Neurofeedback

An alternative therapy for mental disorders

Dr. J. Lucas Koberda*

Neurofeedback follows principles of other biofeedback methods. The techniques used in neurofeedback enable patients to train themselves to self-regulate brain activity.[1] Brain activity can be measured using electroencephalography (EEG) and applying this method to biofeedback paradigms has created EEG-neurofeedback (EEG-NF). The goal of EEG-NF training is to achieve self-control over specific aspects of brain activity through real-time feedback and positive reinforcement, and to endow patients with these self-regulation skills in daily life over the long-term.[2,3] Neurofeedback differs from all external stimulation techniques, such as deep brain stimulation (DBS), in that it allows patients themselves to control their brain activity and therefore contributes to the subjective experience of self-efficacy, which has been hypothesised to be an important therapeutic factor.[4] Although the efficacy of neurofeedback is a topic of heated debate, there is a growing body of evidence supporting its utility in the management of various mental disorders.

An EEG-NF apparatus enables visualisation of the brain's functionality and brain mapping via a computer-brain interface. Patients are compared with healthy controls. Once a sensor-embedded EEG cap is placed on the patient's head, a computer receives and interprets recorded brainwaves while differentiating levels of activity. A reward stimulus, such as continuation of music or video, is provided to the patient when brainwave activity is normal. When brainwaves are discrepant between the patient and control, the music and video pauses until normal activity resumes. Repetition of this training leads to the development of brainwave patterns that lack dysfunctional characteristics. The procedure is non-invasive.

A recent case report describes the benefits of EEG-NF in addiction. After 10 sessions of neurofeedback training, a significant reduction was found in cognitive deficits, anxiety and depression scales. Noticeable improvements were observed in memory and neurological functioning, and the patient no longer exhibited addictive behaviour.[5] Recently, there has been a growing interest in the use of neurofeedback training for attention deficit hyperactivity disorder (ADHD). A recent meta-analysis was performed by Micoulaud-Franchi and colleagues that investigated EEG-NF associated effects on overall ADHD symptoms as well as inattention and hyperactivity/impulsivity dimensions of the disorder using both unblinded (parent assessment) and blinded (teacher assessment) assessments.[6]

Major findings from the meta-analysis by Micoulaud-Franchi et al. include the following: EEG-NF improves ADHD total score on a parent-assessment scale, inattention and hyperactivity/impulsivity dimensions on a parent-assessment scale and inattention dimension on a teacher-assessment scale, albeit with a smaller effect size, attributed to the blind assessment. These results corroborate previous reports that EEG-NF is associated with improvements in measurements of ADHD symptom severity. The presence of different effect sizes depending on the blinding of the assessment indicates that future studies should include blinded assessments. In addition, effects of EEG-NF were greater for the inattention dimension of ADHD than the hyperactivity dimension, similar to previous studies. Micoulaud-Franchi and colleagues confirmed the efficacy of EEG-NF for unblinded assessment of ADHD symptoms.[6]

MECHANISM

Possible explanations as to how self-regulation of brain activity achieved using neurofeedback may benefit ADHD, depression and other mental disorders involve direct and indirect actions. Self-regulation may address primary abnormalities such as specific hyper- or hypoactive areas of the brain. Multiple reports have described electrical dysregulation in patients suffering from depression and neurofeedback therapy aimed at correcting the abnormal activity has improved symptoms.[7,8] Neurofeedback may also activate or suppress circuits that are not primarily abnormal but whose alteration produces clinical benefits.[9] There are many well-known examples of this indirect effect. Monoamine reuptake inhibitors benefit many patients with depression by increasing serotonergic and noradrenergic neurotransmission, not by correcting a monoaminergic deficit.[10,11] Similarly, surgical lesions and DBS in target regions of convergence between brain stem and basal ganglia pathways to the prefrontal cortex alleviate symptoms in patients with obsessive-compulsive disorder, but not necessarily because there are primary abnormalities in these pathways. Thus, clinical benefit may be achieved using neurofeedback techniques through self-regulation training that activates compensatory circuitry for particular cognitive processes or inhibits circuitry that contributes to the patient's pathology.[9]

MAGNETIC RESONANCE

Functional magnetic resonance imaging (fMRI) was invented more than 20 years ago, and since then, fMRI has been a central technique in cognitive and clinical neuroscience. The strengths of fMRI include its spatial resolution, fidelity, whole-brain coverage and ability to reach deep subcortical structures to map functionally connected networks. Imaging studies using this technology have provided major contributions to the understanding of brain correlates of psychopathology and the effects of genetic factors on cognitive and affective networks.[12] Interest in a potential therapeutic application of fMRI-based neurofeedback (fMRI-NF) has peaked recently.

