 DOI:10.3217/978-3-85125-260-6-86

Towards Neurofeedback for Improving Visual Attention

T. O. Zander[1,2], B. Battes[1], B. Schölkopf[1], M. Grosse-Wentrup[1]
[1]*Max Planck Institute for Intelligent Systems, Tuebingen, Germany;* [2]*Team PhyPA, TU Berlin, Germany*

Correspondence: T.O. Zander, TU Berlin, Dep. Biological Psychology and Neuroergonomics MAR 3-2, Marchstr. 23, 10587 Berlin, Germany.
E-mail: tzander@gmail.com

Abstract. We investigated the impact of gamma-activity in a task-positive network on performance of subjects in a general measure for attention (D2-test). Subjects modulated their gamma activity previous to each run of the test with a simple neurofeedback mechanism. Results indicate that visual attention can be increased significantly by tuning activity in the investigated network into a specific state.

Keywords: EEG, Passive BCI, Neurofeedback, Visual Attention, Supportive System

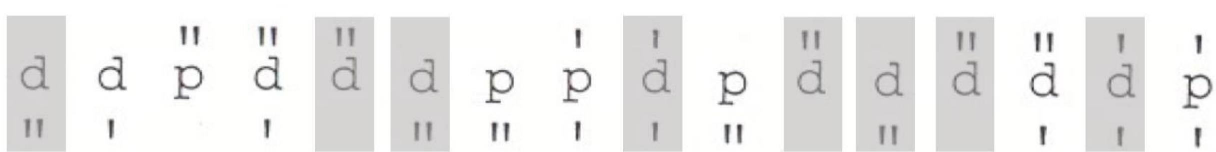
1. Introduction

Gamma activity in a fronto-parietal network was found to correlate with performance in motor-imagery based Brain-Computer Interface (BCI) [Grosse-Wentrup et al., 2011]. Specifically it can be used to predict the performance of a subject before each trial [Grosse-Wentrup and Schölkopf, 2012]. Several studies report that gamma activity in task-positive networks is correlated to attention [Corbetta, 2008]. These results lead to the assumptions that the effect found in [Grosse-Wentrup, 2012] could correlate more generally to attention, and that it can be used, due to its BCI-detectability, to train people to increase their attention on the fly. We have investigated these hypotheses in a standardized measure for attention, the D2-test [Brickenkamp, 1978], and with an EEG based BCI approach.

2. Material and Methods

We ran experiments with 20 subjects, not suffering from any neurological or psychiatric disorders. Participants were equipped with a set of 128 active EEG-electrodes (ActiCap, Brain Products, Gilching, Germany) and sat comfortably in a chair. Before the experiment, the experimenter advised the participant and answered related questions. In a first block the D2-test (see Fig. 1) was introduced to the participants. Following, participants were advised to relax for a period of 5 minutes and fixate a cross in the center of the screen. EEG data recorded in this part of the experiment was used to assess the activity of the network investigated in [Grosse-Wentrup, 2012] by beamforming. Then two Blocks of the standard D2-test were performed by the participants. The results of these runs served as a baseline for each participant's performance in the D2-test. Four Blocks of D2 followed, where each run was preceded by a neurofeedback paradigm. The position of the cursor could be controlled by modulating the gamma activity in the investigated task-positive network. The activity was assessed by the previously defined beamformer and translated into the position of the cursor. In two of the blocks subjects were advised to level the cursor up, in the others to move the cursor down. The order of the blocks was randomized between subjects. Also randomized across subjects was the direction of the neurofeedback – for 10 subjects the cursor would move upwards if they *increase* their activity in the gamma network (like described in [Grosse-Wentrup, 2012]) and move downwards if the activity was *decreased*. For the remaining subjects this procedure was inverted.

Figure 1. *Samples of stimuli of the D2-test. Targets are marked grey, all other stimuli are distractors. Each subject was running 7 Blocks of a computerized D2: 1x Training, 2x Baseline, 4x with Neurofeedback, permuted over subjects.*



 DOI:10.3217/978-3-85125-260-6-86

3. Results

Performance of the participants was measured by errors per run of the D2-test. For each condition ([1] baseline, [2] modulating Gamma up, [3] modulating Gamma down) data from two blocks of D2 were available. The results for each condition were pooled over subjects and tested for statistically significant differences to the other conditions by a permutation test. The results of this analysis are displayed in Fig. 2. For several seconds (see Fig. 2), participants had significantly less errors in condition [2] compared to condition [1] (**) and compared to condition [3] (*). There was no significant difference in errors when comparing conditions [1] and [3].

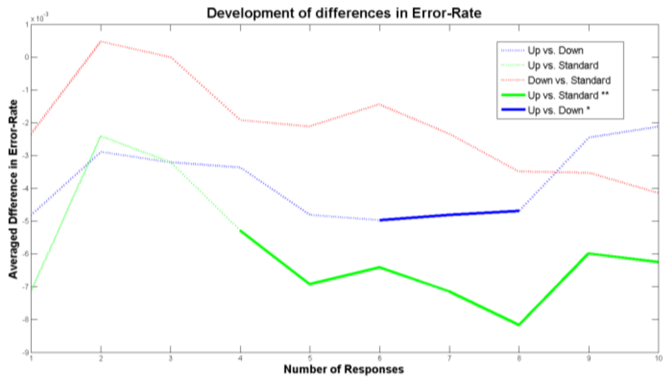


Figure 2. *Differences in error rate between conditions. Solid lines indicate significant differences (*: p<.05 / **: p<.01) within each comparison. X-axis indicates the number of consecutive responses (starting at first response) taken into account.*

4. Discussion

The results of this study show first evidence that attention can be increased by modulating gamma activity in the investigated network. Results indicate two effects. Firstly, we see a clear decrease of error rate between those trials where subjects were asked to increase gamma compared to those with where they were asked to decrease it (green vs. red). Secondly, both neurofeedback conditions show a similar trend (blue) of deceasing error rate over time, which is not the case in the baseline condition (green, red). As the D2 test is a general measure for attention, we expect the positive effect of the neurofeedback training presented here also to apply in various situations and applications. In further studies we will investigate whether the approach presented her could also be used as a Passive BCI [Zander, 2011] informing users about their level of attention during a given Human-Machine Interaction. This could lead to a crucial increase in performance in demanding Human-Machine Systems. This study opens up new fields for applying BCI-technology in a useful way for various populations of users.

References

Brickenkamp R. Test d2. Aufmerksamkeitsbelastungstest. Handanweisung. *Gottingen: Hochrefe*, 1978.

Corbetta M, Patel G, Shulman GL. The Reorienting System of the Human Brain: From Environment to Theory of Mind. *Neuron*, 58(3):306-324, ISSN 0896-6273, 10.1016/j.neuron.2008.04.017, 2008.

Grosse-Wentrup M., Schölkopf B. High Gamma-Power predicts performance in Sensorimotor-Rhythm Brain-Computer Interfaces, *J Neural Eng*, 9(4):046001, 2012.

Grosse-Wentrup M, Schölkopf B, Hill J. Causal influence of gamma oscillations on the sensorimotor rhythm. *Neuroimage*, 56(2):837—842, 2011.

Zander TO, Kothe C. Towards passive brain-computer interfaces: applying brain-computer interface technology to human-machine systems in general. *J Neural Eng*, 8:025005, 2011.