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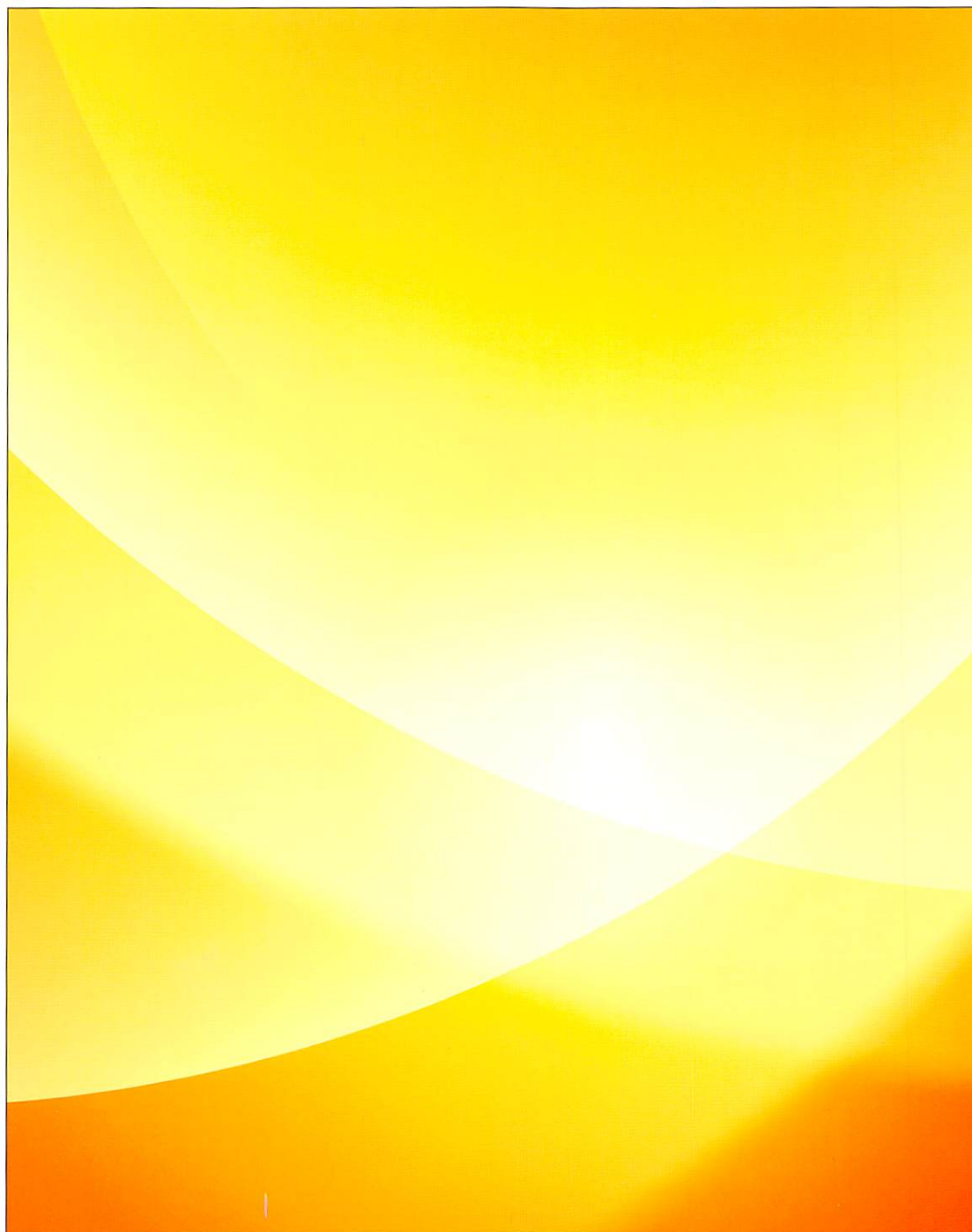
IN MIND-BODY MEDICINE

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Alpha Brain-wave Neurofeedback Training Reduces Psychopathology



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# Alpha Brain-wave Neurofeedback Training Reduces Psychopathology in a Cohort of Male and Female Canadian Aboriginals

James V. Hardt, PhD

## ABSTRACT

**Objective** • The study was conducted to determine if alpha brain-wave neurofeedback training can have positive psychological results by reducing anxiety and other psychopathology.

