

PSYCHOSYNTHESIS SEMINARS

1971-72 SERIES

Fifth Meeting: February 18, 1972

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Topic: Bio-feedback: Brainwaves and Consciousness

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BIO-FEEDBACK: BRAINWAVES & CONSCIOUSNESS

Lester G. Fehmi, Ph.D.

INTRODUCTION

Dr. Frank Haronian: We are glad to have Lester Fehmi with us here tonight. Biofeedback and alpha training are matters that Lester has been very much involved in as offshoots of his primary interests in consciousness, attention, and perception. Biofeedback and alpha training are very relevant to what we in psychosynthesis are concerned about in the training of the will.

Lester comes to us with a very wide and varied background. He started out in electrical engineering at City College; after four years in the Army he switched to physics and mathematics but went on to take his Bachelor's at San Jose State College in psychology. He later went on to do his Master's and his Doctorate in psychology at UCLA. He had a Postdoctoral Fellowship at the Brain Research Institute at UCLA and during the last five years, he has been a member of the psychology faculty at the State University of New York at Stony Brook.

His primary interests are in the fields of attention and perception, the general field of consciousness. He's running two labs, one in perception and one in biofeedback. Tonight he is going to start off with a movie.

Dr. Lester Fehmi: Thank you very much for the introduction and for inviting me here this evening. The film which is about to be shown will give you an idea of the kinds of procedures I use in pursuing my interests in EEG feedback and more generally in the field of biofeedback. The title of the film is "Voluntary? Involuntary control!"

(Movie shown; throughout the voices indicated were on the film. First shots were of a man jogging.)

VOICE: Why do I jog? I jog because I feel better. I find I've lost twenty pounds over a period of time; my friends tell me I look younger, and every day I get out there and I'm ready to face the world.

NARRATOR: By and large, we do things to achieve goals. There are limits to what we can do voluntarily. No matter what good it would do him, this man could not command his heartbeat to decrease now, or so it seems. (Various images shown.)

Composer David Rosenboom volunteers to be a subject in a study to discover whether or not man can control his brainwaves. Dr. Lester Fehmi is fitting David with electrodes, which can detect the tiny electrical activity given off by the brain.

Everyone produces a variety of brainwaves, with frequencies of anywhere from one to 200 cycles per second. David will attempt to control a particular brainwave called alpha, which covers only 8 to 12 cycles per second. A machine detects whenever David's brain emits alpha waves and automatically sounds a tone.

Dr. Fehmi: The amplified brainwave is fed into an analyzing device, such as that alpha detector. When the subject is putting out alpha, the green light will be on

and when the frequency is below alpha, the red light goes on. When it is above alpha frequency the yellow light will be on. When the green light is on the tone will be sounded for the subject.

The traces on the record (record shown) correspond to the locations on the head where we have the electrodes. This is from the left, front, top and back of the head (indicating). Are you ready, David? (Subject indicates readiness.)

NARRATOR: David's task is very clear, to keep the tone on as much as he can by increasing the amount of alpha he emits. In other words, he has been asked to achieve control of his involuntary function.

Dr. Fehmi: (Record shown) If you look at the record closely at the beginning of training, you will notice an absence of pure rhythmic alpha activity. In a little while you will notice a sharp decrease in this rhythmic activity. (Later) The alpha activity is about all that is present on the record at this point. After training - about half an hour - you can hear a great increase in the duration of the tone and you can see that the record shows a great deal of very rhythmic, alpha activity.

NARRATOR: David has increased his alpha activity from 10 to 80 per cent. High output of alpha often produces an unusual state of consciousness which is very pleasant. In fact, outside of the laboratory such levels have been found only in people who have spent years at meditative discipline such as Zen or Yoga. David is able to turn on alpha waves at will after just a few sessions. This ability has other effects in his daily life.

DAVID: Yes, in working, functioning, being able to enhance all aspects of things; the ability to concentrate; the ability to zero in on one thing, stay with it very clearly and then, when it's time to change and go to something else, make a rapid transition and become involved in the next thing that's important to you, whether that might be working, relaxing or whatever.

Then the ability to let down the perceptual inhibitions which everybody has or has built up from his habits and his learning experiences, which are the things, of course, that relate to drugs. But this is a much greater ability, to scan the environment and make instantaneous connections with what you see in it.

Dr. Fehmi: In relation to drugs, how would it compare? How would the state in which you produce a lot of alpha compare with a good drug high? There's almost no comparison; it's much more powerful and much more rewarding. It's a reward. The ability to control and the ability to hallucinate everything and the ability to function so well is the reward for an effort that you've put out; a reward for something you've done.

You've sat down and you've made the distinction; okay, now you're going to try to use control; and everything that you've created you're very conscious that it's come from within you; you put it there. It's not taking a pill and having it happen to you; it's your own thing.

