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QEEG Evaluation of the LENS Treatment of TBI

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ABSTRACT. Previous publications have reported encouraging preliminary clinical outcomes in the treatment of a variety of problems with the Low Energy Neurofeedback System (LENS). However, no previous publication has evaluated outcomes with quantitative EEG (QEEG) comparisons to normative databases. This article presents outcomes from the LENS treatment of a patient who suffered a serious traumatic brain injury 9 years earlier. After 42 sessions of treatment, the patient, now 16 years old, had very significant clinical improvements as well as documented changes in QEEG measures. Further outcome studies involving pre- and posttreatment QEEG evaluations are needed.

KEYWORDS. Biofeedback, Low Energy Neurofeedback System, neurofeedback, QEEG, TBI

INTRODUCTION

The Low Energy Neurofeedback System (LENS; Hammond, 2007b; Larsen, 2006; Ochs, 2006) is a unique and passive form of neurofeedback that produces its effects through feedback that involves a very tiny electromagnetic field, which has a field strength of 10^{-18} watts/cm^2. This feedback, which is only 1/400th the strength of the input we receive from simply holding a cell phone to the ear, is delivered in 1-sec intervals at a time down electrode wires while the patient remains motionless, usually eyes closed. This feedback is adjusted 16/sec to remain a certain number of cycles per second faster than the dominant EEG frequency. Preliminary research and clinical experience have found that LENS rivals and in some cases may surpass more traditional forms of neurofeedback in the treatment of conditions such as traumatic brain injury (TBI; Schoenberger, Shiflett, Esdy, Ochs, & Matheis, 2001), fibromyalgia (Donaldson, Sella, & Mueller, 1998; Mueller, Donaldson, Nelson, & Layman, 2001), attention deficit disorder/attention deficit hyperactivity disorder, anxiety, depression, insomnia, and other conditions (Larsen, 2006; Larsen, Harrington, & Hicks, 2006). LENS has even been used to modify behavioral problems in animals (Larsen, Larsen, et al., 2006). A previous article (Hammond, 2007b) reported a case of moderate severity TBI treated with the LENS, which resulted in the reversal of posttraumatic anosmia of 9½-years' duration, as well as significant clinical improvements. However, an objective quantitative EEG evaluation of outcomes from LENS treatment has never been reported up to this time. This article presents such an assessment.

CASE REPORT

Background History and Initial Assessment

Mary (the patient's name has been changed) was a 16-year-old young woman who had experienced a serious TBI in 2002 at

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the age of 7 when a 30,000 lb chip seal crusher broke loose, rolled down a hill, and hit her. She was found behind a tire of the crusher with her head pinned against a wall. She was unconscious and not breathing. At the emergency room they rated her as having a Glasgow Coma score of 8. Glasgow Coma scores of 13 to 15 are characteristic of a mild head injury, a score of 9 to 12 typifies a moderate disability injury, and a score of 3 to 8 denotes a severe disability injury. The accident left her with a depressed skull fracture in the right posterior temporal-central area, necessitating neurosurgery.

Prior to the TBI she was a normal happy child who always enjoyed her friends and family and was enjoying learning experiences in school. The accident seriously changed her life and that of her family, as her mother described:

