

EEG correlates of attention in humans

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This research was done to demonstrate the capacity of the Silva Graduate to produce Alpha brain wave rhythm voluntarily, and the compatibility of it with the conscious production of images.

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Until recently, scientists have been extremely critical of reports claiming that Yogis have learned to deliberately regulate their heartbeat, body temperature, and other internal body processes normally considered to be of an involuntary nature. Largely ignored also were reports that some subjects in deep states of hypnosis (an altered state of consciousness) could by suggestion be made to effect changes of a physiological nature normally considered not to be under voluntary control: For example, the raising of blisters and control of heart rate.

With the introduction of (bio) feedback techniques, the scientist has come to recognize during the last several years that almost any internal body process can be brought under control. Biofeedback techniques are based on the principle that we learn to respond correctly if we are immediately informed (feedback) of the correctness of the response or how close we are to responding correctly.

Using rewards as a feedback device in animals, psychologist Dr. Neal Miller, currently of Rockefeller University, demonstrated that heart rate changes could be achieved by voluntary control. Dr. Elmer Green, at the Menninger Foundation, showed that by using biofeedback, humans could learn to differentially control the temperature of their hands □ either hand hot, the other cold.

In the wake of brain wave biofeedback experiments of Dr. Kamiya, of the Langley Porter Neuropsychiatric Institute, researchers have shown that these methods are effective in teaching individuals to control their brain wave Alpha rhythm (8-13 Hz) voluntarily.

Other less laboratory oriented techniques have also been used to control internal body organs. For instance, the technique of transcendental meditation attempts to produce a relaxation of internal organs including the brain.

Another system by which subjects can produce relaxation and control of brain waves is the Silva system. Persons who have taken the Silva courses report a sensation of deep relaxation and a belief that they can control their brain waves. These claims were tested in 1971 by Dr. F. J. Bremner, psychologist at Trinity University in San Antonio, Texas. It appeared that people trained in this way can indeed control their brain waves and produce Alpha rhythm when they choose to do so. This was determined in a study in which a group of twenty untrained students volunteered for an experiment in brain wave control. Half of the students were conditioned by a method similar to Pavlov's method of conditioning dogs. That is, when the subjects heard a click it signaled that a strobe light would elicit an Alpha frequency response in the EEG. Soon the click also elicited the Alpha frequency pattern in the subjects EEG readout.

The other ten subjects were trained by Mr. Silva with his system. Both groups showed EEG changes in the direction predicted: That is, both groups increased the percentage of Alpha frequency in their EEG.

At a later time a second experiment was done using subjects with considerable practice in the Silva system. These subjects could start and stop Alpha frequency responses at will and could carry on a conversation while generating Alpha rhythm. One further test was made on these more practiced subjects. Since these subjects had also had considerable experience in ESP exercises (case working), EEGs were recorded while they engaged in ESP exercises. These EEG patterns also showed a high incidence of Alpha frequency.

It seems from these studies that with training, man can exercise a good deal of voluntary control over his internal organs. This holds true for the brain if we accept the electrical responses of that organ as being an indicator of its function. It also suggests that much more research is needed to determine the correlates of the physiological and mental-emotional states and the training procedures required to make the most of voluntary psycho “physiological self” regulation.

A better understanding of the significance of Silva training may be emerging from research on the physiology of the brain, as reported by neurobiologist Dr. Rodger W. Sperry and his colleagues in Los Angeles. These and other scientists have developed laboratory and clinical evidence for the existence of two distinct kinds of consciousness functioning separately but simultaneously within the brains of humans. The one kind of consciousness deals with sequential, logic dependent thinking activities such as mathematics and speech. It is functionally a product of the left hemisphere of the cortex. The other kind is associated with the right hemisphere and accounts for holistic and spontaneously creative, intuitive thinking, with an appreciation for spatiality and music.

The left hemisphere consciousness dominates most of our every day living and is favored even by the educational system as well as by the societal attitudes of the Western world. It is objectively oriented, and usually associated with the generation of much Beta brain wave activity. Right hemisphere consciousness seems to be primarily subjective, receives secondary consideration in our education, and finds its greatest expression in the arts. It is generally accompanied by Alpha or Theta brain wave emanation.

