

NeMoRe: NeuroModulation Rehabilitation of attentional deficits after acquired brain injury

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Introduction

Neurofeedback is a non-invasive neuromodulation technique based on real-time monitoring and feedback of neural activity typically derived from electroencephalography (EEG)¹. It is used to reinforce desired brain states through operant conditioning, with individuals learning to increase or decrease the amplitude of targeted frequency bands when provided with contingent feedback. Neurofeedback (NF) has been established as a clinical intervention in clinical populations with attention-deficit/hyperactivity disorder, anxiety disorders, depression etc². Acquired brain injury (ABI), including stroke, traumatic brain injury, anoxia, and infections, represents a major cause of long-term disability worldwide. Cognitive impairments are among the most persistent consequences of an injury to the brain³, which interfere daily functioning and significantly limit patients' independence and quality of life. Among these, attentional deficits are particularly prevalent⁴ and are usually treated with conventional cognitive rehabilitation, which several systematic reviews have reported producing only mild to moderate improvements. Recent studies suggest that EEG-based NF may improve attention, processing speed, and executive functioning in individuals with stroke and traumatic brain injury⁵.

Given these limited but promising evidence, we hypothesized that neurofeedback-based attentional training can be implemented in a neurorehabilitation program with minimal to no side effects, good adherence and subjective perceptions. Furthermore, we hypothesized that NF training would improve ABI patients' attentional deficits as measured with both behavioural and electrophysiological indicators of attention performance. The objective of this study was to demonstrate the feasibility of implementation of NF within a neurorehabilitation setting as well as explore its effectiveness in patients with ABI.

Methods

Thirty adults with ABI (>6 months post-injury) and attentional deficits were recruited from a neurorehabilitation service and randomly assigned to either a NF plus conventional rehabilitation group or a conventional rehabilitation control group. The control group received 12 sessions of conventional cognitive rehabilitation, while the experimental group received 12 additional neurofeedback sessions integrated into their usual rehabilitation program. Participants underwent pre- and post-intervention neuropsychological and EEG assessments. Motivation, perceived change, and side effects were also tracked and evaluated in the neurofeedback group. Neurofeedback was delivered using a single-channel EEG system and BioGraph Infinity software, where the screen size of personalized movie clips changed according to participants' theta/beta brain activity to encourage sustained attention. Feedback thresholds were dynamically adjusted to maintain engagement and optimize training difficulty. Non-parametric statistical methods were used to assess baseline group differences, intervention effects (both behavioural and EEG), motivation, perceived change, and safety outcomes. Significance was set at $p < .05$, with p -values between .05 and .10 considered indicative of trends.

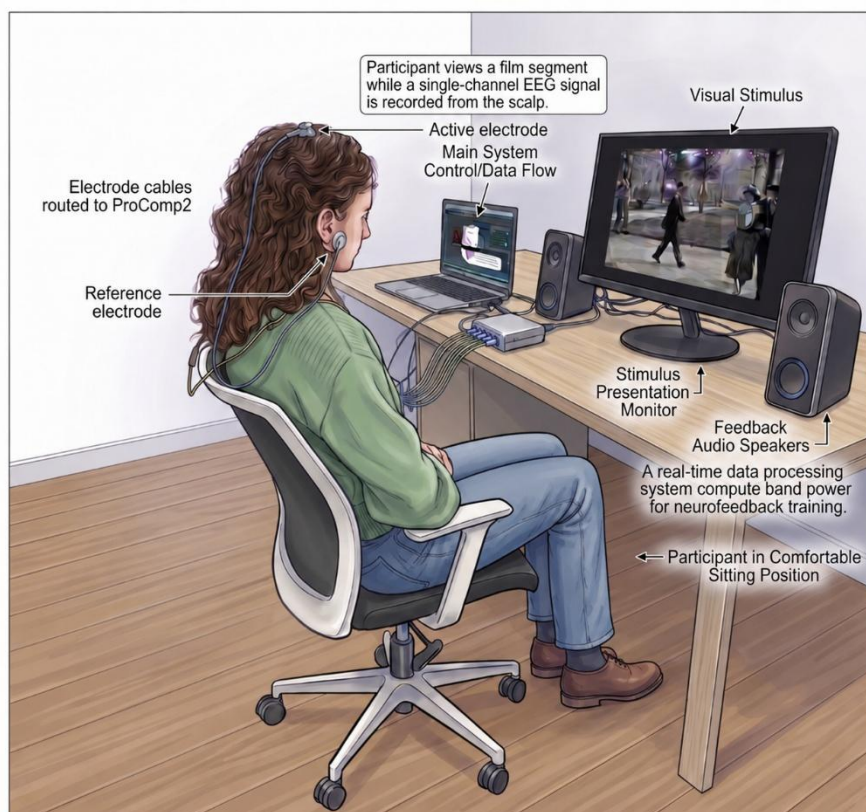
Results

We included 30 patients with ABI. The groups were comparable at baseline, except that the NF group had a longer time since injury and received fewer hours of conventional cognitive rehabilitation. NF was safe, with no serious adverse events reported; mild, transient headaches occurred in 3.9% of sessions and resolved within a few hours. Treatment adherence was excellent, with 99.4% of planned NF sessions completed. Participants reported high levels of enjoyment, usefulness, and perceived competence, alongside low levels of pressure and tension during training. On behavioral measures, both groups improved over time, but no significant Group $\times$ Time interactions were observed. Nevertheless, several trend-level interactions favored the NF group, including *D2-Revised* concentration ($p = .074$), *Digit Span* forward ($p = .085$), and *Digit Span* total ($p = .091$). EEG analyses of resting-state relative power and functional connectivity revealed no significant Group $\times$ Time interactions, after correction. However, event-related potential analyses during the auditory oddball paradigm demonstrated a significant Group $\times$ Time interaction favoring the NF group for the P300 component (P300 mean amplitude: $p = .0014$; P300 peak amplitude: $p = .024$).

Conclusions

Neurofeedback demonstrated excellent adherence, safety, and acceptability within a neurorehabilitation context. Although no significant behavioral improvements were observed (compared to conventional cognitive rehabilitation), trend-level cognitive improvements and significant P300 modulation suggest promising modulation of attentional processes in this population. Larger studies are needed to confirm clinical efficacy.

Figure 1. Set up of the neurofeedback intervention.



The figure shows a participant performing the neurofeedback task by watching a movie on the screen. The laptop on the left shows the experimenter's view, including the recorded EEG signal and artifact monitoring described above. The figure was adapted with ChatGPT (OpenAI, 2026) from an original photo taken with the consent of the patient for dissemination.

References

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