CREATIVITY INCREASES IN SCIENTISTS THROUGH ALPHA EEG FEEDBACK TRAINING

James V. Hardt, Ph.D. Biocybernaut Institute
Raymond Gale, Independent Consultant

CREATIVITY INCREASES IN SCIENTISTS THROUGH ALPHA EEG FEEDBACK TRAINING

James V. Hardt, Ph.D. Biocybernaut Institute
Raymond Gale, Independent Consultant

"Creativity is a matter of having the right brain waves. When creative people go to work on an imaginative task, their alpha jumps ..." *Collin Martindale, 1975*

The key question is whether learning alpha increases through feedback training will increase creativity. The **creative process has four stages**: **Application** (learning the information and problems in a field), **Incubation** (letting acquired knowledge gel), **Inspiration** (flash of insight, creative synthesis, Aha experience), and **Elaboration** (polishing and testing). We hypothesize alpha feedback training is most relevant to the **Incubation** and **Inspiration** stages of the creative process.

Martindale and his associates have provided both enlightening background reports (1973, 1977, 1978, 1984) and misleading alpha feedback studies (1974, 1975) of creativity. His background reports show that **highly creative subjects differ from normal subjects in EEG alpha activity.** When told to rest (baselines), the minds of creative subjects remained activated. They showed less alpha than non creative subjects, who relaxed and deactivated, at rest. However, when given creative problems to solve, **creative subjects shifted into high alpha to solve the problems quickly and creatively. Non creative subjects made no upward shift in alpha, and actually decreased their alpha if they concentrated.** Non creative subjects blocked alpha on all types of cognitive tasks, but **creative subjects blocked only on tasks not allowing for creativity, and actually increased alpha during tasks calling for or allowing creativity.** Creative subjects showed higher alpha during the **Inspiration** phase of the creative process than they did during the following **Elaboration** phase. During creative performance tasks **creative right handed subjects showed increases of left hemisphere alpha**. Non creative right handed subjects did not show this shift to left hemisphere alpha during these creative performance tasks. Intriguingly, this **increase of left brain alpha** is also reported prior to **peak performance** in **golfers** putting, **archers** and **gunners** shooting, and **basketball players** at free throw (Allman, 1992).

Does alpha EEG feedback improve creative performance? Martindale's alpha feedback studies (1974, 1975) **failed to employ recommended methodology (Hardt, 1974, 1990)**, and cannot provide useful answers to this question. Major flaws included: use of Percent Time alpha measures, and too little alpha enhancement feedback time (7 1/2 minutes in one study, 8 1/3 minutes in the other). In the later case, subjects were required to train eyes open and to alternate between enhancement and suppression every 100 seconds. **Bad feedback designs led Martindale to results which were hard to interpret, and which stymied his efforts to extend otherwise excellent work in this area.** Setting aside the Martindale feedback studies as fatally flawed, **the current study followed published design recommendations, and also used a control group** and Pre- and Post- feedback tests of creativity to see if creativity can be increased through alpha feedback training. Both groups were also given Pre- and Post- tests of subjective stress, and were also monitored Pre- and Post- for stress responses using the peripheral physiological modalities of EMG, EDR, heart rate, skin temperature, and respiration rate.

The Current Study

Subjects: Seven experimental subjects were scientists at Stanford Research Institute (SRI), who volunteered for a pilot program of EEG alpha feedback training. **Six control subjects were corporate professionals**, approximately age matched, who volunteered for biofeedback training. All subjects were volunteers.
Method (Equipment): All peripheral modality data (heart rate, frontal EMG, trapezius EMG, skin temperature, respiration rate, EDR) were collected with a J&J I330 system. All **EEG data** were collected with a **Biocybernaut Institute** Mark 7 Hybrid Spectral Analysis system, with 48 channel 12 bit A/D converters. Input to the A/D was provided by 16 EEG amplifiers, each with 3 analog filters. Filter output was a smoothed, full wave rectified signal. **Filters were very sharp** (300-400 dB/octave roll off, and 1/3 dB ripple in the pass band). Filters provided broad band theta, broad band alpha, and broad band beta signals on each of the 16 EEG channels. The Mark 7, a multi-user system, was configured to provide four simultaneous trainees with EEG feedback on their bilateral Occipital and Central EEGs (O1, O2, C3, C4). **Four channel audio feedback was provided simultaneously from broad band alpha at Occipital and Central sites (O1, O2, C3, C4).** Digital scores were given visually. Recording was monopolar to linked ears reference.