> The emotional battle was so hard. The doctors told us Mary will probably either not live or not live on her own. So we tried to prepare ourselves for that. Brain injuries don't come with manuals. From the day Mary started school we started seeing the full effects of the damage. Mary would come home early from school a lot with severe headaches, frustrated because she couldn't remember things. Teachers would give her directions and she could not follow through. We tried many different methods to no avail. She would get so frustrated over the next years because she had no friends and could not handle the emotionalness of relationships and would feel that when someone was joking with her that they were being mean. She didn't understand.
>
> The frustration with school was so hard. I was in the school almost every day trying to get the schools to understand that they couldn't teach her the same way as other children. They always thought that she was not paying attention. I have fought a long, hard battle not only at school but at home. The frustration was always worse at home because she felt safe there and every day she would come home and vent on me. She missed so much school. I tried to find every way possible to find help from someone, to no avail. No one understood the full effect of what this brain injury had done. We have been to so many doctors and tried their suggestions. They don't work unless you have support from schools and family. We did not have that support. Some family members turned their backs on us, believing that she was just faking most of it. Schools just didn't know what to do.
>
> Mary's dad also has a brain injury, so we would make trips to Salt Lake City to the University for his appointments. One day I picked up a brochure about QEEG and neurofeedback. I read it and thought, maybe I'll try this; it sounded so good and we had tried so many other things. I didn't know how much more I could handle. I was at a breaking point. I made the appointment with Dr. Hammond. I didn't think Mary was going to go. She has battled with counseling and would never talk and so we gave up. She went with a fight. She did not want to go. Then he put the goo [electrode paste] in her hair. Every time we left the appointment she was so angry she wouldn't talk to me and stormed off to the car. He had left some goo in her hair and she hated it.

In the intake history it was learned that she had an onset of absence seizures approximately one year after the accident. She had previously been on anticonvulsants, but due to side effects she had not been on medication for 2 years. She had from 3 to 10 absence seizures daily, lasting 1 to 2 min each. At the time of intake, 9 years after the accident, her mother rated the following symptoms on a 0-to-10 scale where 10 represented a severe problem, and 0 no problem at all: overemotionality and mood swings, 8.5; anger and irritability, 6.5; problems concentrating, 9; short-term memory problems, 7.5; poor social/bonding skills, 9; problems reading, 9; and impulsiveness, 10. Even though she was 16 years old, she also still

struggled with cursive writing. She displayed no sense of humor, never smiled or laughed, and was flat in her affect.

Vigilance-controlled EEG was digitally recorded from the patient with recording electrodes placed according to the 19 standard regions defined by the International 10/20 System of electrode placement, referenced to linked ears, with all electrode impedances between 1.7 and 2.0 Kohms. The vigilance level was controlled by noting signs of drowsiness appearing in the EEG, and then pausing the recording and verbally interacting with the patient. A bipolar recording channel was used to monitor eye movement artifact. Thirteen minutes 28 sec of eyes closed data were collected, from which 2 min 21 sec of artifacted data were analyzed. Six minutes of eyes-open data were collected, from which 120 sec of artifacted data were analyzed. Split half reliability was .99 on eyes-closed data and .97 on eyes-open data, whereas test–retest reliability was .98 on both eyes-closed and eyes-open data. The EEG data were then analyzed using both the NeuroGuide (University of Maryland) and NxLink (NYU) databases.

