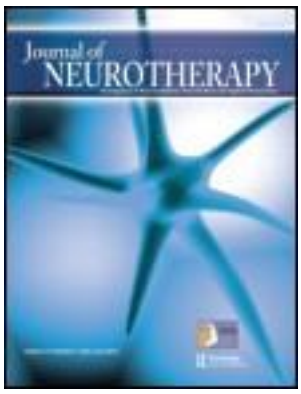

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Cognitive Enhancement Using 19-Electrode Z-Score Neurofeedback

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COGNITIVE ENHANCEMENT USING 19-ELECTRODE *Z*-SCORE NEUROFEEDBACK

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A 23-year-old man presented for a neurological evaluation due to cognitive problems restricting him from college education. He graduated successfully from high school but had problems in college, which caused his subsequent withdrawal. He was interested in trying neurofeedback (NFB) for possible cognitive enhancement. His initial computerized neurocognitive testing showed global cognitive standard score (GCS) of 93.1. The information processing speed standard score was 64.5 and was the lowest of scored domains. Quantitative electroencephalography revealed right frontal and temporal increase in delta power and left frontal and temporal beta power excess. Fifteen sessions of 19-electrode *Z*-score NFB lead to marked improvement of the patient's subjective cognitive perception as well as GCS on computerized neurocognitive testing. His post-NFB GCS was 104.1 and information-processing speed reached 85.2. Also a reduction of the right frontal and temporal delta power expression was achieved, as well as improvement in the left fronto-temporal beta power. This case report illustrates marked increase in cognitive performance achieved by *Z*-score 19-electrodes NFB training and justifies the initiation of larger studies to confirm these promising findings.

INTRODUCTION

Neurofeedback (NFB) has grown increasingly popular since early 1960s, when it was initially reported as an effective treatment in epilepsy and attention deficit hyperactive disorder (Lubar & Lubar, 1984; Sterman & Egner, 2006; Tan et al., 2009). NFB has become attractive to the public due to limitations in the effectiveness of medication treatment and its associated side effects. Some cognitive enhancement has been reported in a few previous reports utilizing NFB training usually at one electrode site (Angelakis et al., 2007; Gruzelier, 2009; Vernon, 2005; Zoefel, Huster, & Herrmann, 2011). At this point the amount of time and the number of sessions necessary for major improvements in cognition to be achieved is unclear.

The recent introduction of 19-electrode *Z*-score and low resolution electromagnetic tomography analysis (LORETA) NFB equipment has generated some hopes for an improvement of NFB efficiency (Cannon, Congedo, Lubar, & Hutchens, 2009; Thatcher, 2010). The purpose of this case study is provide detailed information about a patient that showed improved cognitive functioning in less than 20 sessions using 19-channel *Z*-score NFB.

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METHODS

This case report is based on the results of the first patient who underwent a cognitive enhancing training in our clinic using both 19-channel surface *Z*-score NFB and 19-channel LORETA *Z*-score NFB using a symptom checklist and qEEG software (Thatcher, 2010).

The symptoms of concentration, executive function, anxiety, multitask performance, compulsive behavior, dyscalculia, multitasking problems, sequential planning problems, and obsessive thoughts about self were chosen from the ''symptom check list'' (Thatcher, 2010) to identify training targets based on the patient's symptoms and neurocognitive profile.

The patient was a 23-year-old male who presented for an initial appointment with his parents and complained of cognitive problems affecting his academic performance. His parents were both high achievers (father a college professor, and mother a midwife). Initial testing included normal MRI of the brain and blood work. A commercially available computerized neurocognitive testing was used for the initial and post-NFB assessment (MindStreams, NeuroTrax, Bellaire, TX). NeuroTrax Corporation neurocognitive testing is a computerized neuropsychological assessment where a patient is compared to aged and education-matched healthy controls, where the mean is 100 with a standard deviation of 15. QEEG analysis was completed using commercially available NeuroGuide software (Applied Neuroscience, St. Petersburg, FL) and previously recorded 19-channels digital EEG.

Approximately 1 to 3 min of artifact-free, eyes-closed EEG segments were selected and subjected to further QEEG analysis.

NFB1 (surface Neurofeedback) and NFB2 (LORETA Neurofeedback) using the NeuroGuide system was given in approximately 25-min sessions twice a week using auditory feedback.

