 DOI: 10.3217/978-3-85125-467-9-132

Real-time self-regulation across multiple visual neurofeedback presentations

F. Krause[12*], C. Benjamins[*12], M. Lührs[12], J. Eck[12], Q. Noirhomme[123], M. Rosenke[12], S. Brunheim[124], B. Sorger[1], & R. Goebel[125]

[1]Maastricht University, Maastricht, The Netherlands; [2]Brain Innovation B.V., Maastricht, The Netherlands; [3]University of Liège, Liège, Belgium; [4]University Duisburg-Essen, Essen, Germany; [5]The Netherlands Institute for Neuroscience, Amsterdam, The Netherlands

Brain Innovation B.V., Oxfordlaan 55, 6229 EV Maastricht, The Netherlands. E-mail: florian.krause@maastrichtuniversity.nl

Introduction: The interest in using real-time functional magnetic resonance imaging (rtfMRI) for neurofeedback (NF) has been constantly growing [1]. One crucial, and largely unexplored, aspect is whether the choice of feedback representation can affect neurofeedback efficiency. In the current study, six healthy participants were asked to self-regulate the activation of a pre-defined brain region in the posterior parietal cortex by means of a mental calculation task, with the help of three different visual feedback representations: (1) a vertical thermometer display, (2) a circle display which de-/increased in physical size and (3) a number display showing Arabic digits.

Methods: Six healthy volunteers were engaged in three real-time fMRI neurofeedback sessions at three different days. In each session participants saw one of three visual feedback displays (Thermometer, Circle, Numbers; see Figure 1) while alternately resting or performing mental addition and subtraction with one of three intensities (30%, 70%, 100%). A session consisted of five functional runs. The first (localiser) run was used to select a target region. In run 2 to 4 continuously updated gradual feedback on the activation level of the target region with respect to the previous rest condition was given (feedback runs). After the feedback runs, participants were engaged in one last (no-feedback) run in which no feedback was given. 3T MR images were preprocessed in real-time using *Turbo-BrainVoyager* (version 3.2; Brain Innovation, Maastricht, The Netherlands). Neurofeedback displays were presented with *Expyriment* [3].

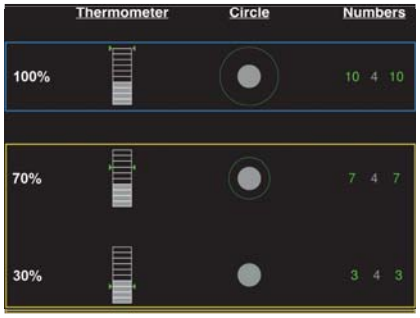

Figure 1. Feedback displays for up- (blue) and fine-grained (yellow) regulation.

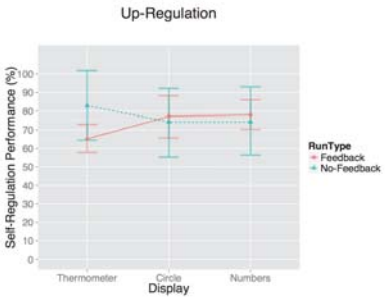

Figure 2. Up-regulation performance as function of NF-display. Err. bars: 95% CI.

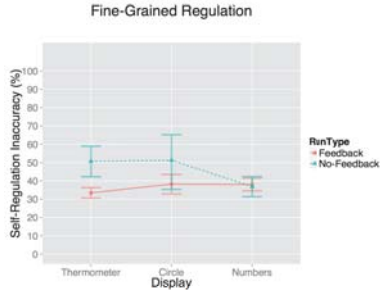

Figure 3. Fine-grained regulation inaccuracy as function of NF-display. Err. bars: 95% CI.

Results: Self-regulation performance data (i.e. reached state) from up-regulation (100%) and self-regulation inaccuracy data (i.e. absolute distance between reached state and targeted state) from fine-grained regulation (30% and 70%) each individually entered non-parametric fixed-effects analysis. Data from all participants was concatenated and 95% bootstrapping confidence intervals (CI) were obtained. While successful self-regulation was generally possible with all three displays, a small but significant difference between displays was observed during feedback runs, for both up-regulation (Figure 2) and fine-grained regulation (Figure 3). In addition, for fine-grained regulation a significant difference between feedback and no-feedback runs was present.

Discussion: We observed differences in self-regulation performance and inaccuracy between different visual neurofeedback presentations in a group of six healthy participants. Interestingly, the directionality of these differences varies between up-regulation and fine-grained regulation, suggesting that different aspects of the visual feedback presentation are relevant for each type of regulation.

Significance: Preliminary evidence that feedback presentation choice can affect neurofeedback efficiency.

Acknowledgements: This research was financially supported by the European Commission's Health Cooperation Work Programme of the 7th Framework Programme, under the Grant Agreement n° 602186 (BRAINTRAIN).

References

[1] Sulzer, J. et al. (2013). Real-time fMRI neurofeedback: progress and challenges. NeuroImage, 76, 386-399.

[2] Goebel, R. et al. (2004). BOLD brain pong: self-regulation of local brain activity during synchronously scanned, interacting subjects. Abstract viewer/itinerary planner. Society for Neuroscience, Washington, DC (online).

[3] Krause, F., & Lindemann, O. (2014). Expyriment: A Python library for cognitive and neuroscientific experiments. *Behavior Research Methods*, *46*(2), 416–28.