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SPECIAL SECTION

Neurofeedback Treatment in a Client with ADHD and ODD

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A case study on neurofeedback and cognitive behavior therapy (CBT) of an 11-year-old girl diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and oppositional defiant disorder (ODD) is presented. The quantitative electroencephalograms (QEEG) demonstrated a low-voltage electroencephalograms (EEG) with excess relative theta. After 31 sessions of theta/beta neurofeedback treatment, the client no longer met criteria for both ADHD and ODD. Her inattentive problems and hyperactive and impulsive behavior declined to normal levels, further evidenced by neuropsychological and event related potentials (ERP) improvements. Also oppositional and aggressive behavior improved dramatically. This case study demonstrates the possibility to treat clients with ADHD and comorbid disorders with combined neurofeedback and CBT. However, further controlled studies are required to replicate and extend these findings and investigate which effects are related to neurofeedback and which to CBT.

Introduction

An 11-year-old girl diagnosed with Attention Deficit Hyperactivity Disorder (ADHD), combined type, and Oppositional Defiant Disorder (ODD) enrolled at our office for neurofeedback treatment and cognitive behavior therapy (CBT). During her elementary school period she received special education. Her parents were worried about her future at a regular high school outside a special education setting.

Given that neurofeedback is only well investigated in the treatment of ADHD (Arns, de Ridder, Strehl, Breteler, & Coenen, 2009), the primary treatment goal was to reduce ADHD complaints by neurofeedback treatment. The recalcitrant and oppositional behavior was targeted with CBT. The parents were informed that the main focus of the neurofeedback was to reduce the ADHD complaints and that in principle, no effects were expected in her ODD behavior. They also signed an informed consent form allowing the use of the obtained data anonymously.

Evaluation

The Diagnostic and Statistical Manual of Mental Disorders (DSM–IV)-based structured diagnostic interview (MINI) demonstrated that she met criteria for ADHD (combined type) and for ODD. Furthermore, a quantitative electroencephalogram (QEEG) was assessed at intake using the Brain Resource Company QEEG (Brainresource Ltd., Sydney, Australia), event related potentials (ERP), and neuropsychological assessment. More information about these methods, reliability, validity, and across site-consistency have been published elsewhere (Arns, Gunkelman, Breteler, & Spronk, 2008; Clark et al., 2006; Paul et al., 2007; Williams et al., 2005, 2010). Her QEEG exhibited a low voltage electroencephalograms (EEG) pattern, with little alpha activity (Figure 1). Examination of relative EEG power disclosed excess relative theta (Figures 1 and 2). Clinical rating scales demonstrated inattentive complaints, hyperactivity, and impulsive, aggressive, and rule-breaking behavior.

Treatment Protocol

Figures 1 and 2 demonstrate that there is excess relative theta in the 6–8 Hz range and little relative beta in the 15–25 Hz range. Our method for QEEG-informed neurofeedback consists of first selecting one of the well-investigated neurofeedback protocols such as a Theta/Beta or a SMR/Theta protocol (Arns, Drinkenburg, & Kenemans, 2012).

Therefore, in this case the first treatment protocol chosen was a Theta/Beta neurofeedback protocol. We inspected the Z score values for theta for at *Fz* ($Z = 2.49$), *FCz* ($Z = 1.99$), and *Cz* ($Z = 1.93$). Therefore, we decided the training site to be *Fz*, based on the magnitude of the deviation, and also given that concentration and impulsivity are considered frontal lobe issues. The frequency bands targeted were 5–8 Hz down and 15–24 Hz up, at *Fz*. That is, feedback was given