Treatment and Progress

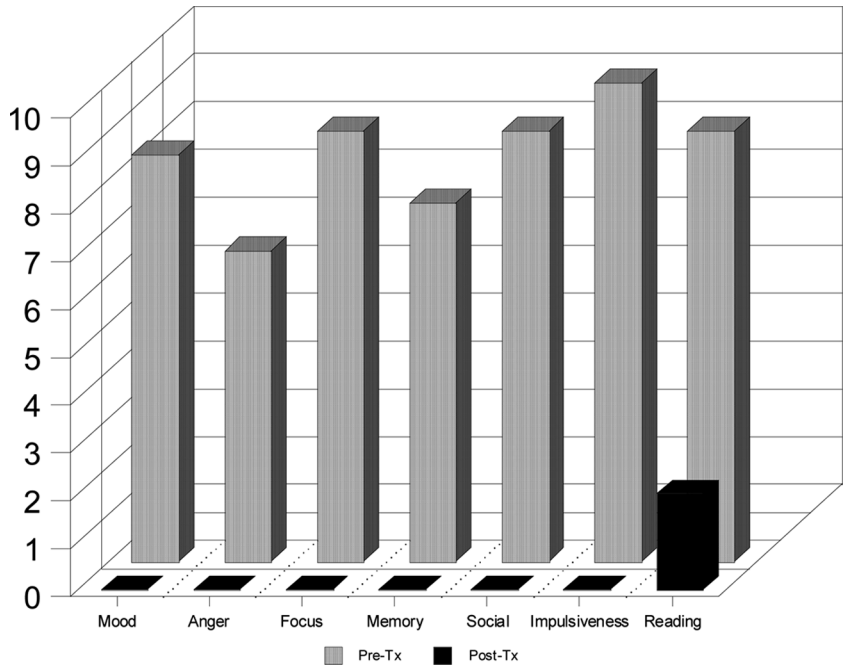
Following informed consent, treatment consisted of 42 sessions of neurofeedback utilizing the LENS. Initially a LENS map was done using a "high-efficiency" LENS program. The high-efficiency LENS program uses a narrow-band carrier wave to provide the feedback. "This means that there is probably a million times less energy used in the HE application. However, what energy there is occurs in a 1-kHz band rather than the usual 139 mHz-wide band" (L. Ochs, personal communication, February 13, 2010). The high-efficiency map consisted of gathering 4 sec of EEG data and giving 1 sec of feedback sequentially at all 19 standard 10/20 electrode sites. After 2 sessions we then provided treatment following a "suppression map." This consists of providing feedback at electrode sites that do not have a high level of variability in the EEG, working from sites where there is less amplitude and variability toward electrode sites with more amplitude and variability. The offset frequency at which she was receiving feedback was initially 20 Hz faster than her dominant brainwave. This method of working using the suppression map and an offset frequency of 20 was chosen to approach treatment more cautiously because of her epilepsy. By the 7th session, 28 sec of feedback were being provided and no side effects had been noted (nor were there ever any side effects reported during the entire course of treatment). Therefore, treatment after the 7th session followed a regular LENS map sequence, providing feedback at 7 electrode sites in a session and rotating through all 19 electrode sites during treatment. By the 10th session she was receiving 35 sec of feedback with an offset frequency of 2 Hz. We continued to systematically increase the amount of feedback every couple of sessions because we were seeing only positive progress and no side effects. Sessions occurred twice weekly.

Improvements in symptoms occurred quickly and were tracked by her mother's weekly symptom ratings in consultation with Mary. After 14 sessions her seizure frequency had declined to once a week, and her mother was reporting that she was now laughing. After 15 sessions and through a 3-month follow-up she has experienced no further seizures. After 42 sessions her mean symptom rating on her other symptoms had decreased from 8.5 to .29, with all symptoms being rated a 0 except for problems with reading, which was rated 2. Figure 1 displays the progress in her symptom ratings (apart from seizures activity) for mood swings and emotionality, irritability/anger, focus (problems concentrating), memory problems, poor social/bonding skills, impulsiveness, and problems reading.

In our last interview, Mary's mother tearfully said, "Thank you for giving me my daughter back." Later she wrote the following to describe the treatment progress:

> After a few weeks the changes started. The trip became mine and her time. We could actually talk and communication was becoming easier. As the

FIGURE 1. Pre- to posttreatment symptom changes.



weeks went by you could see a change in Mary. Initially she would never give Dr. Hammond the time of day. No smile, no nothing. Then one day she smiled. Then she joked and quit being angry about the goo. She would laugh about it. She was bonding with others as well. She would sit and watch TV or have a conversation with a complete stranger. I was in shock. This was not Mary as we had come to know her all these years. She has become so mellow, talkative, and a social butterfly. The school has commented on what a change they have seen. She is willing to try instead of just give up and not understand. She has made new friends this year with great choices. Last year the choices were not so good. She can see now why they were bad choices. Her learning has improved so much that in most of her classes she is getting A's and B's because she tries.