RESULTS

Initial computerized neurocognitive testing completed in May 2011 showed below-average results, with global cognitive score (GCS) of 93.1. Other below-average scores were found on subtests for memory (88.7), attention (93.7), information-processing speed (64.5), and visuo-spatial orientation (89.3; see Figure 1). The QEEG showed a right frontal and temporal excess in delta power as well as an excess in left frontal and temporal beta power (see Figure 2). After completion of 15 sessions of *Z*-score NFB (LORETA and 19-channel surface), another computerized cognitive testing was completed in December 2011 and showed a GCS of 104.1, with marked improvement in memory (104.9), attention (104), information-processing speed (85.2), visuo-spatial function (106.4), and other domains (see Figure 3). Also, a marked reduction occurred in the right fronto-temporal excess in delta power, and the left temporal beta power excess was noted on repeated QEEG testing (Figure 4). The patient also reported an improvement in his subjective perception of cognitive function, including memory, clearness of thoughts, and executive function, as well as a reduction of anxiety.

DISCUSSION

The presented case report illustrates marked improvement in cognitive functions after a relatively short course of 19-electrodes *Z*-score LORETA and surface NFB treatment (15 sessions). The largest increase was in the information-processing speed, where more than 1 *SD* (20 points) improvement after NFB therapy was noted. When compared to traditional 1-electrode NFB therapy, it seems that more rapid improvement may have occurred using *Z*-score 19-electrode NFB training. Larger studies will be needed to explore full potential of *Z*-score 19-electrode NFB for cognitive enhancement.

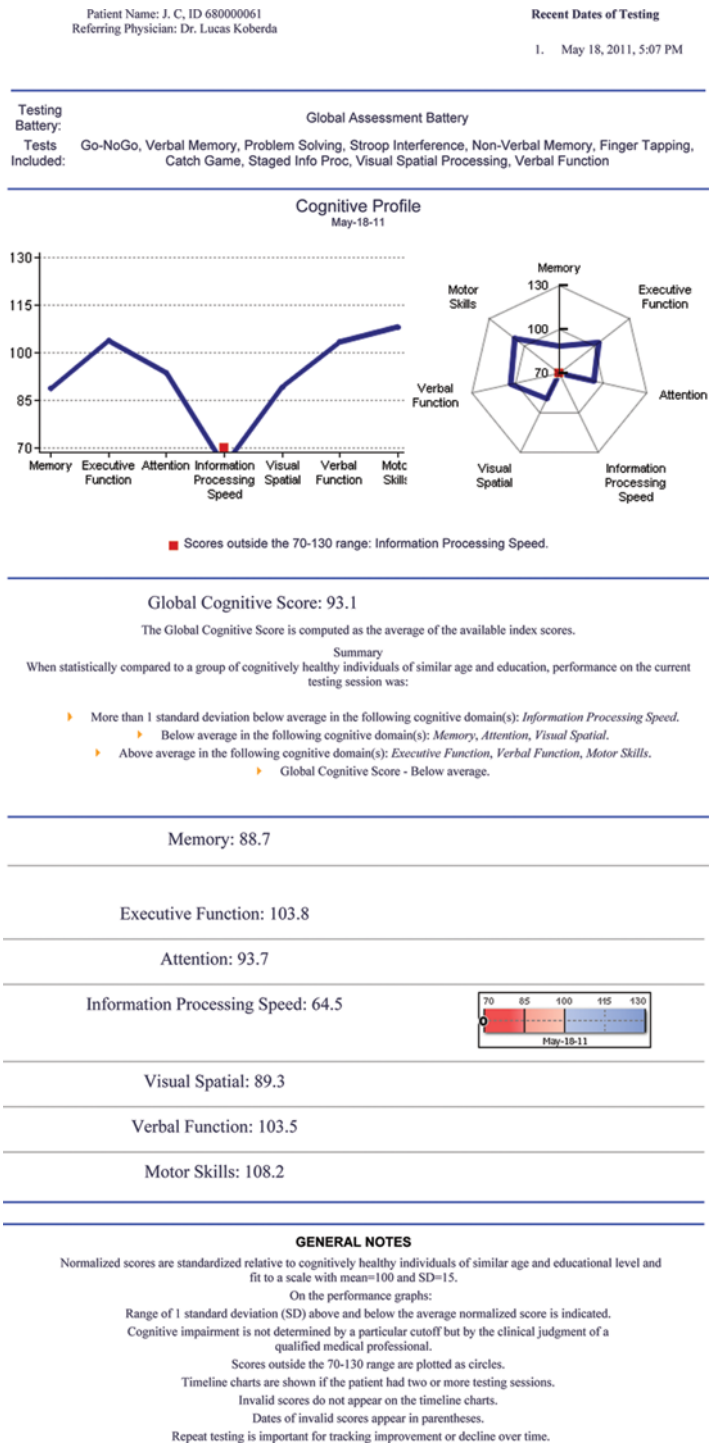

FIGURE 1. Computerized neurocognitive testing results before neurofeedback initiation. (Color figure available online.)