**Method** • The cohort participated in alpha brain-wave neurofeedback training for 76 minutes (day 1) to 120 or more minutes (days 5-7) daily for 7 days. Electroencephalogram (EEG) electrodes were attached to the head with conductive gel according to the 10-20 International Electrode Placement System. During training, participants were seated in a comfortable armchair within a soundproof and lightproof room. Brain-wave signals were amplified for processing by analog-to-digital converters and polygraphs, then filtered to the pure delta, theta, alpha, beta, and gamma bands as well as subbands of these bands of the EEG. For 2-minute epochs, trainees sat with their eyes closed in the dark listening to their feedback tones as the filtered alpha brain-wave EEG signals controlled the loudness of the tones. Then a "ding" sounded and the tones stopped. For 8 seconds, a monitor lit up with dimly illuminated, static numbers, indicating the strength of their alpha brain waves, after which the feedback tones resumed and the process was repeated.

**Participants** • 40 adult volunteers were recruited from the aboriginal population (First Nations, Métis, and Inuit) of Canada. The cohort ranged in age from 25 to 60 years and included males and females.

**Setting** • The study was conducted at Biocybernaut Institute of Canada in Victoria, British Columbia.

**Primary Outcome Measures** • Data was obtained to determine the effectiveness of this training by giving four psychological tests (Minnesota Multi-Phasic Personality Inventory, and the trait forms of the Multiple Affect Adjective Check List, Clyde Mood Scale, and Profile of Mood States) on the first day prior to commencing training and on the seventh day upon completion of the training. EEG data was also compiled throughout the training and analyzed as a factor of the training process.

**Results** • Postintervention data showed positive results with reduction of psychopathology when compared to the data from testing prior to the training. Analysis of this data showed improvement in several areas of psychopathology.

**Conclusion** • Alpha brain-wave neurofeedback training daily for 7 days does have positive psychological results in adult male and female Canadian aboriginals as measured by data from four psychological tests on the participants. (*Adv Mind Body Med.* 2012;26(2):8-12.)

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Dr Hans Berger, the German psychiatrist who developed and recorded the first electroencephalogram (EEG) in July, 1924, published his findings on the subject in 1929.<sup>1</sup> He had a particular interest in alpha brain waves, which earned the distinction of being called *Berger's waves*. Much of the modern knowledge of EEGs is due to his subsequent studies. EEGs are now used primarily to diagnose epilepsy, coma, encephalopathies, and brain death.

Neurofeedback training (NFT) is a set of methods and technologies used for the purpose of providing individuals with immediate information about what their brains are

doing. As a mirror of brain activity, NFT lets the trainee know what his or her brain is doing in real time. In NFT, EEG feedback is provided to trainees on naturally occurring frequencies emitted by their brains.

Most individuals are unaware of the subtle ongoing fluctuations and variations in their brain activities. By learning to voluntarily increase one's alpha brain waves, one can reduce anxiety. This was first reported by Hardt<sup>2</sup> and then by Hardt and Kamiya.<sup>3</sup> This later study showed that anxiety was found to be inversely related to the amount of EEG alpha activity of the brain. Neurofeedback is now increasingly recognized as an effective treatment for both clinical and non-clinical populations.<sup>4,5</sup>

Neurofeedback has been shown to reduce the frequency and severity of pain in 37 migraineurs.<sup>6</sup> Neurofeedback has also been successfully used for more than 3 decades in opioid substance abusers. In a recent study, Arani et al showed how neurofeedback can be used to ameliorate abnormalities related to opioid-dependence disorders when treatment also included neuropsychological interventions.<sup>7</sup>

In patients with depression who show no responses or incomplete responses to pharmacological or psychological treatments, Linden et al showed significant improvement in clinical symptoms using neurofeedback.<sup>8</sup> Predictability of pharmacological treatment success was addressed in a study by Tenke et al, who found that patients diagnosed with depression who showed higher alpha brain-wave amplitude were more likely to respond positively to treatment than those patients with lower alpha brain-wave amplitude.<sup>9</sup> In a randomized, clinical, pilot study, Choi et al found that neurofeedback had profound effects on emotion and cognition by alleviating depressive symptoms and improving performance of executive function tests.<sup>10</sup> Neurofeedback was found to improve surgical technique while reducing time on task by 26% in a study on ophthalmic microsurgeons by Ros.<sup>11</sup>