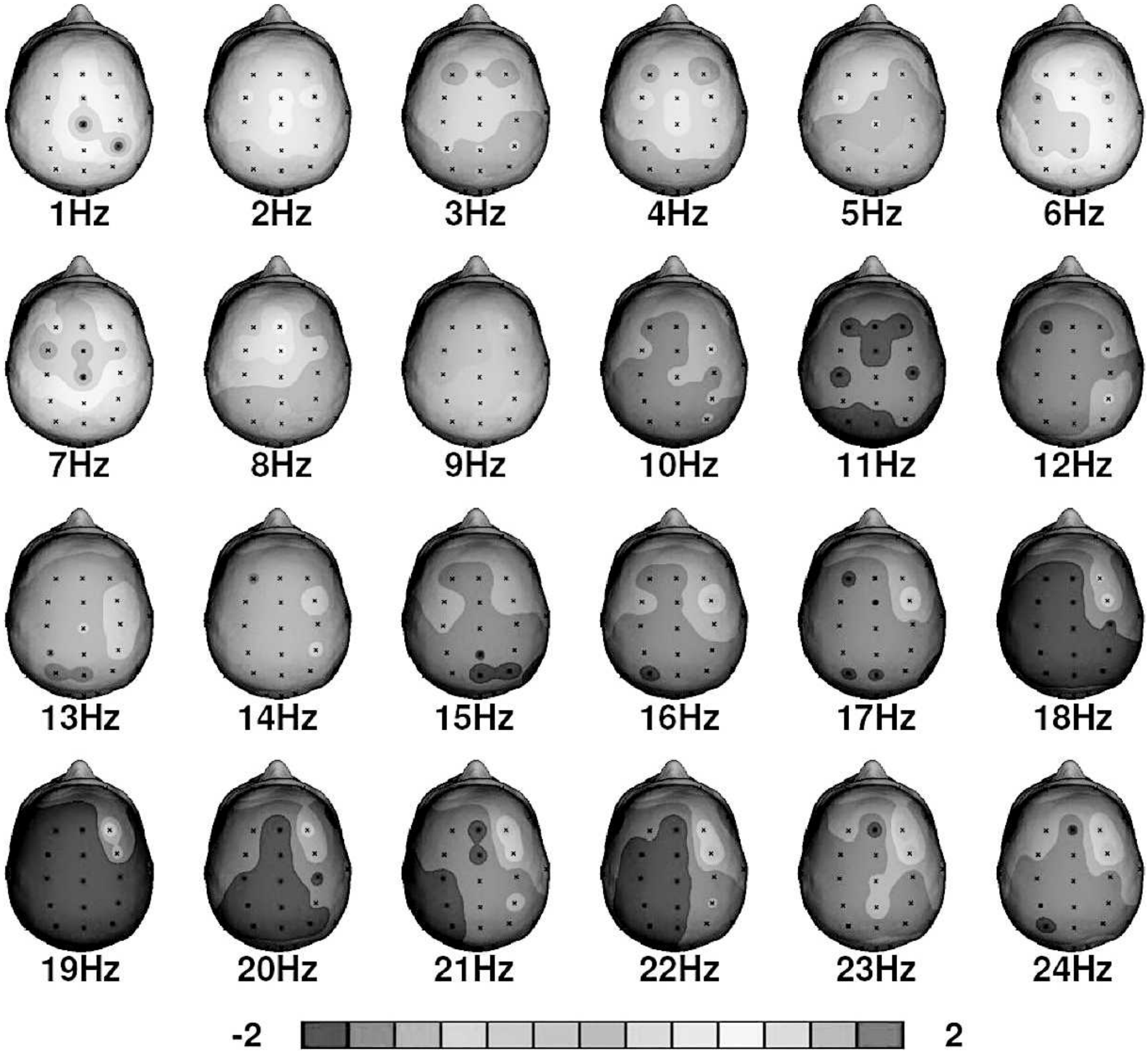

Figure 1. The pretreatment EEG in single Hertz bins during eyes open. Note the low-voltage nature of the EEG specifically for alpha and beta, and the slight theta excess and frontocentral sites at 6 and 7 Hz.

to reward decreases of theta in the 5–8 Hz range, and to reward increases of beta in the 15–24 Hz range.

The neurofeedback treatment focused specifically on treating the ADHD symptoms, and concurrently we hoped some improvements would be gained in ODD symptoms. In addition, treatment sessions also incorporated CBT. Sessions lasted 45–50 minutes and took place twice a week. In the beginning the client was not very motivated. She had a negative attitude and would not listen to the instructions. After a few good conversations about the meaning of this treatment, she was more cooperative and motivated, and she wanted to change her behavior. After about 15 sessions, her parents and school observed improvements in concentration and oppositional behavior. This improvement continued with further sessions and the client also noticed the improvements, which motivated the client further.

