

## Time course of clinical changes associated with neurofeedback

### Michelle Hampson

Associate Professor of Radiology and Biomedical Imaging, Psychiatry, and the Child Study Center, Director of real-time fMRI, Yale School of Medicine

### **Abstract:**

Changes in behavior and neural function have been found to persist for weeks 1-3 or even months 4-6 after real-time fMRI neurofeedback (NF) interventions. Similarly, there have been reports that EEG NF can induce changes that are still present months following an intervention<sup>7</sup>. However, the temporal patterns of changes in brain function and behavior induced by NF have not been well characterized. Interestingly, one NF study that examined changes in functional connectivity patterns found these changes were more pronounced the day following NF than immediately after NF<sup>8</sup>. Unfortunately, as the subjects were not followed for more than one day, it is not known at what point in time the alterations peaked.

We have recently observed a pattern of increasing symptom change following NF extending over a time period of weeks. Importantly, this pattern seems to be present across different clinical applications. We present data from NF studies targeting different brain areas for different disorders that show the same temporal pattern of symptom change. That is, an increasing symptom improvement for weeks following the intervention.

This finding has implications for the design of NF studies. Those that do not include long term follow-up may be underpowered. Furthermore, the optimization of dose response (in terms of optimal number of NF training sessions) is complicated by this phenomenon. Studies that measure symptom change (or brain function change) after each session and interpret increasing improvement as evidence that more sessions are beneficial are based on potentially incorrect assumptions and may yield flawed conclusions. Thus, it's important for NF researchers to be aware that symptoms and brain patterns may continue to change after the intervention, to design their studies accordingly, and to monitor the temporal patterns of change.

### **References:**

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