Using alpha brain-wave biofeedback training, Alekseeva et al were able to show enhanced fluency and accuracy in cognitive performance in 14 male participants.<sup>12</sup> Zoefel, et al showed that neurofeedback training significantly enhanced the cognitive performance when compared with a group who did not receive neurofeedback training.<sup>13</sup>

In this study, with the aid of neurofeedback, neural signals generated by each trainee's own brain were presented to the trainees instantly and continuously through loudness of musical tones, which were periodically interrupted to display digital scores in one or more of three colors. This visual and auditory feedback brought even subtle brain activity into a trainee's awareness and thereby opened the door to that person learning effective control of brain states that underlie and give rise to mental states and emotions. Using this method, NFT encourages the participants to produce more alpha waves by immediately giving them pleasant tones as feedback, which alerts them whenever alpha activity has just occurred. When the alpha waves get bigger in amplitude, the tones become louder. This feedback, combined with the

trainees' intention to make more alpha waves, encourages the brain to make more of the brain waves that just triggered the feedback.

We set out to determine if a properly designed program of training individuals to increase the occurrence and amplitude of alpha brain waves generated by their own brains can reduce anxiety and other types of psychopathology.

## METHODS

### Participants/Trainees

The cohort of alpha brain-wave trainees included 40 adult trainees. The patients were males and females, of the First Nations, Métis, or Inuit peoples, whose ages ranged from 25 to 60 years of age.

Exclusionary criteria were anyone suffering from alcoholism or addiction to any substances, and any pregnant female.

This study is adherent to the tenets of the Declaration of Helsinki. The trainees gave their signed informed consent. The trainees were not compensated for their participation. A private donor provided funding for the purpose of this study to research the effects of alpha brain-wave NFT for aboriginals.

### Protocol

For 7 consecutive days, each trainee spent 10-12 hours at the training center in activities that included NFT and debriefing after the NFT and reviewing and discussing their results, which included viewing their 8-channel EEG polygraph recordings, graphs of their numerical alpha EEG scores, and reviewing the results of their twice-daily computerized mood scales. Psychological testing was done before starting the training and repeated after completion. During each day, trainees were given ample time to use the bathroom and meals were catered.

The method included attaching electrodes daily with conductive gel to the trainee's head in carefully measured locations, according to the 10-20 International Electrode Placement System (O1, O2, C3, C4, T3, T4, F3, F4). Gold disc electrodes (Grass Technologies, West Warwick, Rhode Island) were used with 48-in leads that consisted of very fine silver wires, braided together for flexibility and low resistance, as silver is a very effective conductor.

With the electrodes in place, the trainee was shown to a soundproof and lightproof isolation room and seated in a comfortable armchair. The electrodes were plugged into an amplification system consisting of a preamplifier and power amplifier combination that boosted the EEG signals 100 000 times, making them sufficiently large for processing by analog-to-digital converters and polygraphs. The amplified brain waves were then filtered to obtain pure delta, theta, alpha, beta, and gamma bands, and subbands within these bands, and only the filtered alpha (broad-band) brain waves were used to drive sensory feedback signals to the trainee.

The first feedback modality was acoustical tones. The amplitude of the filtered alpha brain waves instantaneously

controlled the amplitude of feedback tones in the 400-800 Hz range. Alpha brain waves were detected separately on eight different head sites. Each site of the four feedback sites (O1, O2, C3 and C4) was designated a different feedback tone frequency and broadcast to the trainee from one of four different speakers in four different spatial locations.

Visual feedback was also provided to trainees via a dimly illuminated monitor with a 5 000 000:1 contrast ratio, meaning that it was almost totally dark when it was not receiving input. Visual feedback was given during both alpha enhancement and alpha suppression and included static numerical values for integrated amplitude scores on O1, O2, C3 and C4 as well as the HemiCoherence scores (HC) for the occipital pair (O1:O2) and the central pair (C3:C4). HC scores were the percent time (times 10) that both members of each HC pair were above 60% of the highest 15 second score that each member, respectively, had attained during that day's first white noise baseline. All six of these scores, four integrated amplitude scores and two HC scores, were displayed in one or more of three colors: white indicated that compared to the previous 2-minute epoch, the change in score was less desirable, blue indicated that the score was more desirable than that of the previous epoch, and green indicated that a new best score was attained. For enhancement, the desirable trend was higher, while for suppression, the desirable trend was lower.