Method (Procedure): Within the limitations of a 5 day training, efforts were made to follow recommended procedures for successful alpha enhancement training (Hardt, 1974, 1990). **Subjects had 5 consecutive days of alpha feedback training**. Each day had eyes open, eyes closed, and white noise **baselines**. Over 8 hours of total alpha enhancement training time was provided over 5 days. Each Subject had **4 feedback tones** from 4 spatially separated speakers (O1, O2, C3, C4), with **tone volume proportional to instantaneous amplitude of the alpha envelope**. Feedback tones operated for **2 minute intervals [epochs]**, then stopped for an **8 second display of 4 integrated amplitude alpha scores**, one from each of the 4 feedback sites. Then score displays turned off and tone feedback resumed. **After each session, a trainer asked for subjective reports and reviewed results.**

Before and after their alpha feedback training, alpha subjects completed both creativity and stress tests including: [1] Christensen & Guilford's test of Ideational Fluency (to measure creativity of ideas), [2] Guilford's test of Associational Fluency (to measure verbal fluency), [3] Signals of Stress Inventory (SOSI), to measure subjective stress, and [4] subjects were given stress tests (mental, emotional, and auditory startle stress) while monitored by the J&J I330 for physiological stress responses. **Control subjects also completed all these tests, waited one week, then completed the tests again.** Tests [1] and [2] were administered in different forms for the Pre- and Post-testing. Both experimental and control subjects saw their peripheral modality physiological patterns on the monitor of the J&J I330 system, and received coaching on healthy, low stress patterns from a BCIA certified trainer. Thus **all subjects had two sessions of feedback on peripheral modalities. However, only the experimental group received alpha EEG feedback training.**

Results

On the first day of alpha training, **during alpha enhancement feedback, one of the 7 SRI scientists experienced a Break-Through Insight on a problem in his research**. He had been working on this problem for several years. He was so eager to apply his new insight to his research immediately (**Elaboration**), that he dropped out of training at the end of the first day, leaving only 6 SRI experimental alpha feedback subjects.
The **first step of data analysis** compared experimental and control groups on their **Pre-tests** to see how well the two groups were matched (significance is $p<.05$). **The two groups were very well matched on all three types of Pre-tests (Creativity, Subjective stress [SOSI], and Physiological stress measures).** There were **no significant differences** between the 2 groups in **Pre-test levels of subjective stress** [SOSI]; moreover there were **no significant differences** in **Pre-test Ideational Fluency** (creativity-of-ideas); there were **no significant differences** in **Pre-test Verbal Fluency**, and **no significant differences** in 4 of the 6 **peripheral modalities (EMG frontalis, EMG trapezius, skin temperature, and heart rate)**. Only EDR and respiration rate showed any differences between the two groups. Initial EDR was higher in the alpha group, but only in the first resting condition of the first session. Respiration rate was slower in the alpha group, but only in the two rest conditions and the auditory startle stress.

The **second step of data analysis** compared experimental and control groups on the **Post-tests** to **detect possible influences of alpha feedback training through changes** in creativity of ideas, verbal fluency, subjective stress, and physiological measures of stress.

Creativity Results. **Creativity scores (Ideational Fluency) in the alpha feedback group increased dramati-**

cally after 5 days of alpha training. This increase was **highly significant** (paired t=5.3057, df=5, p<.004). The control group had no significant changes up or down. **Verbal fluency scores (Associational Fluency)** for the control group decreased significantly, while the alpha group had a non significant increase.

Subjective Stress Results. Stress scores on the SOSI **decreased an average of 57.6% for the alpha feedback group** after 5 days of alpha training. This change was **very highly significant** (paired t=6.636, df=5, p<.001). The control group, after just waiting for 5 days, had an average 5% increase in SOSI scores, which was not significant.