She has also learned how to control her emotions. She has learned how to problem solve, instead of storming out of a room or yelling. She has learned how to let someone know she is frustrated and she goes for a walk or somewhere to calm down. Then she talks about it. She knows how to take a joke and boy she can give it right back to you.

We started in therapy in May of 2009. By July 2009 Mary became seizure free. Her reading is improved. She can now follow directions and understand them. Mary is so happy now, as well as the rest of the family. We finally have peace of mind and Mary will live on her own as they never predicted she would. She has the most amazing personality and strength, and is so caring of others. Thank you for giving us our life back and proving the doctors and other people wrong. She actually drives now!''

The week after completion of the 42 LENS treatment sessions, another quantitative EEG analysis was done and analyzed in the same manner. Thirteen minutes 32 sec of eyes-closed data were gathered, from which 167 sec of artifacted data were

analyzed, and 6 min of eyes-open data were gathered from which 132 sec of artifacted data were analyzed. Split half reliabilities on eyes-closed and eyes-open data were both .99, and test–retest reliabilities were both .95. The pretreatment and posttreatment summary results from the NxLink database analysis are seen in Figures 2 and 3. Figures 4 and 5 display 1–20 Hz single hertz maps from NeuroGuide for pre- and posttreatment.

The QEEG evaluation showed a reduction in posterior and central delta, a dramatic reduction in excess absolute power theta throughout the head, and a decrease in absolute power alpha, as well as beta and high beta activity. When the mean *Z*-score for theta absolute power across all 19 electrode sites was calculated from the pretreatment QEEG analysis in the NxLink database, it was 3.01 versus a 1.34 *Z*-score average after treatment. Comparable positive outcomes were also seen in the eyes-open QEEG analyses. The excess that continues to be seen at C4 represents breach rhythm artifact that is present from her neurosurgery. The greatest improvements were seen in absolute power, but we would not expect to see as many changes in coherence and asymmetry data due to the breach rhythm artifact compromising comparisons. Figure 6 presents the pretreatment and posttreatment absolute power maps from the NeuroGuide database. The very positive changes in QEEG findings are congruent with the impressive clinical changes reported by the patient and her mother.

SUMMARY AND CONCLUSIONS

Previous outcome studies (e.g., Donaldson et al., 1998; Hammond, 2007a; Larsen, Harrington, et al., 2006) utilizing the LENS have reported positive clinical changes,

FIGURE 2. Pretreatment NxLink quantitative EEG.

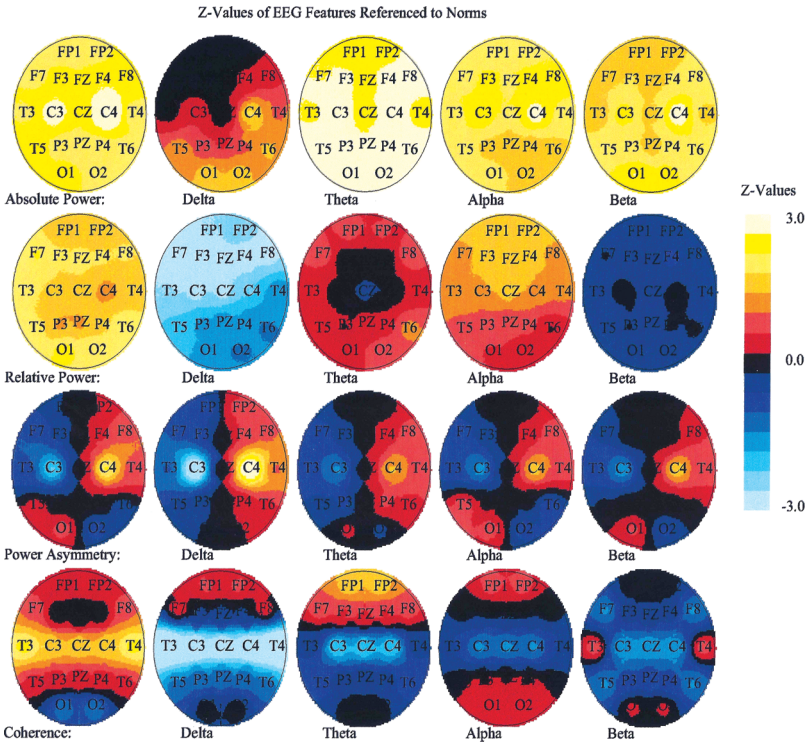


FIGURE 3. Posttreatment NxLink quantitative EEG.