Treatment Outcome

After 31 treatment sessions, treatment was concluded. The ADHD rating scale (Kooij et al., 2005) scores across sessions

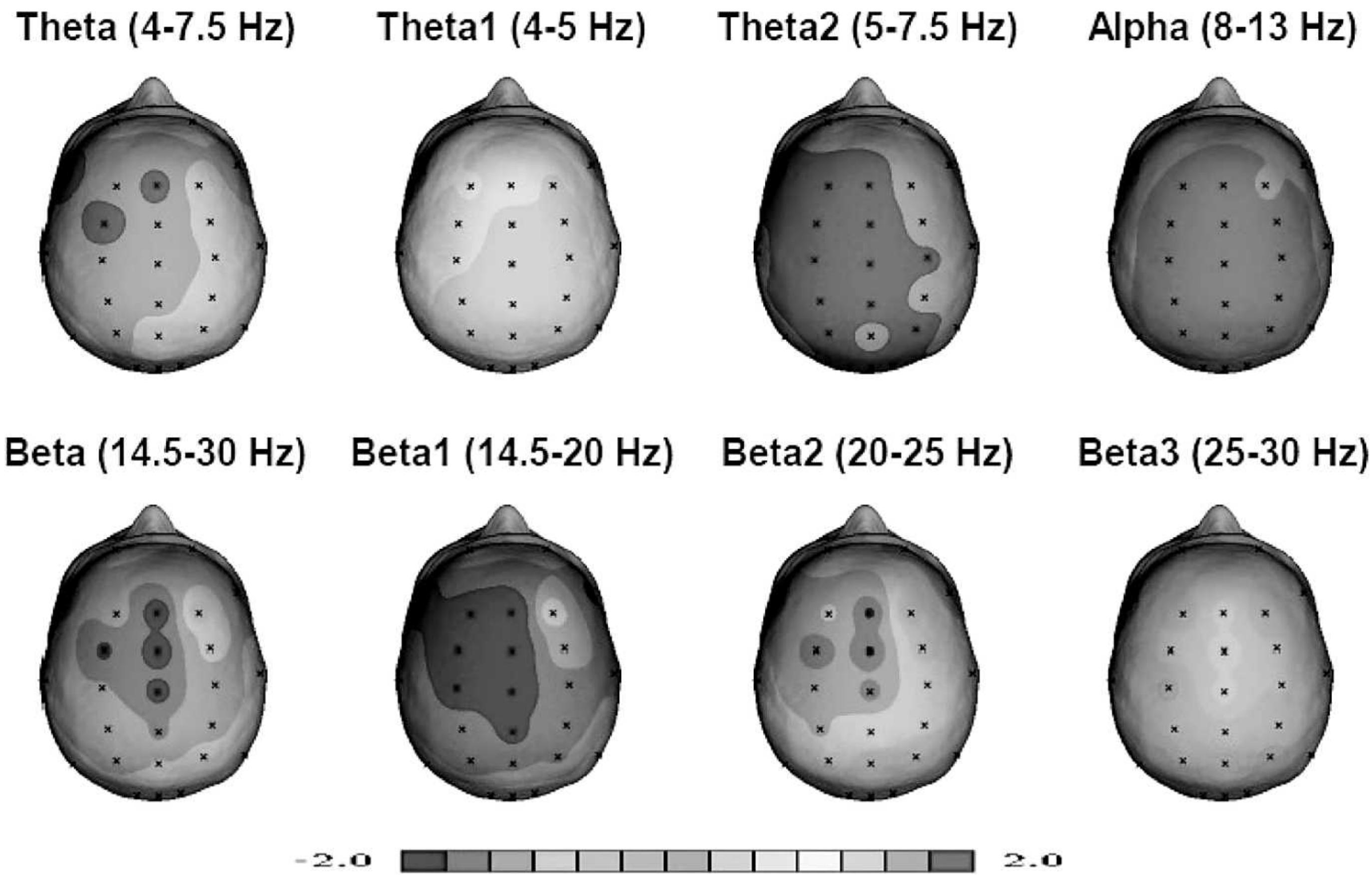

Figure 2. This figure demonstrates the relative power *Z*-scores for the different frequency bands. These data clearly demonstrate the excess theta, most specifically in the Theta 2 (5–7.5 Hz) band.

