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Neurofeedback and Dyslexia

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What is neurofeedback?

Neurofeedback (also called neurotherapy or neurobiofeedback) is a technique whereby an individual's brain activity is measured and displayed in real-time with the aim of teaching self-regulation of brain function. Typically, the individual's brain activity is measured using an electroencephalograph (EEG). EEG uses electrodes that are attached to the scalp to record the electrical activity in different areas in the brain at a fast rate but without specific spatial resolution (i.e. compared to other functional brain imaging devices such as fMRI, EEG is able to show brain activity at the time of doing a task rather than after a delay however it doesn't provide us with a precise location from where in the brain the activity came from). The patterns of electrical activity recorded by EEG can indicate differing ways in which the brain processes information across a variety of settings and is therefore useful in measuring differences across individuals during tasks such as reading. The brain activity can then be compared to help isolate differences at various stages of processing that may be contributing to a particular problem (in this case, reading difficulty).

How does neurofeedback work?

In neurofeedback, the individual is fed information about their brain activity and in some way is required to self-modify these recordings. For instance, in some cases, auditory tones or graphics displays are presented to alert to the individual whether or not their signal is displaying a certain desired pattern of activity. This feedback is either rewarding/positive to reinforce the desired brain activity or inhibiting/unpleasant to signal to the individual to change these patterns on an unconscious level.

The main stages of neurofeedback include (1) recording brain activity either during rest or while the individual performs an activity; (2) comparison of the recording to normative data (i.e. a database of recordings under the same conditions that are considered 'normal'); and (3) provision of feedback either through visual or auditory display (See Figure 1). The idea is that the feedback alerts the individual on a subconscious level to alter brain activity in some way that provides positive reinforcement (thereby working on an operant conditioning model).

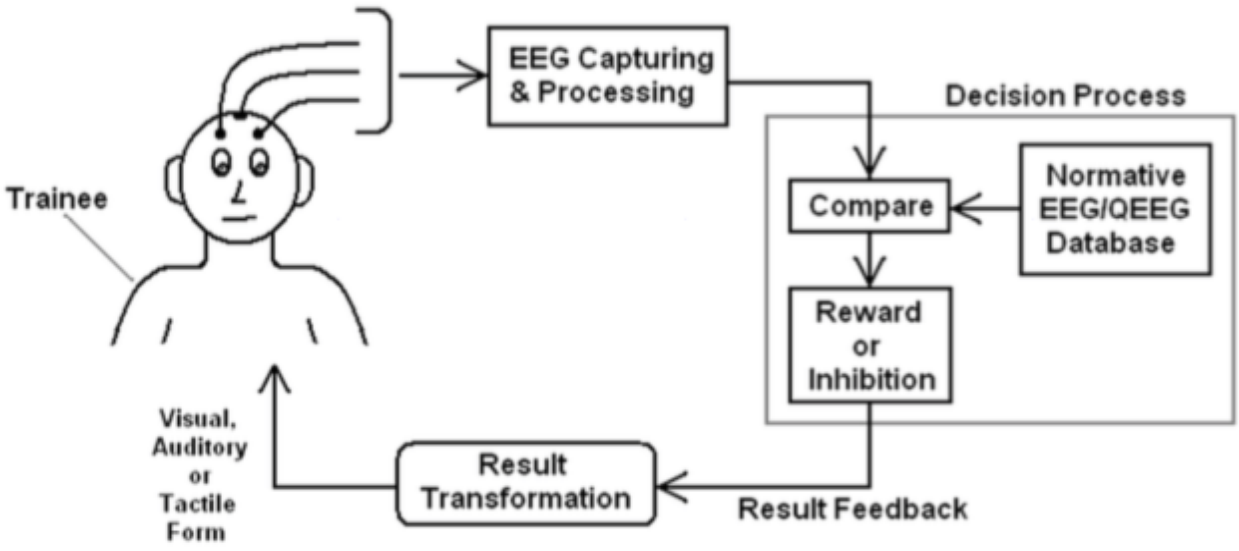

Figure 1. Basic setup of the process of neurofeedback (taken from Cheung, 2011).

Problems with the neurofeedback model.

While differences have been found in EEG patterns comparing individuals with dyslexia and those that do not have reading difficulties, the causes for these differences is not always clear as the direction of the relationships can be difficult to tease apart (i.e. is it that different patterns of brain activity mean an individual is unable to adequately learn to read or is it that the individual has not been able to acquire adequate reading skills and thereby has been unable to train these brain processes?). Neurofeedback also relies on a subconscious ability to alter brain processes which is not clearly defined. While biofeedback overall has strong support in other domains such as reducing symptoms of anxiety by receiving information about heart rate, the translation of this to reading ability is not yet established.