Because of the natural physiological reactivity of alpha brain waves to different types of sensory stimuli, and because light is the most disruptive modality to alpha brain waves, effective alpha NFT requires the use of dark and nearly soundproof isolation rooms. For epochs of 2 minutes at a time, the trainees sat in the dark with their eyes closed listening to their feedback tones wax and wane based on the strength of the filtered EEG signals. Then a "ding" sounded and the tones stopped. For the next 8 seconds, the monitor displayed color-coded numerical feedback of their alpha brain-wave integrated amplitude and HC scores. At this point the feedback tones resumed and a new cycle began. This process was repeated throughout each training day.

### Outcome Measurement

To obtain data that could be quantified to help determine if the alpha brain-wave NFT was effective, four personality tests (Minnesota Multi-Phasic Personality Inventory [MMPI], Multiple Affect Adjective Check List [MAACL], Clyde Mood Scale [CMS] and Profile of Mood States [POMS]) were administered to each trainee prior to starting the program on day 1. The trait forms of the latter three assessments were used. The same tests were administered on the final day of the program (Day 7).

Data review included analysis of baseline and post-training scoring on the four psychological tests administered. Statistical analysis utilized SPSS software version

20.0 (IBM Corporation, Armonk, New York).

## RESULTS

### Minnesota Multi-phasic Personality Inventory

Statistically significant effects of one week of alpha brain-wave training as measured by the MMPI are presented in Table 1. The table compares day 1 to day 7 results for the aboriginal patients. There were statistically significant decreases in eight negative dimensions of personality, which included anxiety, depression, hypochondriasis, hysteria, masculinity/femininity, psychasthenia, schizophrenia, and social introversion.

### Mood Scale Trait Forms

In addition to the results of the NFT that are described above in the results of the MMPI, there are other beneficial personality changes that were seen in the cohort of aboriginal trainees. When the changes in personalities were viewed through the lens of the trait forms of the three daily mood scales, a number of important new dimensions of change emerged. In addition, there was confirmation of dimensions of change seen in the MMPI. When the MAACL, CMS, and POMS are administered with the instructions to "Describe how you feel *in general*," they become personality tests instead of indicators of more transient moods.

**Multiple Affect Adjective Check List.** The MAACL measures anxiety, depression, and hostility in both conscious and unconscious forms, as well as the total, which is the sum of the conscious and unconscious components. Thus, there are nine different dimensions of personality measured by this test instrument. Looking at the changes in the trainees from day 1 to day 7, the difference in all nine of the MAACL measures were statistically significant. Table 2 presents the reductions in these negative traits.

**Clyde Mood Scale.** The CMS test instrument measures six dimensions of personality: (1) friendly, (2) aggressive, (3) clear thinking, (4) sleepy, (5) unhappy, and (6) dizzy moods. Looking at the changes from day 1 to day 7 in the trainees, the difference in four of the six measures were statistically significant (Table 3).

**Profile of Mood States.** The POMS test instrument measures six dimensions of personality: (1) tension/anxiety, (2) depression/dejection, (3) confusion/bewilderment, (4) anger/hostility, (5) fatigue, and (6) vigor. Looking at the changes from Day 1 to Day 7 in the trainees, the difference in all six of the six measures were statistically significant (Table 4).

## DISCUSSION

### An Anishinaabe Teaching

*The notion is not that human beings are at the center of the universe but that our lives are nested in complex relationships. Our words, actions, and even our thoughts have wide-reaching, timeless*

**Table 1. Negative Dimensions of Personality From the Minnesota Multi-phasic Personality Inventory Showing Statistically Significant Decreases After 1 Week of Neurofeedback Training**

Dimension	<i>t</i>	<i>df</i>	<i>P</i>	Statistical Significance
Hypochondriasis	-3.766	36	.0005	Highly significant
Depression	-4.328	36	.000	Highly significant
Hysteria	-2.141	36	.0195	Significant
Psychopathic deviance	-1.338	36	.0945	Not significant
Masculinity/Femininity	-1.752	36	.044	Significant
Paranoia	-0.655	36	.2585	Not significant
Psychasthenia	-3.190	36	.0015	Highly significant
Schizophrenia	-2.108	36	.021	Significant
Mania	+0.215	36	.4155	Not significant
Social introversion	-4.864	36	.000	Highly significant
Welsh anxiety	-2.736	36	.005	Highly significant
Ego strength	+1.191	36	.121	Not significant