are shown in Figure 3. The scores for Inattention as well as Hyperactivity/Impulsivity were decreased and she no longer met criteria for ADHD. In accordance with the results from the meta-analysis by Arns et al. (2009), it can be seen from Figure 3 that inattention required more sessions to improve, whereas hyperactivity/impulsivity showed a gradual decline, with most gains obtained within 20 sessions.

The behavior of the client was dramatically improved. Teachers at school told her parents and the client that she now worked really hard and her concentration was much improved. She worked very diligently on her assignments. Her parents noted that she was much calmer in her behavior and she was quieter. She was no longer hyperactive and tense, and the impulsivity was much improved.

At the closing session, the girl no longer met criteria for ODD, according to the MINI (DSM–IV-based structured interview). She was less dominant and forceful. She was now aware of her share in arguments and other situations. The relationship between the client and her parents and sister had also improved greatly. She wanted to cuddle the entire day and rarely argued. She tried to be more honest. She still sometimes lied and screamed, but this was much less frequent and severe than before.

As can be seen in Figure 4 the sleep behavior also improved, as measured with the Pittsburgh Sleep Quality Index (PSQI). The client had difficulty falling asleep and frequent awakenings before she started treatment. After 20 sessions the sleeping problems were very much improved. Interestingly, the biggest gain for inattention was made after 20 sessions (Figure 3), suggesting that perhaps normalization of sleep was required for further improvements in inattention to take place.

Figures 5a and 5b demonstrate the changes in the QEEG from the pre- to the posttest. As can be seen, theta is still increased, but it is less widespread throughout the cortex. Figure 6 further demonstrates the changes in auditory ERP from pre- to posttreatment with a clear increase in P300 amplitude posttreatment (note: up is negative, and down is

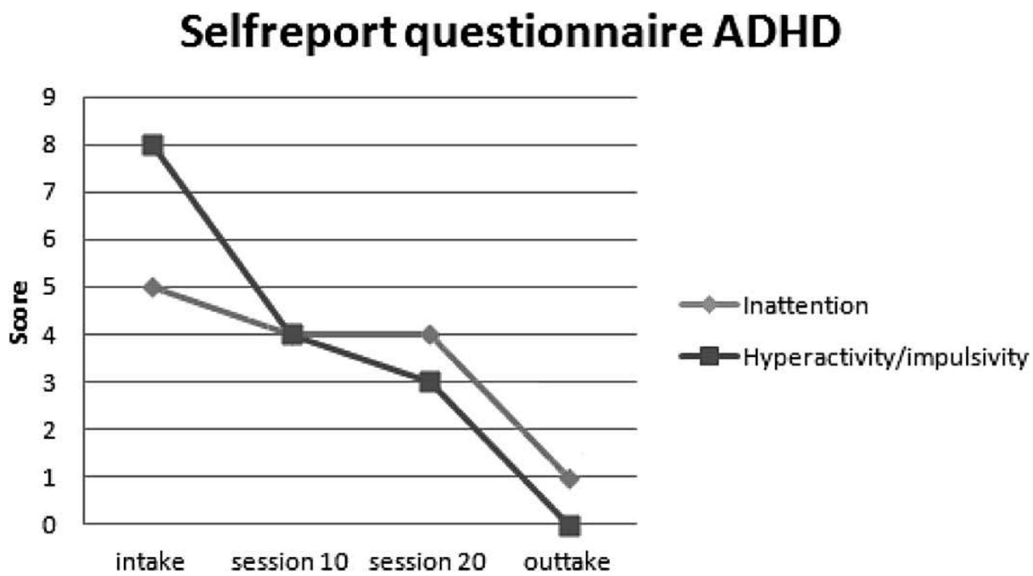

Figure 3. Self report questionnaire for ADHD symptoms across sessions.

positive). This component has been associated with attention and memory updating (for a review, see Kenemans & Kähkönen, 2011) and hence further supports the observed behavioral improvements in attention.

