Upper Alpha Neurofeedback Training over the Motor Cortex Increases SMR Desynchronization in Motor Tasks

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Introduction

Problem Statement

Desynchronization of sensorimotor rhythms (SMR) is a distinctive feature that provides a discriminative pattern for BCI operation. However, individuals such as BCI illiterates can not produce these discriminable patterns with sufficient reliability. Additionally, SMR desynchronization can become deteriorated or extinct in patients with spinal cord injury or a cerebrovascular accident. In all these situations BCI usage is compromised.

In this work is proposed an intervention based on neurofeedback (NF) training of the upper alpha (UA) frequency band to improve SMR desynchronization. The feasibility of this intervention is demonstrated in a preliminary study with five healthy subjects.

Methods

The experimental design consisted of five consecutive days. Each day a NF training session was executed. EEG screenings were performed immediately before and after each training session to assess changes in the EEG. In addition, a motor assessment was carried out at the beginning of the first training session, and at the end of the last training session, to assess changes both in behavior and in EEG patterns due to NF application.

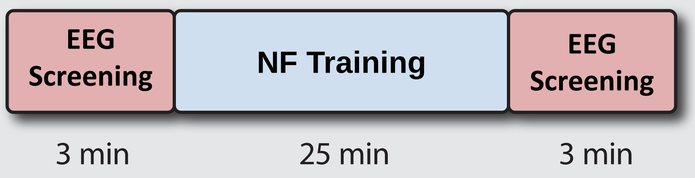
Conclusions

The UA activity was significantly increased for all subjects across training sessions. This increase in basal state led to an increase in the SMR desynchronization during the execution of a motor assessment after NF application. Additionally, performance measurements in the reaction time task were also improved, although this improvement was not statistically significant.

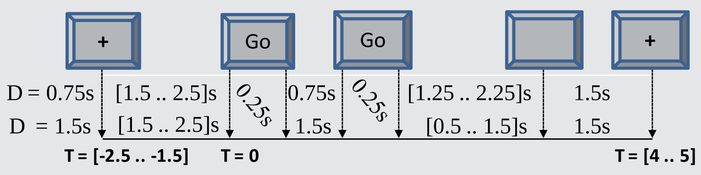
Neurofeedback Training

NF Training Procedure

- NF Training:
  Days 1, 2, 3, 4, 5



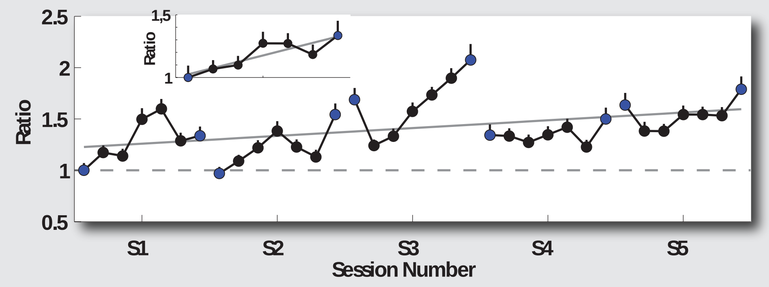
- Motor Assessment:
  Day 1, Pre-Training; Day 5, Post-Training



- **EEG Screening:** active task to challenge subjects cognitively. Averaged UA power during the screening is considered as the session baseline.
- **NF Training:** enhancement of UA activity over the motor cortex (C3, Cz, C4, CP3, CPz, CP4). UA is computed individually as range [IAF, IAF+2] Hz. The feedback is provided visually by a square on a screen, either red or blue according to whether the UA power is higher or lower than the baseline, respectively.
- **Motor Assessment:** Go/No-Go task designed to measure both SMR desynchronization patterns and motor performance. Subjects had to click a mouse button, on 'Go' trials, and to stay relaxed on 'No-Go' trials.

