group

1 session of TMS-NF and EEG
- 1 session of TMS-NF
- 2 sessions of EEG-BCI

Data

HYPOTHESES

(H1) TMS-NF will be a faster and, or more efficient way to train participants for EEG-BCI
(H2) CSP can be used to find a state responsible for high MEP amplitudes and can be used as EEG-BCI driver
(H3) The groups will show differences in topography or oscillations, and classification accuracy rates

ANALYSIS

This section discusses hypothesised study outcomes (data collection has not yet occurred).

EEG-BCI Success Rate (H1)

To investigate success rates between groups, there are three interesting comparisons:
- Comparison 1: EEG-BCI success rate between the two groups at Session 3

This shows if two sessions of TMS-NF are more efficient than two traditional EEG-BCI sessions for success rates of EEG-BCI.

HYPOTHESIS 2 & 3

BCI Drivers (H2 & H3)

- Control group and experimental group used different controls for the EEG-BCI
- Differences in topography, oscillations and successful state categorisation between the groups could be related to the performance

CONCLUSIONS

- TMS-NF could be an alternative way to train participants for EEG-BCI use. The MEP feedback from TMS-NF could be valuable for participants who have difficulties using traditional EEG-BCI (for example due to a brain injury)
- The quick and successful transition from TMS-NF to EEG-BCI could enable a two step programme for BCI using a portable EEG-BCI for homebased, patient driven neurorehabilitation, after TMS-NF training