Figure 7 demonstrates improvements in cognitive function as assessed with neuropsychological tests, using *Z*-scored performance corrected for age, gender, and education. The continuous performance test (CPT) demonstrated a normalization of the reaction time, albeit impulsivity errors did not improve dramatically. Performance on the Go-NoGo task was improved for reaction time, as well as for impulsivity and inattention errors. These results further underline the behavioral effects reported by parents and teachers, although some impairment (impulsivity errors) is still present in the CPT performance.

Conclusion

This case report demonstrated that neurofeedback treatment had a profound effect on ADHD symptoms based on ADHD rating scale data, as well as neuropsychological data and ERP changes. Furthermore, the client no longer met the diagnostic criteria for ODD. Whether this improvement is due to the neurofeedback treatment or to CBT, or to the

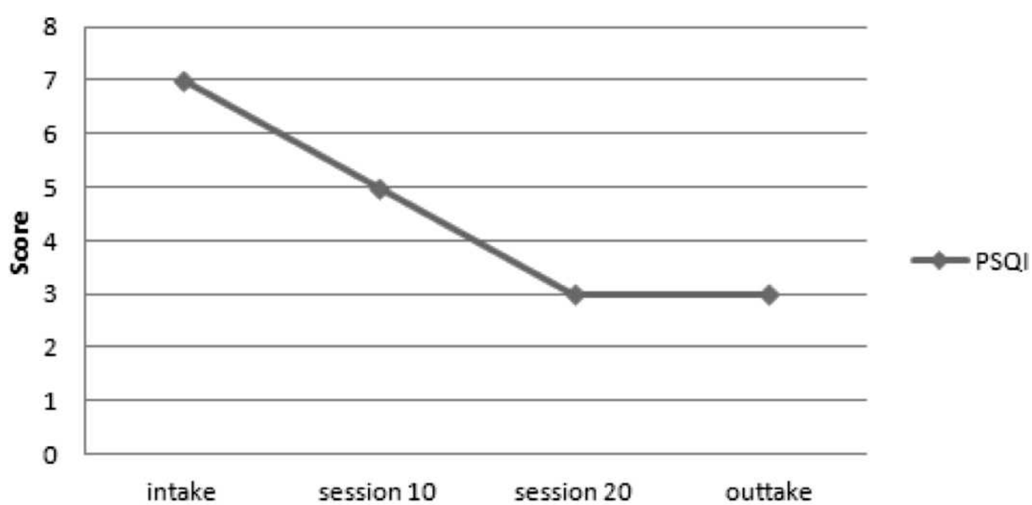

Figure 4. Pittsburgh Sleep Quality Index (PSQI) for client across sessions. Note the stabilization of improvement after 20 sessions, and as can be seen from Figure 3, the biggest gain in inattention took place after 20 sessions.