**Table 2. Reduction in Negative Traits as Measured by the Multiple Affect Adjective Check List After 1 Week of Neurofeedback Training**

Dimension	<i>t</i>	<i>df</i>	<i>P</i>	Statistical Significance
Anxiety, total	-6.891	39	.000	Highly significant
Anxiety, conscious	-3.619	39	.0005	Highly significant
Anxiety, unconscious	-5.859	39	.000	Highly significant
Depression, total	-8.128	39	.000	Highly significant
Depression, conscious	-2.168	39	.018	Significant
Depression, unconscious	-8.493	39	.000	Highly significant
Hostility, total	-6.121	39	.000	Highly significant
Hostility, conscious	-3.168	39	.0015	Highly significant
Hostility, unconscious	-5.190	39	.000	Highly significant

**Table 3. Changes in Mood as Measured by the Clyde Mood Scale After 1 Week of Neurofeedback Training**

Dimension	<i>t</i>	<i>df</i>	<i>P</i>	Statistical Significance
[more] Friendly	+3.345	39	.001	Highly significant
[less] Aggressive	-3.455	39	.0005	Highly significant
Clear thinking	+0.442	39	.3305	Not significant
[less] Sleepy	-4.736	39	.000	Highly significant
[less] Unhappy	-3.319	39	.001	Highly significant
Dizzy	-0.249	39	.4025	Not significant

**Table 4. Changes in Personality Dimensions as Measured by the Profile of Mood States After 1 Week of Neurofeedback Training**

Dimension	<i>t</i>	<i>df</i>	<i>P</i>	Statistical Significance
[less] Tension/anxiety	-4.489	39	.000	Highly significant
[less] Depression/dejection	-4.354	39	.000	Highly significant
[less] Confusion/bewilderment	-5.896	39	.000	Highly significant
[less] Anger/hostility	-4.948	39	.000	Highly significant
[less] Fatigue	-5.820	39	.000	Highly significant
[more] Vigor	+6.336	39	.000	Highly significant

impacts that cannot be discerned by our physical senses. Conversely, our lives are impacted by forces and events in the larger world, whose origins and intentions are often beyond our knowledge or understanding. To navigate successfully in such a complex environment requires more than physical, emotional, and intellectual competence. Achieving good life, long life—called *pimatziwin* in Anishinaabe tradition—requires spiritual awareness as well. Thus, another central teaching is that life must be lived holistically—balancing body, mind, feelings, and spirit.

As a result of disenfranchisement and historic systematic attempts to eradicate the culture of Canada's First Nations, Métis, and Inuit peoples in the name of assimilation, these peoples lag behind the nonaboriginal population in educational level and prosperity. The incidence of psychological, cultural, sexual, and physical trauma in Canada's First Nations is many times that of nonaboriginal Canadians, leading to greater incidence of anxiety and other psychopathology.<sup>14,15,16,17</sup>

Although the Canadian government and aboriginal organizations have initiated numerous programs that have met with varying degrees of success, there is still a great amount of need in these communities. The private funding that enabled Canadian aboriginals to participate in this study as trainees provides a population for research with demonstrated incidence of psychopathology, while at the same time offers this population a possible new avenue to escape the cycle of affliction that ensnares them. The results presented here show that NFT has efficacy in affecting psychopathological disorder and reveal a new tool for improving individuals' ability to function in society.

Depression is so widespread in the aboriginal communities that the study's finding of reductions in depression revealed by the MMPI instrument is of importance to everyone concerned with aboriginal mental health issues. The significant reductions in psychasthenia as measured by the MMPI in the aboriginal students who completed NFT demonstrate another important mental-health dimension to the benefits that come from doing NFT.

Chief Wilton Littlechild, member of Canada's Truth and Reconciliation Commission and a former Canadian Member of Parliament, completed NFT. He has expressed an opinion that all of the people with approved claims of abuse before his Commission should do the Biocybernaut Institute NFT programs as a part of their healing process.

## CONCLUSION

This pilot study shows the psychological benefits of alpha brain-wave NFT in a cohort of Canadian aboriginals. The data from the four psychological tests document the improvements of the 40 trainees by comparing the results from before and after their training. Recommendations for future work include longitudinal studies that would inte-

grate socioeconomic data and populations with broader ethnicity and socioeconomic diversity.

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