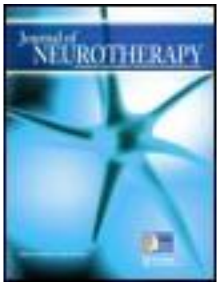

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Is It Better to Train Power First or Coherence First?

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ABSTRACT. *Introduction.* This study was done to see to what extent power training would correct coherence abnormalities in head-injured patients and to what extent coherence training would correct power abnormalities in a similar group of head-injured patients.

Method. Ten patients had power training first, and 10 patients had coherence training first (4 protocols with 5 sessions/protocol in each case).

Results. Either power or coherence training first resulted in normalization of most power and coherence abnormalities. Coherence training first resulted in significantly more new power abnormalities (10/client vs. 5/client for new power abnormalities). Power training first resulted in significantly more new coherence abnormalities (6/client vs. 2/client).

Conclusion. We did not find a clear-cut advantage for doing either power or coherence training first. However, we would recommend a repeat QEEG after doing either power or coherence first, since most original abnormalities will have resolved and there are likely to be several new abnormalities to be remediated.

KEYWORDS. QEEG, neurofeedback, power, coherence

INTRODUCTION

Prior to the development of neurofeedback for residual effects of closed head injury, there was no reliably effective way to remediate the chronic problems that these individuals develop. Ayers (1993) was the first to report improvement in head-injured patients trained with protocols to reward production of increases in bipolar beta frequencies, in a controlled study comparing neurofeedback with psychotherapy. Othmer (1994) described the use of monopolar beta training at central sites for closed head injury, with improvement of symptoms in most patients, usually requiring 60 sessions on average. In 1998, Thatcher published his first normative database. Using this database, it became possible to detect with precision and quantization the effects of head injury on individual patients (Thatcher, 2000). Based on the quantitative EEG (QEEG), it was possible to design protocols specific for that individual. Using this approach, Hoffman, Stockdale, and Hicks (1995) found that 60% of mild traumatic brain injury patients showed improvements in cognitive performance and/or self-reported symptoms, and their EEGs showed normalization after 40 neurofeedback sessions using power training. In later studies Hoffman, Stockdale, and van Egeren (1996) showed significant improvements and EEG normalization in only 5 to 10 sessions. Laibow, Stubblebine, Sandground, and Bounias (2001) correlated changes in the power spectra with patient symptoms and used targeted neurofeedback to resolve the symptoms with good success.

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Horvat (2003) was the first person to use QEEG-guided coherence training to remediate residual effects of closed head injury. Using Horvat's approach Walker, Norman, and Weber (2002) found that coherence training alone (no power training) was effective in remediating residual effects of head injury. Five training sessions were used to address each coherence abnormality. Significant improvement was noted in 88% of the patients, and 19 patients who had worked before the head injury were able to return to work. On average, 19 sessions were required versus 38 sessions in a group of patients trained with Cz-beta training (Walker et al., 2002). When both power and coherence abnormalities are addressed with QEEG, even better results are obtained (Walker & Horvat, 2010). The effect of power training on coherence abnormalities and the effect of coherence training on power have not been well studied. There is no question that coherence training can normalize some power abnormalities and that power training can normalize come coherence abnormalities, but there are no published studies on the incidence of such normalization. The current study was done to see if doing power training first or coherence training first would lead to a better result.

METHODS AND MATERIALS

Twenty patients with mild closed-head injuries were entered into the study. There were 8 females and 12 males, aged 6 to 72. Duration of time since the head injury ranged from 18 months to 36 months. They were randomized to training with power first or coherence first. EEGs were acquired with the Cadwell EEG acquisition instrument (Cadwell Easy PSG/EEG, version 1.7.3, 2002). Prior to treatment full cap EEG data were collected using an Electrocap® of appropriate size. Data were processed by Fast Fourier Transform after eliminating artifacts. Absolute and relative power were measured for delta (0–4 Hz), theta (4–7 Hz), alpha (8–12 Hz), and beta (13–30 Hz) and for coherence in those bands (eyes open). The data were compared with the Thatcher Neuroguide Database (Thatcher, 1988). Neurofeedback training consisted of 20 min of auditory and visual feedback while the patient was seated in a quiet room. The training site locations were derived from the individual NeuroGuide absolute power eyes-open abnormalities. For power abnormalities the single Hz bins were used to define the abnormalities to be treated. Both absolute and relative power abnormalities were trained. An abnormality was defined as greater than 2 *SD* above or below the mean for the control group in the database. Only down-training of the observed abnormalities was done, whether there was excessive slow activity (1–10 Hz) or excessive fast activity (11–30 Hz). No deficiencies of fast activity were noted. Only the abnormal frequencies were trained (not broadband). The protocol was followed for five sessions for each of the four most statistically significant power abnormalities. For coherence training, the four most significant coherence abnormalities were trained up (if decreased) or down (if increased) using the coherence electrode arrangements described by Collura (1995). Pretreatment and posttreatment QEEGs were done to evaluate the effects of training. Abnormalities were considered to be resolved if the posttreatment result was within 2.0 *SD* above or below the normal mean. The symptoms included memory loss, headache, irritability, attention deficit, anxiety, calculating ability, speech fluency, motor control problems, auditory processing, and visual processing.