The Silva system trains individuals to maintain speech and other Beta thinking activities at Alpha as well as indulge in Alpha thinking processes of a creative, intuitive nature as part of a deliberate undertaking to provide for more equal distribution of function between left and right hemispheres. It helps balance an otherwise unequal preoccupation with left hemisphere function when undertaking to solve problems. It would seem to accomplish a more effective use of brain potential through the encouragement of deliberate right hemisphere function.

EGG CORRELATES OF ATTENTION IN HUMANS

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An attention model has been presented by Bremner and his co-workers which makes use of EEG changes as a dependent variable (Bremner, 1970; Ford, Morris, and Bremner, 1968; Eddy, Bremner, and Thomas, 1971; Hurwitz and Bremner, 1972). This model considers that there are different classes or subsets of attention but that, while these subsets are orthogonal, they are not arranged in a hierarchy. The subsets already defined are: Expectancy, counter-expectancy, orientation, arousal, and non focus (Hurwitz and Bremner, 1972).

The utility of the above model will increase as its generality increases. The present study attempts to extend the generality of the model from the animal data used for its original conception to data concerning human attentional states. The present study concentrated on two aspects of generalizing the model. One of these aspects was to see if human EEG was sensitive to changes relative to any of the previously proposed subsets. The other aspect was to determine if there was any unique attentional subset present in humans but either not present in animals or not testable in animals.

Because much of the experimentation used to test the model has been directed toward the expectancy subset, this was the subset chosen to test human attention. The reader is reminded that expectancy is used here to mean that the subjects (Ss) have learned a relationship that stimulus B follows stimulus A.

Since the details of the procedure will be elaborated in the method section, suffice it to say that this will be done by means of a classical conditioning paradigm. This paradigm followed as closely as possible that used to gather the animal data. The animal data, however, capitalized on the ready availability of Theta rhythm. Human EEG data on the other hand are characterized by high probability of Alpha rhythm. Therefore Alpha rhythm was used as data for the dependent variable. The second aspect of this study may well be the more interesting. Psychologists have often debated the existence of a human inner consciousness. The present model addresses itself to this question by making internal focus a subset of attention. The internal focus subset is characterized by the absence of exteroceptive stimulus and by being testable only in the human. It is proposed that this subset can be measured by EEG changes that occur following Ss responses during meditational and deep relaxation states.

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METHOD

Subjects: The Ss were 20 volunteer male college students from an introductory psychology class, ranging in age from eighteen to twenty-five. They were told that the experiment was about self-control of brain waves, and were assigned irregularly to two groups of 10 Ss each.

Apparatus: A Beckman Type T electroencephalograph was used. Electrodes were stainless steel, attached subcutaneously over the vertex and occipital area. EEG data were visually monitored as well as tape recorded. Through an auditory biogenic feedback system, the brain waves in the Alpha range (8-13 Hz) could be filtered from the occipital EEG and presented to the S through earphones as an analog of the Alpha frequency. A Digital Equipment Corporation logic programmer was arranged to indicate a binary number, turn on a half second CS, and 10 seconds later to turn on a one second UCS. The CS was a click delivered to the earphones worn by the subject, and consisted of the opening and closing of a relay connected to a six volt battery. The UCS was a Grass PS2 Photostimulator strobe light set at the S eyes closed Alpha frequency. All data were recorded on a 8 track Ampex Sp 300

Analog tape deck, and the completed analog tape was digitalized by an A/D converter connected to an IBM 360/44 computer before analysis.

Procedure: This experiment was reviewed and approved by a University Committee for Humane Treatment of Humans as Experimental Subjects. Each S was asked to fill out a protocol sheet asking for such information as last use of alcohol or drugs, history of epileptic seizures, and previous experience with hypnosis, Yoga, or Alpha conditioning. In addition, the first time an S was brought into the lab, he was asked to sign a statement consenting to participate in the experiment and asserting that the nature and purpose of the procedure had been explained to him.

A baseline EEG was run on each S, with no feedback provided. The S was given a "close eyes" instruction as stimulus. The graph was marked with a binary number, and separate recording channels were used for the unfiltered and filtered brain waves. This procedure was then repeated with an "open eyes" instruction. The S's face was monitored with closed-circuit television, and the total time in the chamber for the baseline data was approximately 30 minutes for each S. If the baseline reading was inadequate, the baseline procedure was repeated until artifact free data were obtained.