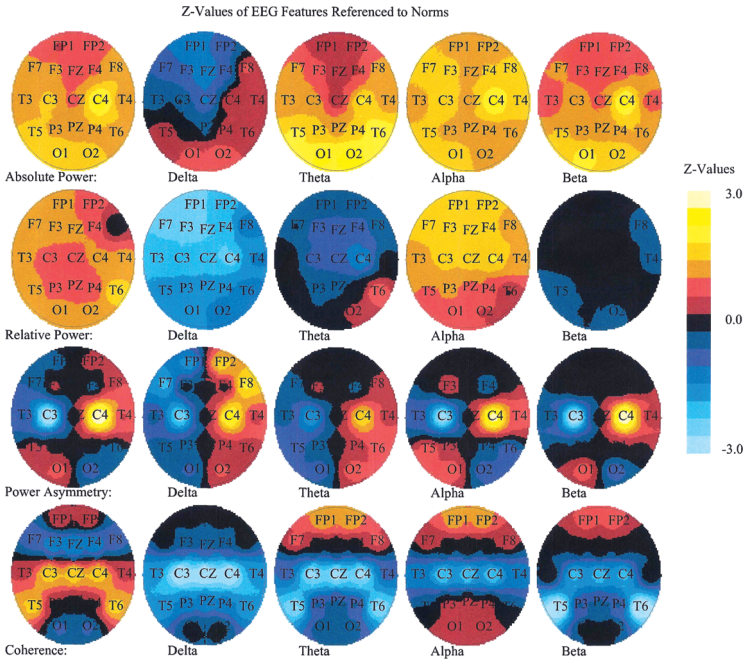


FIGURE 4. Pretreatment absolute power single Hertz maps.

