TU Informatics

Modelling the Effect of emotional Feedback as Stimulus in fMRI Neurofeedback

Victoria Caic
Biomedical Engineering

TU Wien Informatics
Institute of Visual Computing & Human-Centered Technology
Research Unit of Computer Graphics
Supervisor: Univ. Prof. Dipl.-Ing. Dr. techn. Eduard Gröller
Assistence: Dipl.-Ing. Manfred Klöbl, BSc

Problem Statement

Functional magnetic resonance imaging neurofeedback (fMRI-NF) is a promising therapeutic tool for several neurological and psychiatric disorders. In a pilot study of Klöbl et al. [1] feedback was given in the form of an emotional stimulus (a smiley with changing facial expressions) in order to test the most suitable feedback design for future applications. The target area in the brain, the subgenual anterior cingulate cortex (sgACC) is involved in emotion processing and shows pathological change in depressed patients. In this work it is investigated whether the perception and processing of the emotional feedback leads to an additional activation in the target region and whether there is a difference between positive and negative feedback.

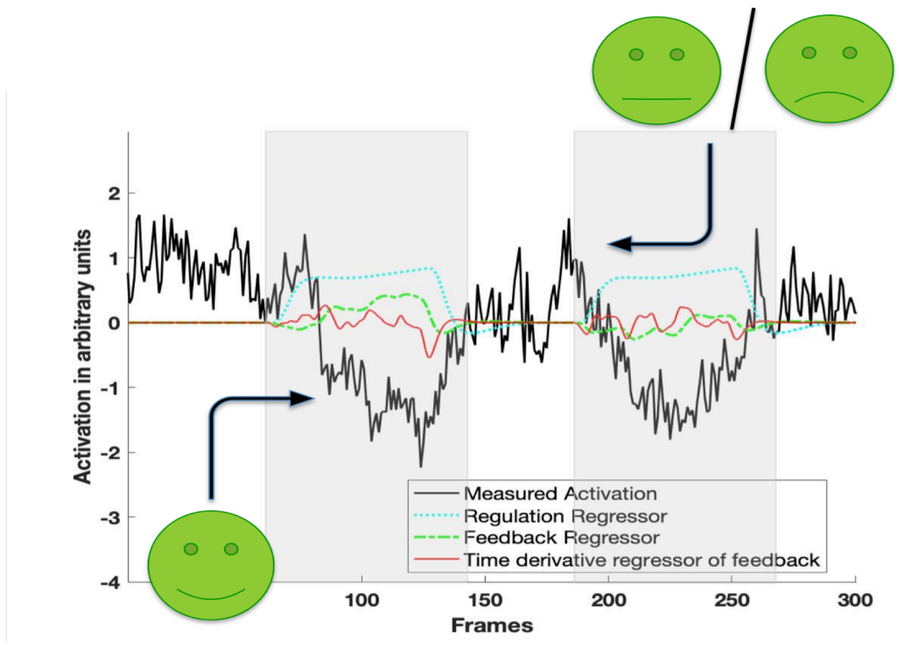

Figure 1: Overview of regressors and feedback schemes. To describe the measured activation, the following regressors are convolved with a hemodynamic response function and integrated into the general linear model: The regulation during the feedback period, the given feedback, and its time derivative. For deactivation of the target area positive feedback (happy face) is given. If the target area is activated, two different feedback schemes were examined: one group received neutral feedback, the second group received negative feedback (neutral or sad face).