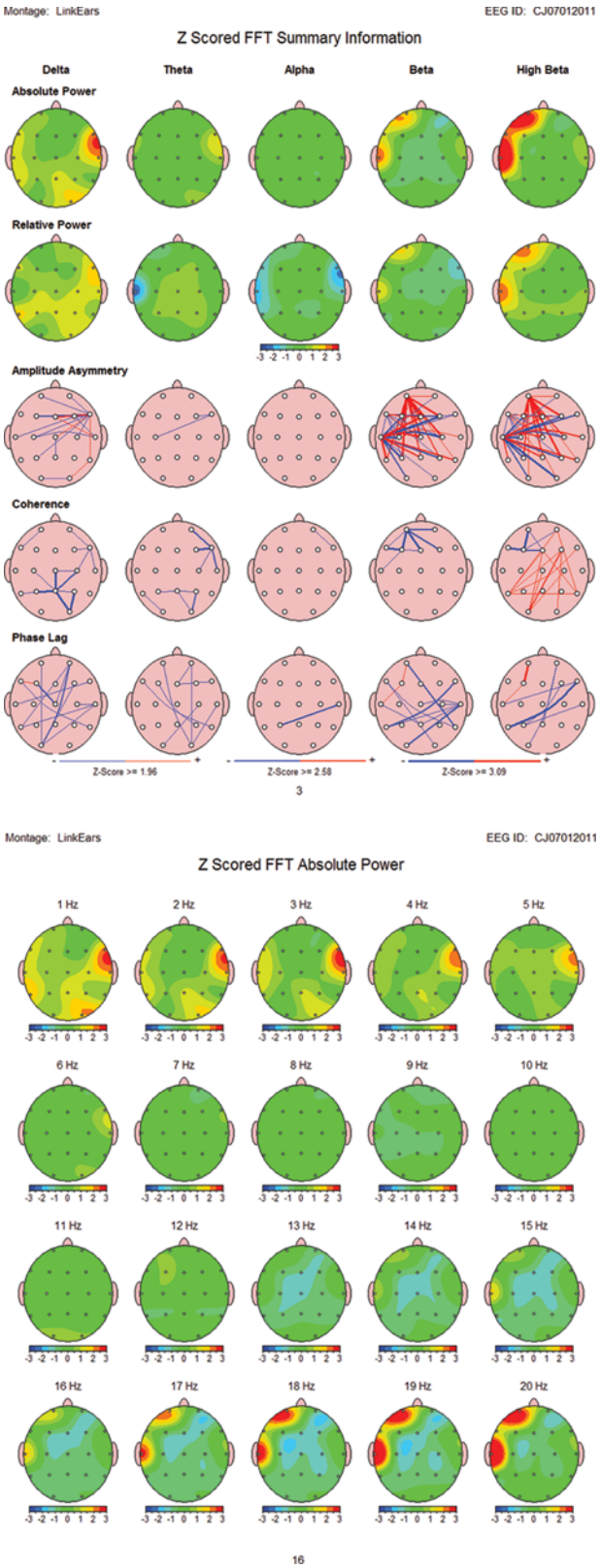

FIGURE 2. Pretreatment quantitative electroencephalography maps showing evidence of increased right frontal and temporal delta power as well as left frontal and temporal increased beta power. (Color figure available online.)