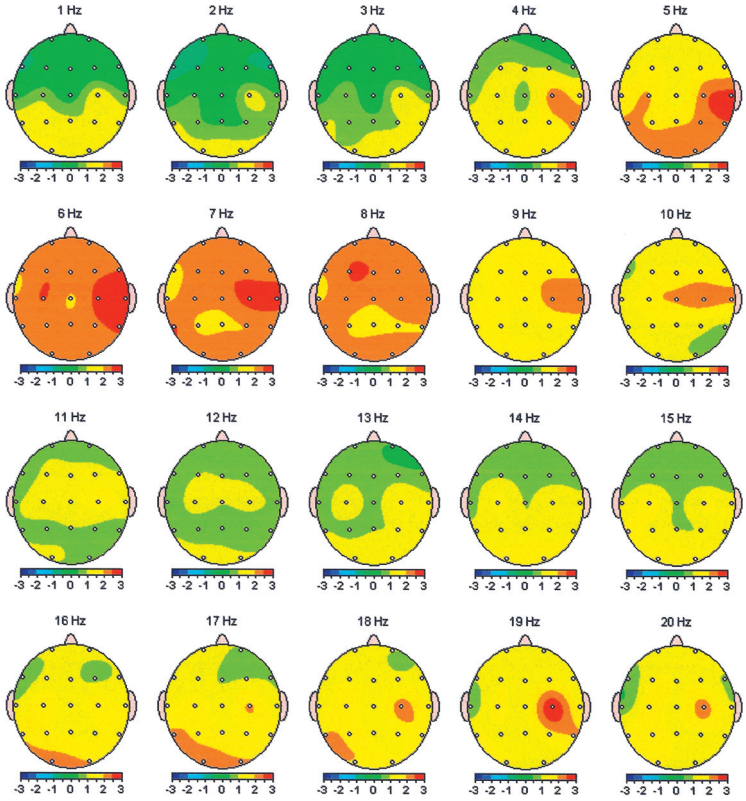
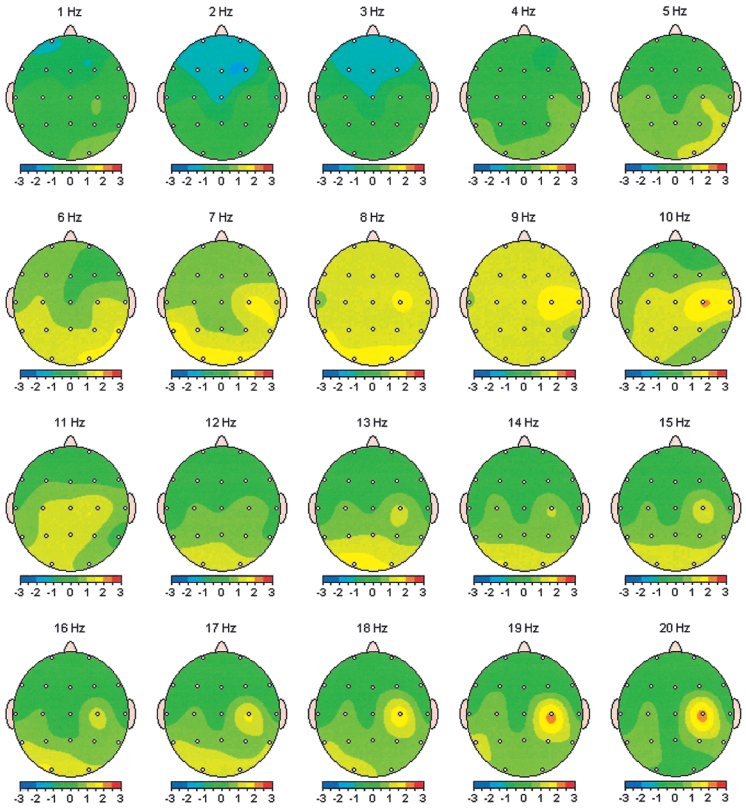
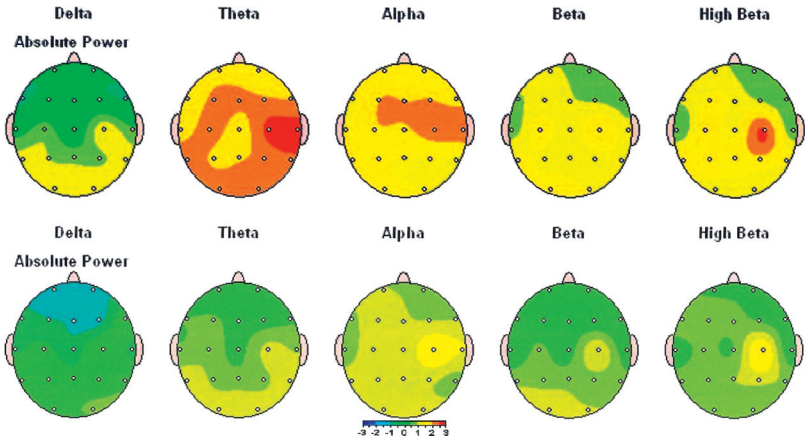


FIGURE 5. Posttreatment absolute power single Hertz maps.



usually based on patient self-report symptom ratings and brief, 4-sec measures of EEG amplitude at single sites. This article is the first report of an objective comparison of pre- and posttreatment QEEG data validating positive clinical outcomes from LENS treatment. Larger studies that include QEEG evaluation are needed.

FIGURE 6. Pre- to posttreatment absolute power NeuroGuide maps.



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