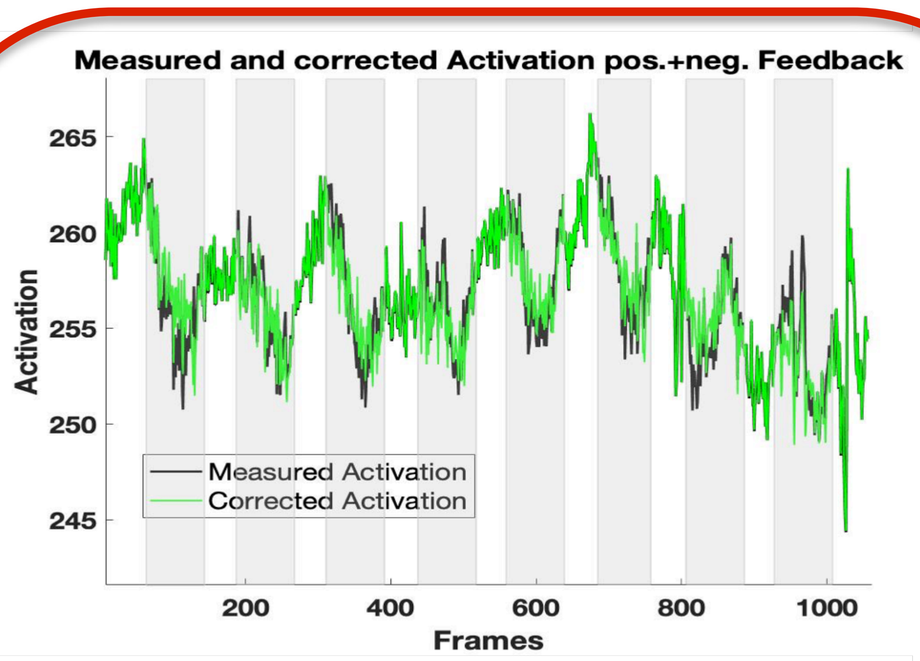

Figure 3: Activation of the target area corrected for the feedback influence. The activation is corrected by subtracting the modelled influence of the feedback and its time derivative from the measured activation. The difference is only visible during the regulation blocks (grey areas) as no feedback was given during the baseline periods (white areas).

Methods

It is assumed that the additional activation is proportional to the magnitude of the shown feedback. An additional regressor accounting for this influence is convolved with a hemodynamic response function and integrated into the general linear model, which is used for the statistical evaluation of the fMRI data (Figure 1). To account for a possible temporal delay of the reaction, the time derivative of the feedback was also added as regressor. In a separated approach, the difference between positive and negative feedback was examined. Using a linear mixed effects model and a cross-validation, the found effects were tested for their generalizability.

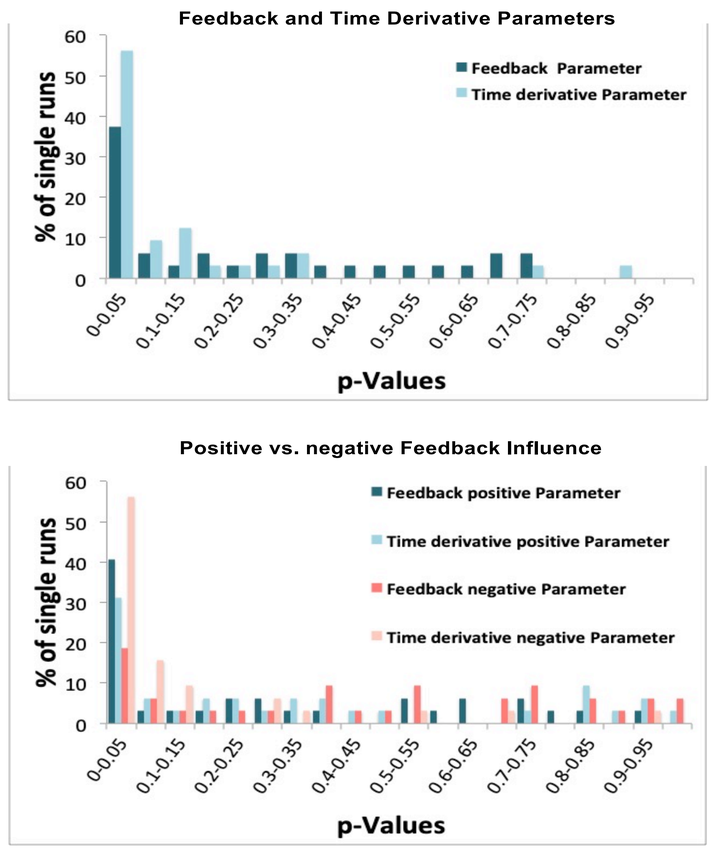

Figure 2: Distribution of p-Values for different regressors. There is a considerable number of single-run parameters with $p<0.05$. Especially the time derivative regressor showed a high percentage of significant values. Considering the different influence of positive and negative feedback, positive feedback has a higher number of significant values for the feedback parameter, whereas the time derivative of the negative feedback is more often significant.

Results

At single run level, a significant influence ($p<0.05$) of both the feedback and its change over time was found (Figure 2). Positive feedback more often had a significant impact on the activation than negative feedback. With regard to the change over time, significant results could more often be found with negative feedback. At group level, only the change in feedback showed a significant influence. In the cross-validation, it was not possible to determine generalizability beyond a single run.

Conclusion

The examined effect is highly individual for both subjects and measurements and should be treated separately from case to case. In neurofeedback studies using emotional feedback, integrating the influence of the feedback presentation into the online processing algorithm could increase the accuracy of the given feedback and thus enhance learning outcomes and therapeutic success (Figure 3).

[1] M Klöbl, P Michenthaler, GM Godbersen, S Robinson, A Hahn, and R Lanzenberger. Reinforcement and punishment shape the learning dynamics in fMRI neurofeedback. *Frontiers in human neuroscience,* 24:304, July 2020