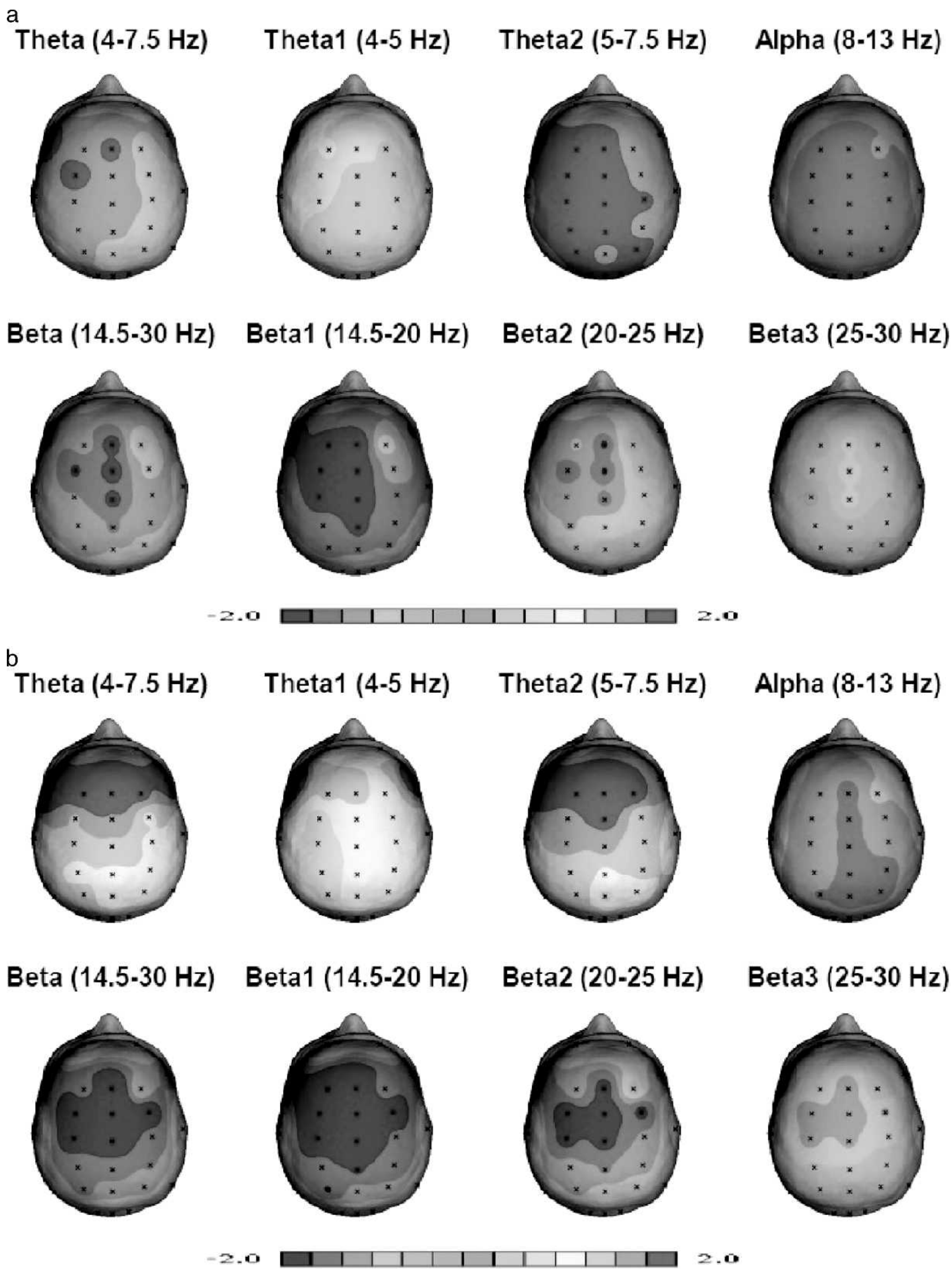

Figure 5. (a) Relative power *Z* scores Eyes Open, pretreatment. (b) Relative power *Z* scores Eyes Open, posttreatment.