Following the baseline procedure, Ss were divided into two groups of 10 Ss each. One group (Silva) was given a 14 hour weekend session of the Jose Silva Mind Control Method training course (Shah, 1971). While the Silva Mind Control technique is unique unto itself, it capitalizes on both deep relaxation and group hypnosis like procedures. Some time is also spent in what best can be described as ESP exercises. At the beginning of the following week, the Ss were brought into the lab, and an EEG was taken for 20 minutes. Recordings were made both with eyes closed and with eyes open, while the Ss were practicing their Silva technique. On another occasion, an EEG was taken on the same Ss, with auditory biogenic feedback under similar instructions.

The second group (CC) of 10 Ss was run through a classical conditioning paradigm of 50 trials per session. Each trial consisted of a CS of a half second click, followed by a 10 second inter-stimulus interval (ISI), followed by a UCS consisting of 10 seconds duration of a strobe light set at the S eyes closed Alpha frequency. The intertrial interval (ITI) was irregular, with the experimenter starting the trial when S appeared relaxed. No feedback was provided for this set of trials. A 50 trial session lasted 20 to 30 minutes, and the sessions were repeated until S was conditioned to produce Alpha, or until the experimenter was convinced S could not produce Alpha sufficiently. The final 50 trial session was conducted for the CC group with biogenic feedback provided. All classical conditioning data reported were taken under eyes open conditions.

TREATMENT OF RESULTS

For purposes of analysis, the EEG data were sampled in terms of epochs, one epoch being 10 consecutive seconds of data. For the baseline data, one epoch was taken for each S under eyes closed and one epoch under eyes open conditions. For the Silva Ss, after the 14 hour training session, one epoch was taken for eyes closed, and one epoch for eyes open conditions, without feedback. Eyes closed and eyes open epochs were also taken on the Silva group when feedback was provided. For the CC group, an early trial (trial 3 if it was artifact free) was taken, and the epoch was the 10 second ISI. A similar epoch was taken from the last trial before the biogenic feedback, and a final epoch was taken after the feedback was started.

Each epoch was A-D converted and spectrally analyzed, yielding the power at various EEG frequencies (Walter, 1968). Only the eyes open data will be reported in this paper.

RESULTS

Figures I and II, summarize the results of the CC group and Silva group respectively. The effect of biogenic feedback can also be seen in each figure. The three aspects of the experiment were projected on a common axis; thus a comparison between baseline readings, improvement in Alpha frequency production through either experimental procedure, and the influence of biogenic feedback can be observed on the figure for each group.

Turning first to the CC group (Figure I), a definite increase in Alpha production due to the CC procedure is indicated by a peak in the middle line at frequencies 8 to 9 Hz. The baseline data did not appear to indicate a dominant Alpha rhythm output, as seen by the broad and rather flat spectra. The increase in mean percent power is distributed among a smaller number of frequencies. An additional change in the Alpha band is observed when biogenic feedback is introduced, and this is accompanied by a further narrowing of the spectra. That is, the introduction of biogenic feedback yielded yet another frequency shift.

