The Efficacy of Neurofeedback Training on Healthy College Students

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Background

The purpose of this project is to determine the effectiveness of quantitative electroencephalographic (qEEG) neurofeedback training (NFT) as a behavioral intervention for patients with Mild Cognitive Impairment (MCI) and mild Alzheimer's Disease (AD). NFT is a form of biofeedback in which the subject trains to control attributes of EEG brain wave activity directly through operant conditioning.

NFT has previously been used to effectively improve the attentional deficits in Attention Deficit/Hyperactivity Disorder (ADHD) by modifying cortical activity through reinforcement to increase high frequency activity while simultaneously decreasing low frequency activity (e.g., theta suppression / beta enhancement). Given that AD patients display similar power spectral profile abnormalities as well as similar attentional impairments as patients with ADHD, this type of NFT protocol designed to target both higher and lower frequencies power spectra simultaneously may also be effective in improving cognitive functioning in AD.

The specific goal this summer was to develop and validate the NFT protocol and assessment tools by examining the short-term effects of NFT on healthy young college-aged subjects.

Methods

Participants

Eight right-handed subjects (6 male and 2 females, mean age 20.9 ± 0.35, range 19-22) with no history of neuropsychological impairment participated in this study.

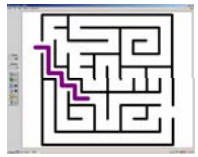
NFT protocol

Each subject completed a single 16 minute NFT session that included 2 minutes of pre-training baseline and 2 minutes of post-training baseline recording. Electrodes were attached to C3, C4, Fz, Pz and FPz using the international 10-20 electrode placement system. Linked ears were used for the ground. The subject was told to sit and relax while watching a silent video and listening to reward beeps, which were linked to his or her brainwave activity through the BrainMaster 3.09 system. Authothresholding was used during the pre-training baseline to determine the bandwidth amplitudes and reward thresholds for each individual subject. During the 12 minutes of training, subjects were rewarded for increases in Beta (15-20Hz) on C3, increases in Low Beta (12-15Hz) on C4, and decreases in Theta (4-7 Hz) on C3 and C4.

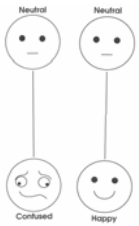
Assessment Battery

Computerized Mazes

- Designed to assess visuospatial, visuomotor, and executive processes
- Subjects used computer mouse to trace path
- Total time and total score were recorded for each maze



VAMS

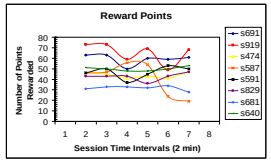


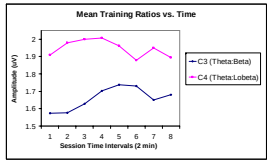
- Visual Analog Mood Scale designed to assess current mood state across eight dimensions
- Subjects placed mark across line to describe current state

N-Back

- Test of attention and working memory
- Subject must determine whether position of current stimulus matches that from 1, 2, or 3 trials back
- Accuracy and reaction time recorded

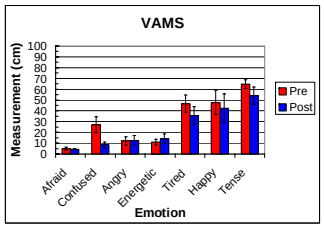
Results: Brain Activity





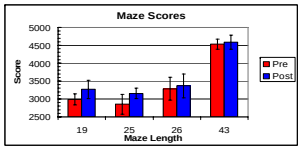
- Variability in points awarded were observed both across individuals averaged over the entire training session, and within a single individual across the session
- No significant changes in overall Theta:Beta or Theta:Low Beta ratios were observed across the session
- Results suggest that several training sessions and larger number of subjects may be necessary to see real changes in this healthy young population

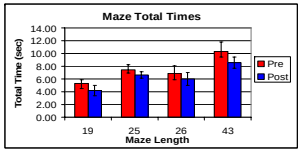
Results: VAMS



- Significant differences in pre-training and post-training mood states were found only for confusion and happiness
- Results suggest either that this particular NFT protocol had little effect on emotional well-being in this group, or that the VAMS was not sufficiently sensitive to detect such effects

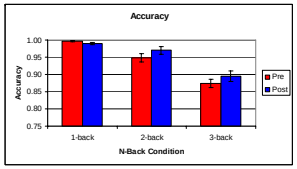
Results: Mazes

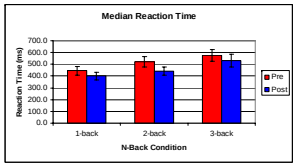




- As expected, total score and total time increased as maze length increased
- Subjects displayed increased total scores and faster total times after NFT training
- Results suggest that NFT may have positive effect on executive function and on visuospatial and visuomotor processing

Results: N-Back





- As expected, accuracy decreased and reaction time increased as task difficulty increased
- Subjects displayed increased accuracy and faster reaction times after NFT training
- Effect of NFT on accuracy was greatest at moderate level of task difficulty (2-Back)
- Results suggest that NFT may improve working memory and attention

Conclusions

Given the preliminary nature of this pilot study, the results obtained to date are limited by the small number of subjects and the absence of a comparison control group. In addition, perhaps not surprisingly, the use of a single NFT session did not produce any significant changes in targeted brain activity within this group of healthy young subjects: This lack of change in targeted brain activity may simply reflect the fact that brain function exists at optimal levels in this group. It is anticipated that changes in targeted brain activity will be more apparent within the MCI and AD patient groups, even within a single session, due to their documented EEG power spectral abnormalities. Despite not observing any change in targeted brain activity, however, this group did show modest improvement in performance across the N-Back and maze tasks, suggesting that NFT training may indeed prove effective as a behavioral intervention for patients with MCI and AD in improving working memory and attention, as well as executive processes.

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