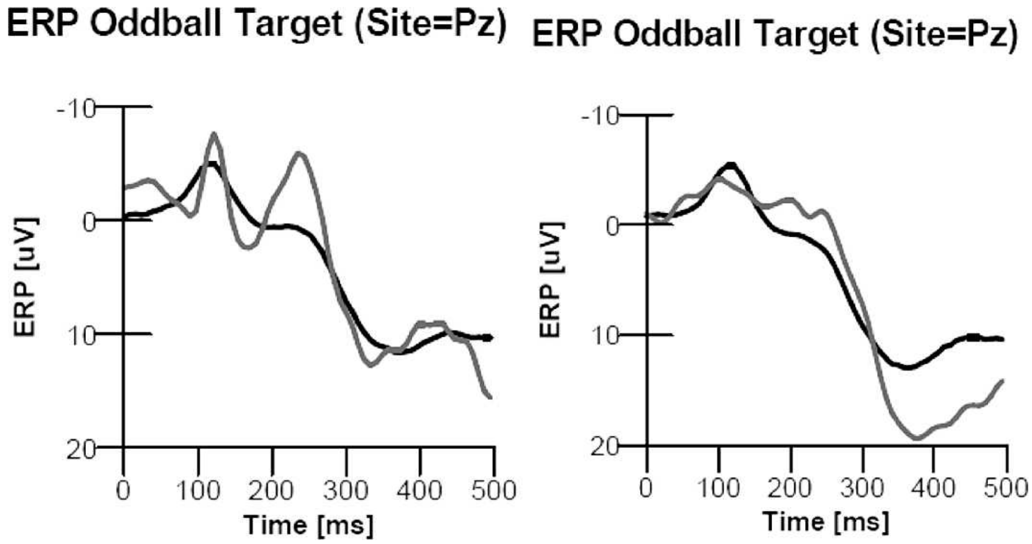

Figure 6. This figure shows the auditory event related potential at *Pz* for pretreatment (left) and posttreatment (right). Note the increased P300 amplitude posttreatment relative to normal, which is indicated by the black line.

combination of these two, is at present not known. Future studies should investigate whether these effects are more related to neurofeedback, CBT, or the combination. This case study demonstrates that it is possible to treat clients with ADHD and comorbid disorders, and that systematically tracking progress of treatment and outcome might further our knowledge of the strengths and limitations of neurofeedback and concurrent psychotherapy.

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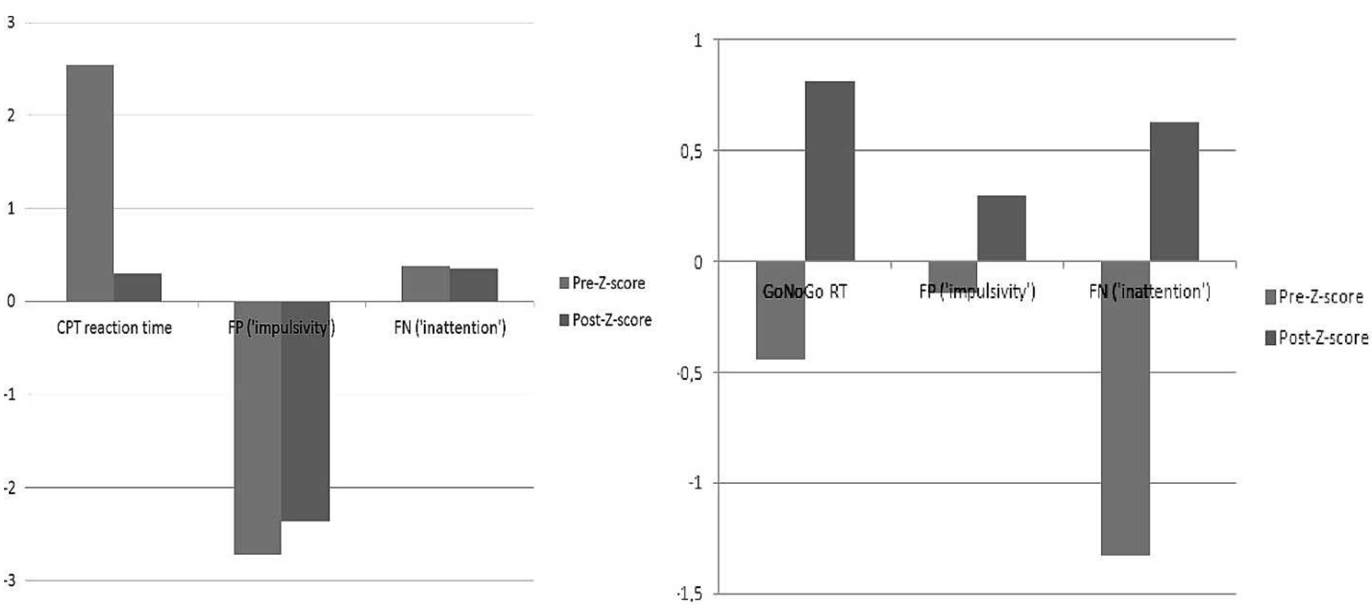

Figure 7. *Z*-scored performance data for pre- and posttreatment on the Continuous Performance Test (sustained attention) and the Go-NoGo test (inhibition).

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