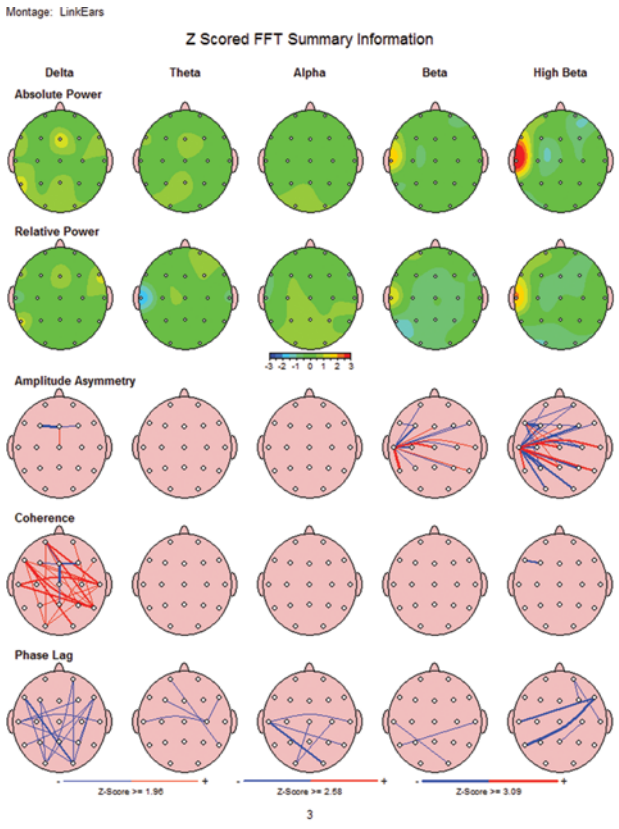

FIGURE 3. Postneurofeedback quantitative electroencephalography maps showing an improvement in right fronto-temporal delta power as well as left fronto-temporal beta power. (Color figure available online.)

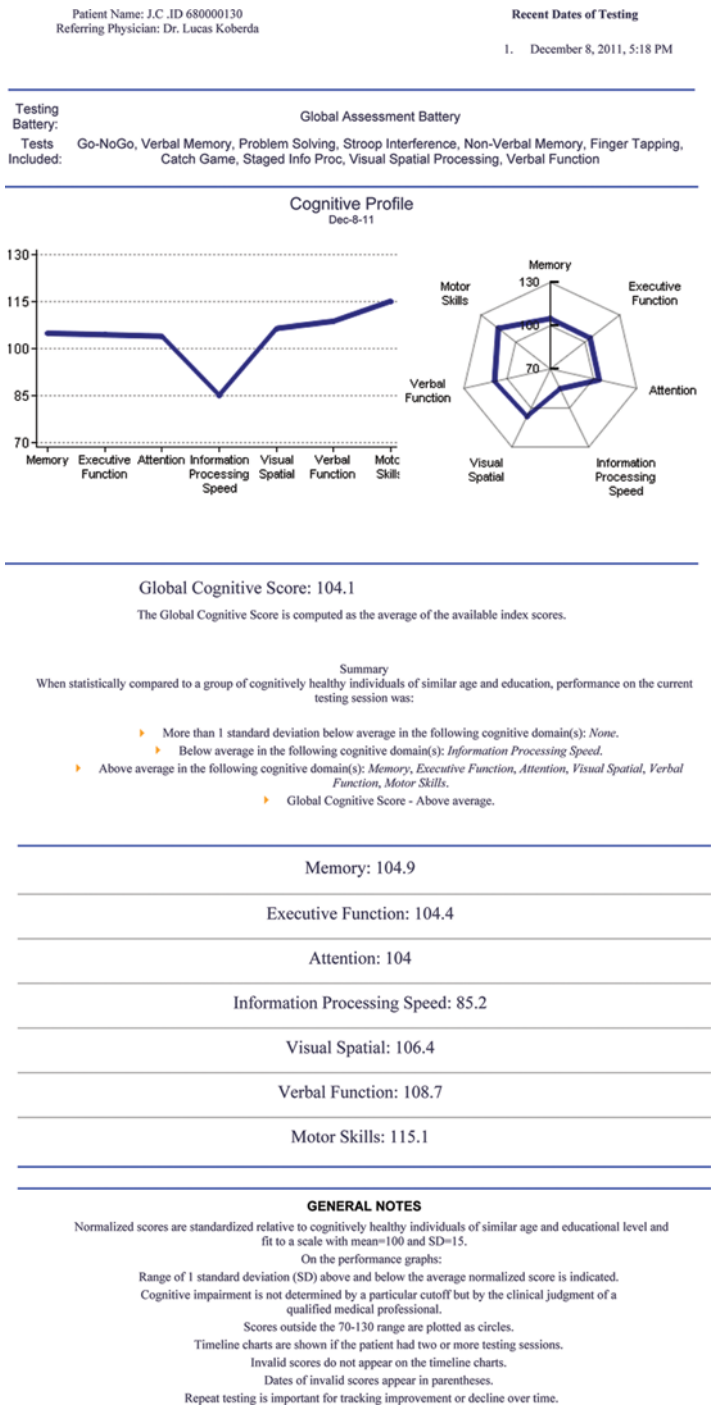

FIGURE 4. Postneurofeedback computerized neurocognitive testing shows marked improvement in cognitive scores. (Color figure available online.)

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