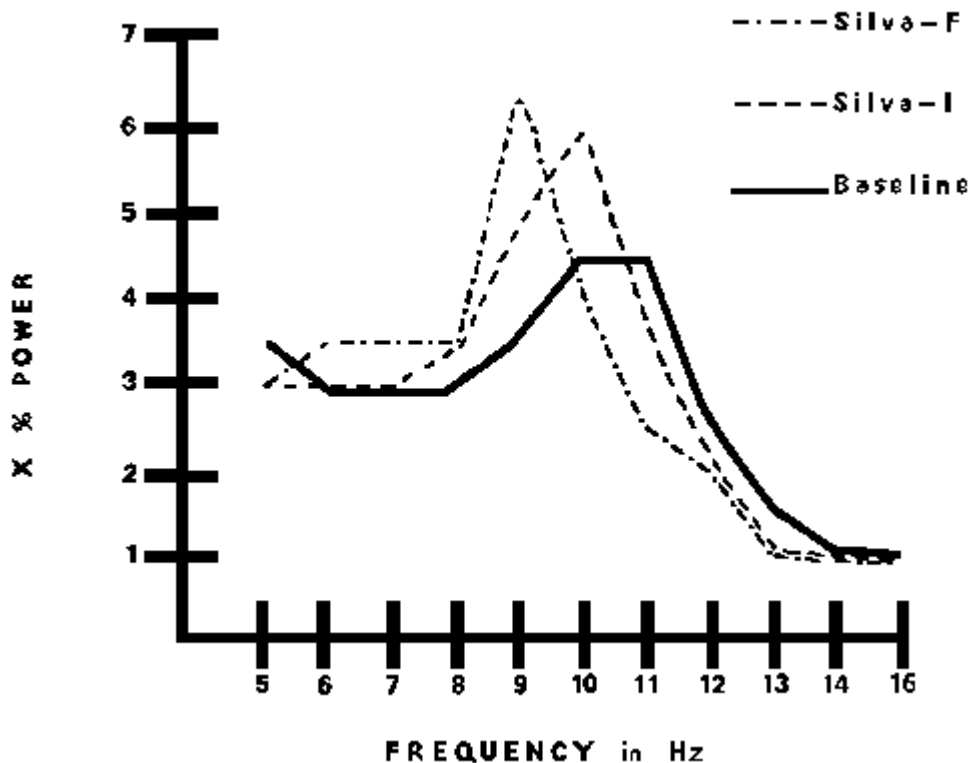
Similar observations can be made of the Silva group data (Figure II) but caution must be exercised in comparing the figures of the two groups. Observation of the figure, however, indicates that the Silva Ss were quite capable of producing the Alpha rhythm following treatment, although not in the quantity demonstrated by the CC Ss. (see Figure I). Again a downward frequency shift occurred and it appears to be greater here than in the CC group. This conclusion may not be entirely correct because the Silva group baseline readings included elevated production of higher frequencies, such as in the 10 to 12 Hz range, while baseline readings in the CC group did not. It is difficult, therefore, to make a judgment on the degree of relative shift in the two groups. It is worth noting, however, that the frequency shift occurred in the same direction in both groups and that the biogenic feedback had the same effect in both cases. (see Figure II).

DISCUSSION

The data reported above would apparently support the Bremner attention model, particularly the expectancy and internal focus subsets. It is rather interesting to compare the human data recorded in this study with animal data originally used to define the expectancy subset. (See Figure III). If one compares Figures I and III, a certain similarity becomes apparent. The baseline and CS alone curves are broad and flat, while the conditioning curves are peaked. Also both graphs show a frequent shift. The authors realize that the frequency shift is in the opposite direction. This is attributed to the fact that the animal data are from hippocampal sites while the human data are most closely associated with the occipital cortex. It seems, therefore, that expectancy as conceived by the model is correlated with the shape of the spectra and a frequency shift. Other authors have reported frequency shifts in human Alpha rhythm that would support an expectancy subset (Knott and Henry, 1941; Williams, 1940) or at least a correlation of Alpha with attention (Jasper and Shagass, 1940).

It is the contention of the authors that the subset internal focus is demonstrated by Figure II. These Ss trained in the Silva system used no external stimuli to generate their data but rather what can best be described as mental imagery. One of the values of the Bremner model in this regard is that by defining the subset "internal focus" it becomes unnecessary to use terms such as "consciousness" or "mental imagery." Internal focus depends on antecedent conditions, such as instructions to the Ss, and on the EEG changes observed. It is of course realized that additional controls will be needed in order to test the reliability and validity of the internal focus subset. This is particularly true in the light of Harts s

(1968) criticism that Ss left to themselves in a dimly lit, quiet room for several minutes will increase their Alpha production. The present study (and Brown, 1970) may not be as vulnerable to this criticism, since it makes use of frequency shifts and shape of spectrum as opposed to those studies which rely on quantity or amplitude of Alpha (Kamiya, 1968). Nevertheless, it is interesting to speculate about the additional frequency shift following introduction of the biogenic feedback. In the case of the CC group it might have served to make the UCR and CR more overt, thus changing the classical conditioning paradigm into an instrumental conditioning situation with a CR of high incentive value. For the Silva trained group, on the other hand, the feedback might make explicit to the Ss a correlate of internal focus that is not subjective.



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