Physiological Stress Test Results. EDR was selected for analysis, as it discriminated most clearly. The alpha group and the control group showed significantly different EDR reactions after the intervening week, which had alpha training for the alpha group, and no training for the control group. **In four different conditions the alpha group showed declines in EDR stress responses, while the control group showed increases**. These distinguishing conditions were: Emotional stress (t=2.8037, df=10, p<.02), Auditory Startle stress (t=2.4024, df=10, p<.05), and both of the rest conditions in the stress test, First Rest (t=3.0578, df=10, p<.02), and Final Rest (t=2.8603, df=10, p<.02).

Discussion

The highly significant increase in creativity of ideas (Ideational Fluency) in the alpha feedback group suggests that it may be possible for a wide range of people to become more creative. If supported by further studies, this finding could have positive implications for the conduct of daily life, and the development of human culture. Congress has designated the 1990s as "The Decade of the Brain", recognizing that the brain, and development of the mind, have become the new frontier of human exploration. Some societies, like Germany and Japan, are quick to adopt new processes that promise better performance and greater perfection. They will recognize the potential of this EEG feedback process to improve their most valuable resource, the minds of their people. Other societies may suffer competitive disadvantages to the degree that they lack the resources and the vision to make this technology and process broadly available.

The control group's significant decline on **verbal fluency** (Associational Fluency), and the non significant increase in the alpha group may suggest the second test was harder, and **only the alpha-trained subjects could resist lower scores**. It is also apparent that **alpha training reduced stress in the alpha group, which had a very highly significant reduction** (p<.001) in subjective stress on the SOSI. In 4 out of 5 conditions, the **alpha group showed *declines* in EDR stress response, while the control group showed *increases*.** This invites comparison with **Hardt & Kamiya's (1978) report that alpha feedback reduces anxiety in high anxiety subjects.** Further studies are needed for confirmation, but these results already fit well into contexts provided by Martindale for creativity and by Hardt & Kamiya for anxiety reduction. This study suggests that there are at least two different categories of **beneficial results from feedback training to increase EEG alpha: increased creativity and reduced anxiety.**

References

Allman, W.F., The Mental Edge, *Science & Society, In U.S. News & World Report,* **113**(5), 50-56, August 3 (1992).

Hardt, J.V. Alpha EEG responses of low and high anxiety males to respiration and relaxation training and to auditory feedback of occipital alpha. *Dissertation Abstracts, International*, **35**(4), Catalog No. 74-19309, 1912B-1913B, (1974).

Hardt, J.V. and Kamiya, J. Anxiety change through EEG alpha feedback: Seen only in high anxiety subjects. *Science*, ***201,*** 79-81, (1978).

Hardt, J.V. EEG Biofeedback Method and System for Training Voluntary Control of Human EEG Activity, *United States Patent #4,928,704*, May 29, (1990).

Martindale, C. & Greenough, J., The Differential Effect of Increased Arousal on Creative and Intellectual Performance, *The Journal of Genetic Psychology*, **123**, 329-335 (1973).

Martindale, C. & Armstrong, J., The Relationship of Creativity to Cortical Activation and its Operant Control, *The Journal of Genetic Psychology*, **124**, 311-320 (1974).

Martindale, C., What Makes Creative People Different, *Psychology Today*, 44-50, July (1975).

Martindale, C. & Hines, D., Creativity and Cortical Activation During Creative Intellectual and EEG Feedback

Tasks, *Biological Psychology*, **5**, 91-100 (1975).
Martindale, C., Creativity, Consciousness, and Cortical Arousal, Journal of Altered States of Consciousness, **3**(1), 69-85, (1977-78).
Martindale, C. & Hasenfus, N., EEG Differences as a Function of Creativity, Stage of the Creative Process, and Effort to be Original, *Biological Psychology*, **6**, 157-167 (1978).
Martindale, C., Hines, D., Mitchell, L., Covello, E., EEG Alpha Asymmetry and Creativity, *Personality & Individual Differences*, **5**(1), 77-86 (1984).