The patients' response to treatment was estimated using the Global Improvement Score (Kadowsi, Corruble, & Falissard, 2006). This is derived by having the therapist interview the patient before neurofeedback training with regard to all symptoms (totaling 100%). The Global Improvement score represents the percentage improvement from baseline at the follow-up interview with the therapist.

For each patient, five sessions each were done for the four most statistically significant abnormalities in the power or in the coherence measures. Training was carried out using Brainmaster® equipment (Collura, 1995). Statistical comparisons were made

TABLE 1. Power training first (pre vs. post).

Client	Power Abnormalities Resolved	Coherence Abnormalities Resolved	New Power Abnormalities	New Coherences Abnormalities
1	3/6	3/3	7	1
2	10/11	2/2	13	5
3	3/11	20/20	4	6
4	6/16	7/7	0	3
5	6/9	8/15	4	12
6	17/26	3/9	0	3
7	8/13	19/24	1	3
8	5/8	8/18	7	3
9	8/12	4/4	10	7
10	15/17	3/6	5	21
Total	64/103 (62%)	87/108 (81%)	51 (5/client)	64 (6/client)

using Fisher's exact probability test (Lentner, 1982). Overall improvement was estimated using the Global Assessment of Improvement (Walker et al., 2002). No objective measures other than QEEG were used to assess improvement. We did not analyze the data for the specific clinically correlated effects of training the specific power or coherence abnormalities.

RESULTS AND DISCUSSION

Coherence training first resulted in a slightly better normalization of power abnormalities, 67% versus 57% (*ns*). Coherence training and power training resulted in an almost identical rate of normalization of coherence abnormalities: 82% versus 81% (*ns*). Coherence training first resulted in a significantly higher rate of *new* power abnormalities: 8.5/client versus 5.1/client ($p < .01$). Power training first resulted in significantly more new coherence abnormalities than coherence training; 6/client vs. 2/client ($p < 2.01$). Overall improvement was about the same, whether power training was done first (78% improvement) or coherence training was done first (69%; *ns*).

Our approach was to try to normalize significant abnormalities. It is possible that even better results could be obtained if we knew which of the abnormalities needed to be trained to above or below the normal range.

Neurofeedback seems to be a powerful technique for remediating residual effects of

TABLE 2. Coherence training first (pre vs. post).

Client	Power Abnormalities Resolved	Coherence Abnormalities Resolved	New Power Abnormalities	New Coherences Abnormalities
1	9/15	10/10	2	4
2	7/10	4/4	6	0
3	5/5	7/7	12	4
4	1/5	5/6	9	0
5	4/5	4/6	5	6
6	5/5	3/4	13	5
7	9/12	6/8	5	1
8	5/7	3/3	5	1
9	6/11	6/16	18	0
10	6/10	15/19	20	2
Total	57/85 (67%)	60/83 (72%)	105 (10/client)	23 (2/client)

TABLE 3. Global assessment of improvement.

Power First: After power training −51%
After power plus coherence training −78%
Coherence First: After coherence training −24%
After coherence plus power training −69%

brain injury (Thatcher, 2000; Walker et al., 2002). The goal of the present study was to see if it would be possible to improve the normalization of the QEEG by beginning with power training or with coherence training.

It appears that when one does power training first that most coherence abnormalities are remediated. When coherence training is done first, most power abnormalities are remediated. There was a trend (not significant) toward better normalization of coherence abnormalities with coherence training as opposed to power training. Overall improvement was about the same, whether power training or coherence training was done first.

With regard to the production of new abnormalities, there seemed little reason to prefer power first over coherence first. However, power first or coherence first training resulted in significant numbers of new abnormalities. It would therefore seem wise to remap after doing either power or coherence first, to be sure that one is training the remaining or new abnormalities rather than the initial abnormalities, which may already be remediated. If one does not remap, there is a risk of overtraining and possibly producing a reversal of the new abnormality (e.g., converting decreased coherence to increased coherence). We have seen cases where such "flipping" has resulted in an adverse effect (an increase in seizures in one patient, an increase in confusion in another patient).

The best approach would be to begin with either power or coherence training, remap, then do the opposite (power or coherence training). Future studies of neurofeedback to remediate the residual symptoms of closed head injury should take this into account. They should be done with a placebo or wait-list control group, and also should incorporate the results of neuropsychological testing pre- and posttraining.

CONCLUSIONS

1. Twenty sessions of either power training or coherence training (5 sessions for each protocol) resulted in normalization of the majority of power and coherence abnormalities. It is possible that a better result would have been obtained with more sessions per protocol, perhaps 7 to 10.
2. There was a trend toward better normalization of coherence abnormalities with coherence training versus power training.
3. Power training produced significantly fewer new power abnormalities than did coherence training.
4. Coherence training produced significantly fewer new coherence abnormalities than power training.

It should be noted that all of the patients reported significant improvements in their postconcussive symptoms and none reported significant new symptoms, despite the numerous new power and coherence abnormalities that were observed. Overall improvement was similar in the two groups at the completion of training. It would appear that either power training or coherence training may be done first, but a repeat QEEG should be done before the alternate type of training is done, to avoid overtraining and/or the development of new abnormalities.

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