

A Rationale for Q-EEG-Guided Neurofeedback

TBI reduces brain function efficiency, as seen in reduced processing speed and attentional impairments (e.g., focused, sustained, selective, alternating, and “divided” attention). Because cognitive functions such as language, visuospatial construction, and reasoning integrate multiple more “basic” functions like attention, the effects of mTBI on attention can indirectly affect other cognitive domains. Some have compared brain function following TBI to highway flow during construction when high flow funnels down from many to just one or two lanes. This results in less smooth and efficient flow, with traffic moving in an accordion-like stop-and-start manner with occasional fender benders.

After TBI, the experience can subjectively feel like one’s mind is similarly acting in a halting fashion, jumping around, and alternatingly freezing, overheating, and melting down because greater mental effort is required for tasks that were formerly easy because of their overlearned efficiencies. Alternating and divided attentional deficits can affect cognitive and emotional domains.

During even mild injury events such as relatively low-speed impact or acceleration/deceleration injuries from car accidents or sports or other events such as falls, neurons in the brain can experience some mechanical stress. Geddes-Klein and colleagues (2006) found that the deformation of the brain during mTBI resulted in a complex type of strain throughout the brain tissue. This was more pronounced when the forces occurred from multiple directions, such as when automobiles impacted each other or objects multiple times during a single crash. This also occurs, for example, when several players impact an opposing player during a football tackle.

Chaves and colleagues (2021) found significant changes in the accumulation of amyloid β peptide, which is often implicated in the development of Alzheimer’s disease, following the mechanical stresses experienced during mTBI. Yap and colleagues (2017) found changes in even very mild mTBI events, specifically in the alteration of axonal signaling functions related to collapsed axonal growth cones.

These findings suggest that, although imaging studies such as CT, MRI, fMRI, and DTI do not identify such minute injuries, they are nonetheless present and may contribute to the self-reports of many mTBI patients of continuing cognitive deficits.

Neurofeedback is an efficacious and specific treatment for ADHD, which is characterized by prominent attentional and executive dysfunction. If NF helps ADHD’s attentional and executive impairments, it might address similar impairments post-mTBI. However, similar symptoms do not guarantee the same underlying mechanisms. Therefore, NF’s mechanism of action in ADHD and mTBI may differ.

Neurofeedback Efficacy for TBI

Foster, Foster, and Gross (2023) assigned a level-3 rating of *probably efficacious* to neurofeedback for TBI based on four randomized controlled trials (Ayers, 1993; Keller, 2001; Polich et al., 2020; Schoenberger et al., 2001) in *Evidence-Based Practice for Biofeedback and Neurofeedback* (4th ed.).

Task Force Criteria for Clinical Efficacy	
Level 1: Not Empirically Supported	Supported only by anecdotal reports and/or case studies in non-peer-reviewed venues.
Level 2: Possibly Efficacious	At least one study of sufficient statistical power with well-identified outcome measures but lacking randomized assignment to a control condition internal to the study.
Level 3: Probably Efficacious	Multiple observational studies, clinical studies, wait-list controlled studies, and within-subjects and intrasubject replication studies demonstrating efficacy.
Level 4: Efficacious	<p>In comparison with a no-treatment control group, alternative treatment group, or sham (placebo) control utilizing randomized assignment, the investigational treatment was shown to be statistically significantly superior.</p> <p>The studies were conducted with a population treated for a specific problem, for which inclusion criteria were delineated in a reliable, operationally defined manner.</p> <p>The studies used valid and clearly specified outcome measures related to the problem being treated. The data were subjected to appropriate analysis.</p> <p>The diagnostic and treatment variables and procedures were clearly defined to permit replication of the study by independent researchers.</p> <p>The superiority or equivalence of the investigational treatment was shown in at least two independent research settings.</p>
Level 5: Efficacious and Specific	The investigational treatment was statistically superior to credible sham therapy, pill, or alternative bona fide treatment in at least two independent research settings.

The authors concluded that the diverse nature of TBI requires tailored treatments. NF will be most successful when it addresses specific client symptoms. Quantitative Electroencephalography (qEEG) and other functional neuroimaging techniques allow clinicians to correlate presenting complaints with neural network anomalies more precisely.

Promising NF training advances include operant conditioning utilizing real-time normative database comparisons (z-score training) and training several measures concurrently (e.g., inhibiting 4-7 Hz and rewarding 15-18 Hz activity). EEG tomography through **Low-Resolution Electromagnetic Tomography Analysis (LORETA)** offers greater training specificity and TBI treatment customization.

Clinicians can supplement mTBI improvement evaluation with the pre-post assessment of various measures of attention (e.g., continuous performance test, N-back, Auditory Consonants Trigrams, Paced Auditory Serial Addition Test).

Conclusion

The qEEG can be helpful in identifying the physiological changes in brain function resulting from even a single mTBI as well as from multiple mTBI events. It can also be used to show the resolution of such changes. The qEEG is especially helpful following mTBI and more severe forms of traumatic brain injury in guiding neurofeedback to train the brain to correct atypical and dysregulated patterns, ideally to recover functions impaired by such injuries. Based on four randomized controlled trials, NF is probably efficacious in treating TBI.

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