Use of a normative database is a fundamental aspect of neurofeedback and directly controls the determination of what is considered 'abnormal' in this case. While there are good quality databases available of EEG data, it is not always possible to have 'normal' data that was obtained under the same conditions. EEG data is highly variable to interference from a number of factors including light exposure, other sources of electrical activity (such as mobile phone signals) and levels of alertness. It is therefore integral that data that is compared is obtained under the same conditions with participants with similar characteristics (i.e. similar ages, ethnicity, handedness etc;). EEG data can also be measured and analysed in a number of ways and this too has to be controlled for.

Does neurofeedback work for dyslexia?

Relatively few studies have been conducted looking at the use of neurofeedback in individuals with dyslexia (see table 1 below). Across published studies, a variety of samples have been used with large variability in the protocols used during 'neurofeedback training'. The frequency and duration of sessions reported in the research also vary from 12 sessions of 40 minutes through to upwards of 50 sessions of 10 minutes so it is unclear what type and dose of neurofeedback training is required to result in changes to reading ability.

The main problems with studies that are available is that samples are not well defined and often contain individuals have a variety of problems and/or characteristics including medication use and comorbid diagnoses that make it difficult to generalise the findings to others. In addition, many studies also involve concurrent reading whilst receiving neurofeedback. Therefore, improvements in reading ability cannot necessarily be attributed the provision of neurofeedback as it may well be the case that exposure to reading in isolation has improved the individual's abilities. The methodology used by these studies does not allow us to establish the role of neurofeedback independently as they do not often use control comparison groups or well-validated experimental designs preferring to report on individual case studies. This also means that we are yet to delineate whether neurofeedback is more efficacious for certain individuals than others. While it is important to understand the brain processes that help support reading and how these differ in those with dyslexia, it is unlikely that adapting these supportive networks are the only way to remediate reading.

Conclusion

Currently, large-scale studies with conclusive evidence for the use of neurofeedback to specifically remediate reading is yet to be established. While there is some evidence of improvements on individual case-by-case basis, **this form of remediation is not yet evidence-based.**

Table 1.

Summary of some of the available studies assessing neurofeedback with children with learning difficulties.

Study	Summary
Tansey 1991	- Case study design (no control comparison groups) - 24 participants with a history of learning disabilities (combined ADHD, learning difficulties) - Training = 40 minutes per session, scheduled once per week with an average of 28 sessions - Results = 22 of 24 had increases in IQ points *Note: It is not valid to conduct consecutive WISC assessments within 12 months as improvements may reflect practice effects
Fenger 1998	- Case study design (no control comparison groups) - 38 participants with reported academic and/or attentional problems (not confirmed through rigorous assessment) - Training = 45 minute sessions scheduled at least twice per week with an average of 46 sessions - Results = improvements on tests of spelling, reading and arithmetic (not clear if this difference is statistically significant)
Thornton and Carmody 2005	- Case study design (no control comparison groups) - Two participants both with reading difficulties (participant characteristics are not clear) - Training involved 40 sessions for one participant and 20 sessions for the other (the duration and frequency of sessions is not disclosed) whereby participants were required to complete reading and auditory memory tasks (i.e. active training) - Results = Improvements found for both participants (one with reading and the other with overall IQ score) although it is not clear whether these are statistically significant
Walker and Norman, 2006	- 12 case studies - Participants ranged in age and degree of reading difficulty (not all diagnosed with developmental dyslexia, many of the participants were reading at only one grade behind - Training = sessions were conducted for 10 minutes at varying numbers across cases (some had upwards of 40 sessions, others had 20) - Results = Improvements were reported for all participants in terms of reading level however it is not clear how this was measured
Fernandez et al., 2003 and Becerra et al., 2006	- The Fernandez group conducted a controlled study (with a placebo administered to the control group) without randomisation of allocation. After two years, Becerra and colleagues followed up participants to re-examine learning performance - 10 participants included with a diagnosis of 'learning disorder not otherwise specified' (not specific to reading) - Training = 30 minutes with a total of 20 sessions over 10-12 weeks (placebo group received the same number of sessions but reward feedback was random) - Results = immediately after the sessions the experimental group showed significant improvements in total IQ and ADHD scores while the control group did not show improvements. At follow-up 4 out of 5 of the participants in the experimental group had 'overcome learning disabilities' (although it is unclear how this was determined) while those in the control group continued presenting learning disabilities
Breteler et al., 2010	- Randomised controlled pretest-posttest design (experimental group and control group that did not receive any neurofeedback) - 19 participants diagnosed with dyslexia by remedial teachers using a structured protocol assessing reading and spelling with thorough exclusion criteria utilised - Training = 20 sessions across 10 weeks with concurrent reading and spelling training - Results = clinically relevant improvements in spelling but no improvements seen in reading ability after comparisons across experimental and control groups

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