EPILEPSY CURRENTS

Current Literature
in Clinical Science

Epilepsy Currents
2020, Vol. 20(3) 134-135
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DOI: 10.1177/1535759720916178
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Seeking Alpha: Can Neurofeedback Actually Work?

Neurofeedback Impacts Cognition and Quality of Life in Pediatric Focal Epilepsy: An Exploratory Randomized Double-Blinded Sham-Controlled Trial

Morales-Quezada L, Martinez D, El-Hagrassy MM, et al. *Epilepsy Behav*. 2019;101(pt A):106570. doi:10.1016/j.yebeh.2019.106570.

Objective: Children with epilepsy experience cognitive deficits and well-being issues that have detrimental effects on their development. Pharmacotherapy is the standard of care in epilepsy; however, few interventions exist to promote cognitive development and to mitigate disease burden. We aimed to examine the impact of 2 different modalities of neurofeedback (NFB) on cognitive functioning and quality of life (QOL) measurements in children and adolescents with controlled focal epilepsy. The study also explored the effects of NFB on clinical outcomes and electroencephalography (EEG) quantitative analysis. Methods: Participants ($n = 44$) with controlled focal epilepsy were randomized to 1 of 3 arms: sensorimotor rhythm (SMR) NFB ($n = 15$), slow cortical potentials (SCP) NFB ($n = 16$), or sham NFB ($n = 13$). All participants received 25 sessions of intervention. The attention switching task (AST), Liverpool Seizure Severity Scale, seizure frequency, EEG power spectrum, and coherence were measured at baseline, postintervention, and at 3-month follow-up. Results: In children and adolescents with controlled focal epilepsy, SMR training significantly reduced reaction time in the AST ($P = .006$), and this was correlated with the difference of change for θ power on EEG ($P = .03$); only the SMR group showed a significant decrease in β coherence ($P = .03$). All groups exhibited improvement in QOL ($P \leq .05$). Conclusions: This study provides the first data on 2 NFB modalities (SMR and SCP) including cognitive, neurophysiological, and clinical outcomes in pediatric epilepsy. Sensorimotor rhythm NFB improved cognitive functioning, while all the interventions showed improvements in QOL, demonstrating a powerful placebo effect in the sham group.

Commentary

Mind control! It has a lot of appeal. It could change the way we understand concepts of mind and brain, especially in the field of epileptology. The fact that we could change our brain waves volitionally is revolutionary. If it is possible, then maybe we can change our mental states, our stress level, and by extension, our susceptibility to seizures. It is at least emotionally appealing if not intuitive to think in this manner. The problem is that there is little evidence to show that these efforts yield robust results, especially in pediatrics.

Neurofeedback (NFB) is not a particularly complicated therapeutic intervention. The idea is that a few electroencephalography (EEG) leads are connected to patients who can visualize their tracings in real time. The actual feedback is consolidated in some manner to reflect activation or relaxation. Patients then volitionally change their demeanor and concentration in order to influence those tracings. The 5 established brain waves, γ, β, α, θ, and delta, in that order, reflect the spectrum of arousal ranging from full alertness to deep sleep. At least the first three—γ, β, and α—may be more obviously under volitional control. "Alpha" is a level of maximal relaxation that is not sleep but still maintains alertness. Some consider this level of consciousness to be the target of meditation or mindfulness, reflecting a Zen-like state. Presumably, or perhaps only wishfully, such a state may be less susceptible to seizure activity.

Whether relaxation states may be well revealed by EEG tracings and whether an individual can influence their own EEG is still up for debate, but the idea of NFB has been around since the 1970s. Rather than a pop psychology phenomenon, it does seem to have a basis in neuroscience, and furthermore, has extreme appeal because it allows individuals to be proactive in meaningfully defining their own mental states. Evidence reinforces this, showing that with training in NFB, patients improve diverse conditions such as cancer, Tourette syndrome, and Attention Deficit Hyperactivity Disorder.[1-3] Even in epilepsy, at least one report suggests that NFB may reduce hyperexcitability and in so doing, reduce seizure frequency (SF).[4]

The recent paper by Morales et al reinforces the idea that people may train themselves to improve their mental state and reduce the likelihood of seizures.[5] Although the subject numbers were low, the study itself was straightforward and controlled. The participants were between the ages of 10 and 18 and very stable, with seizure frequencies less than once every 3 months. Two different strategies of NFB were tested and compared with controls. Controls received random EEG tracings as opposed to direct feedback about their neuroelectrical states. The training sessions themselves were quite intense, involving daily training sessions each weekday for 5 straight weeks. The participation and retention rates for enrolled subjects were impressively flawless.

The key concepts for this study include two different strategies for NFB. The first, sensorimotor rhythm (SMR), involves thinking about but not moving the contralateral hand. Inhibitory networks are involved in order to prevent actual movement and appear to emerge from thalamocortical circuits. From an epilepsy perspective, activating inhibitory networks is quite appealing. The second strategy involves slow cortical potentials (SCP), which are more widespread signals reflecting larger regions of the brain. A summative direction of electrical positivity suggests that overall neuronal excitation is less likely, that is, seizure thresholds may be increased.

The two methods, SMR and SCP, were compared and outcomes included quality of life ratings, attention tasks, SF, and severity. No significant group differences in SF were seen, though the treatment groups trended toward improvement and the control group trended toward worsening. This finding is encouraging but the study was not powered to detect small differences.

The group outcomes did differ on the attention tasks. The improvements in reaction times were marked in participants using the SMR method compared with the SCP method. The concept of β coherence or connectivity is posited to explain this difference. Focusing on a narrow region of the brain—NFB in the somatosensory cortex—allows better understanding of regional cortical activity. Beta hyperconnectivity is considered to be associated with neuronal hyperexcitability that can lead to seizure propagation. Reduction in β coherence suggests that inhibitory thalamocortical networks are more influential in that region, thus reducing hyperexcitability and the likelihood for seizures. Although this outcome was related to attention tasks, the fact that focused efforts may improve inhibitory networks in the brain cannot be discounted.

Quality of life uniformly improved, including in the control group. Certainly, this reflects a placebo response, but in no way is the improvement invalid. To the contrary, it means that even the idea of being proactive for mental control is appealing and plays a role in regaining an internal locus of control—critical for preventing depression and managing a wide variety of health conditions.

Perhaps persons with epilepsy are more likely to improve with NFB. The notion that unstable brain waves can be corralled and redirected is intrinsically appealing. Even if partially true, to accept that a person can influence their own seizure threshold challenges notions of seizures being purely "organic" and independent of mental control. Such concepts of multiple etiologies delve precariously close to the domain of psychogenic nonepileptic events, where idiopathic physiology reigns.

Neurofeedback complicates pathophysiologic notions not only for neurologists but also for psychiatrists. Many psychiatrists similarly like to consider that mental illness is purely a result of a chemical imbalance, functionally beyond the realm of volitional control or psychotherapeutic interventions. Neurofeedback is an inconvenient wrinkle in the paradigm of psychiatric disease as pharmacologically malleable. Or is it?

If anyone with neuropsychiatric illness is actually "seeking alpha" or at least seeking a relaxation state that can be healing or rejuvenating, then maybe the entire medical model of illness requires amendment. If we can train people to locally reduce their β coherence as shown in this study, then comprehensive care becomes broader. Additionally, the placebo response adds to the evidence that proactively directed mental effort may improve physical and mental states simultaneously.

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