The future of neurofeedback technology may involve fMRI, as applying imaging follows similar principles as EEG-NF. Feedback is captured via real-time analysis of the time course of blood oxygenation level-dependent (BOLD) signals (see Figure 1), which indicate neuronal activity. The BOLD signals are interpreted by a computer, which relays visual feedback to the patient. Instead of wearing a sensor embedded cap for EEG-NF, patients must be inside an MRI system. There are several advantages of fMRI-NF, including higher localisation accuracy and better access to deep brain structures.[9]

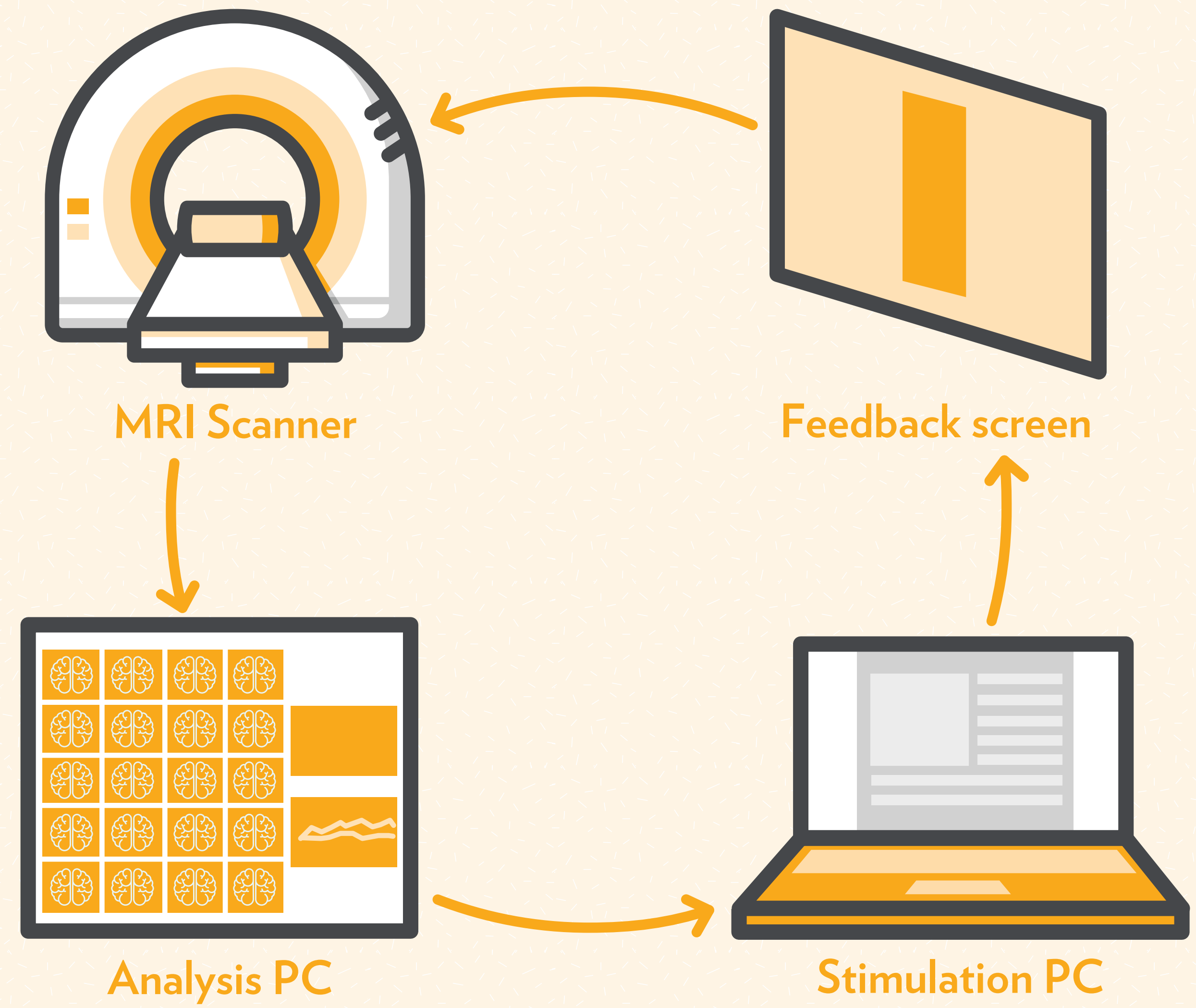

Figure 1. Diagrammatical representation of a brain-computer interface for neurofeedback facilitated by functional magnetic resonance imaging (adapted from Linden).[7]

*Director and Owner, Tallahassee Neuro-Balance Center, Tallahassee, Florida, USA

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