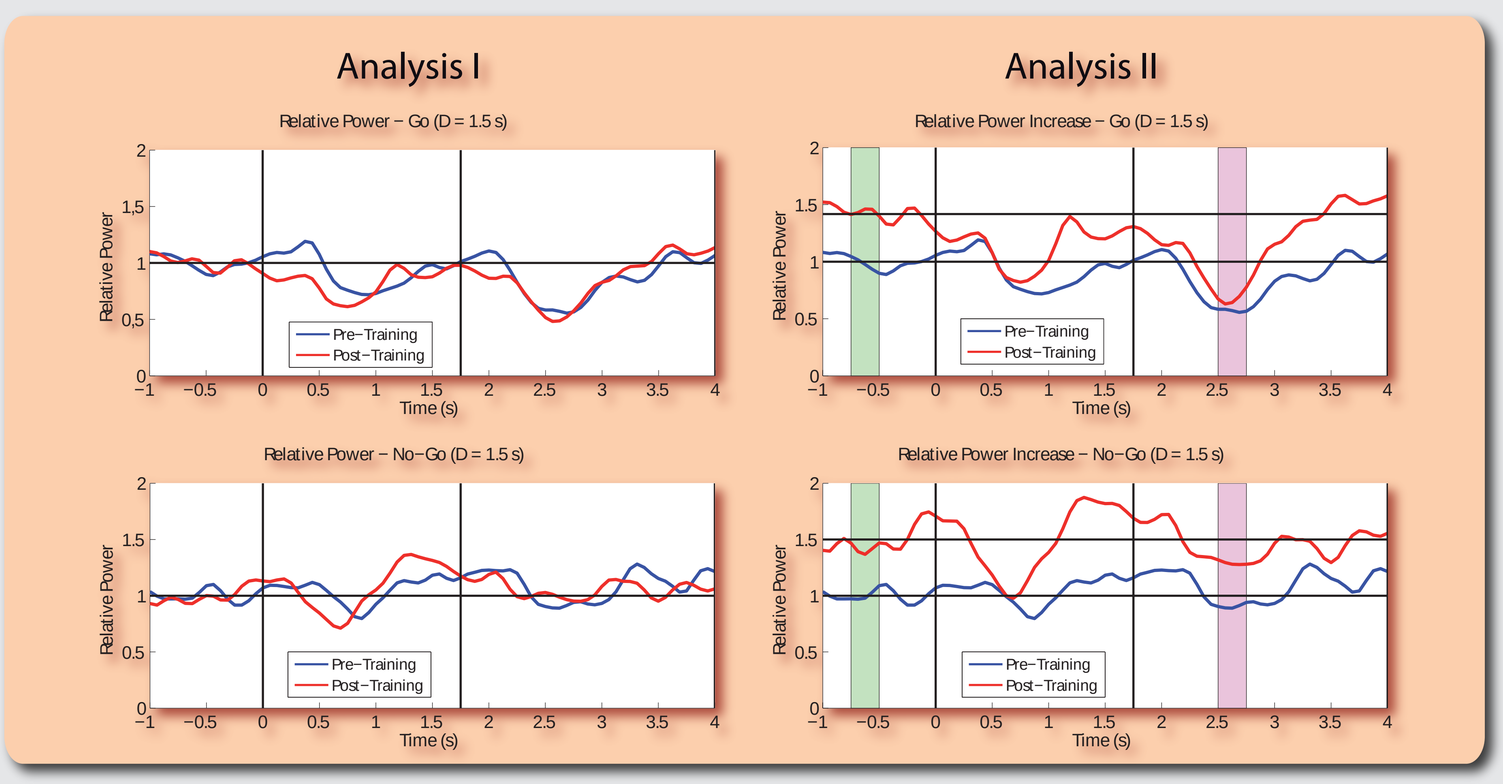
NF Trainability

- Training progress reflected by a significantly positive tendency of the UA power across the sessions ($p = 0.035$). The averaged UA power increased 79% from the pre-screening of session 1 to the post-screening of session 5.
- A positive tendency was also obtained within a session ($p = 0.016$). The average UA power within sessions from pre-screening to post-screening was increased 34%.



SMR Desynchronization Analysis

- The entire alpha band, [IAF-2, IAF+2], was considered for desynchronization analysis. Time course of alpha power along Go/No-Go trials is evaluated using two different analyses.
- **Analysis I:** Temporal power, relative to baseline [-1, 0], for motor assessments performed Pre- and Post- Training. No significant differences in desynchronization values.
- **Analysis II:** Temporal power, relative to baseline [-1, 0] of Pre- training assessment, for motor assessments performed Pre- and Post- training. A power increase of 50% is observed in rest interval for both conditions.



BCI Features

Subsets of Rest and Task (Go, or No-Go) were considered, and the power distribution of 0.25 seconds-long time windows were studied.

- $\delta 1$: distance between means of the power distributions in Rest and Task classes.
- $\delta 2$: distance between the upper confidence interval of the Task distribution (only for Go condition) and the mean Rest distribution.