NARRATOR: David's control over his brainwaves is helpful, but perhaps it is not direct control. Emotional feelings are involuntary, but method actor Don Berry can control them indirectly. (new image shown)

DON BERRY: You can depend on the amount of anger that you can get. There are two ways you can do it; you can do it just purely mechanically. You can press your hands together and produce frustration and anger; you can do a physical thing that produces anger - just blind, unfocused anger, or you can do an emotional recall where you get the sounds and smells and even the sense of space that you had; you can get a specific

place where something happened. I can recall a room with a beamed ceiling and a fireplace, and an oak table with a round top, and I think it's late in the afternoon, and there's a girl with short black hair, and she's looking at me and she's saying, "Darling, I don't know how I can stand the pain," and I keep looking away from her. (starts to fear) I guess I'm looking out the window, and there are plants there, and she's crying. (Don Berry appears convincingly emotional.) That's kind of a mild emotional recall.

NARRATOR: This indirect control of involuntary function is acceptable because it preserves our conception that some functions are involuntary; that is, they're not subject to direct control. However, a series of experiments by Dr. Neal Miller and his associates is forcing a reconsideration of the traditional concept of involuntary functions.

(Man shown in a laboratory with a white rat.)

This rat is injected with curare a drug which paralyzes the voluntary muscles. The involuntary muscles and the consciousness of the animal are unaffected. In this experiment the rat is rewarded for increasing his heart-rate. He is paralyzed to prevent him from indirectly changing his heart-rate by physical movement. When the curare has taken effect, an artificial respirator is fitted; the respiratory muscles are paralyzed.

(Little white rat shown with respirator attached.) Electrodes are attached to monitor its heartrate.

After a period of adaptation the experiment is begun. The heartrate is continuously converted into beats per minute. At the beginning of the experiment the heartrate is about 400 beats per minute - a normal rate. The rate does vary somewhat from moment to moment and because of this it is possible to select the higher points and reward the rat further. The arrow on the left indicates the criterion level. Any time the rate is above that level, the computer initiates a reward indicated by the lower pen.

Initially, the criterion is set at 405 beats per minute, but the level is only occasionally reached. Within a few minutes the rat has increased his heartrate so he has received increasing rewards. His average rate has now increased and so the reward criterion can be raised. In another few minutes his average has increased again and in turn the criteria level can be moved up.

By this step-by-step "shaping" procedure, the rat can be induced to raise his heart rate to high levels. (Chart shown) By the end of the experiment the rat has increased his average heartrate by one hundred beats per minute.

Rats have also been rewarded for decreasing their heartrate, with the same degree of success. In fact, the decrease is so significant that some rats actually died. The fact that an animal could alter a vital function to this extent has profound implications for human psychosomatic symptoms. Psychosomatic illnesses involve just such involuntary functions as heartrate, blood pressure, stomach and intestinal activity.

All of these organs, plus the kidney and uterus have been reward-trained by Dr. Miller and his colleagues. One study involved the blood supply of the ear.

Dr. Miller: We tried to see if we could train the rat to blush with one ear and not with the other. We put little photoelectric transducers on each ear and the amount of light that was picked up was the function of the amount of blood in the ear. We

specifically rewarded the blood flow through the two ears and to our great delight it worked and the rat learned to do this. This is particularly good because it's hard for you to imagine that the rat could cheat on any physical movement it could make, or get more or less excited, causing him to blush in one ear but not in the other.

VOICE: Do you think that this would apply to people as well as to animals?

Dr. Miller: We're working with some patients, trying to see if we can train a patient who has too fast a heartrate to slow it down.

VOICE: How do you reward a patient?

Dr. Miller: In my opinion the best reward, when you're trying to do something, is the knowledge that you've succeeded, especially with a patient; if a patient is trying to lower his blood pressure, it's a little bit like playing golf when you see the putt drop into the hole, then that's a reward for having made the correct shot. If you were to imagine you were trying to do this blindfolded, you wouldn't learn very much. What we do, essentially, is to take off the blindfold; give the signal that tells them the blood pressure is falling just a little.

I want to emphasize that so far, in trying this as an experiment, we do not yet know whether we can produce changes that are long enough, large enough or long-lasting enough to generalize from the experimental situation to the real life situation, to be of any therapeutic value. We don't know this yet; it's just in the initial stages of trying it out.

VOICE: Do you suppose any of these psychosomatic symptoms could have been learned through reward training?

Dr. Miller: Theoretically it certainly is possible that psychosomatic symptoms can be learned by rewards or what psychiatrists call secondary gain. Suppose a child was scared to death in school on a certain day because he had an important examination for which he was utterly unprepared. The fear might just naturally produce a number of symptoms such as grumbling stomach, or feeling faint. Suppose a mother ignored a number of these symptoms but when the child looked very pale she said, "You're sick and can't go to school today." Phew! Just tremendous relief on the part of the child, which theoretically could reward that symptom.

NARRATOR: In the past, a few men, using disciplines such as Yoga, have achieved control over involuntary functions. It now seems likely that what they achieved was direct voluntary control. The work on reward training of involuntary behavior may soon make such powerful inner control realizable to everyone.

DON BERRY: Okay. You've done all the exercises and you've become fairly free. It becomes very easy to bring up emotions.

Dr. Miller: A diver, for example, has very good voluntary control over his body. Somebody who hasn't practiced diving doesn't have very good voluntary control. I think it's merely a matter of practising and getting rewarded for successes, such as a nice clean dive into the water, and when a person does the wrong thing, such as a belly-flop that stings when he goes into the water. So I think this is exactly the way one gets voluntary control over any function.

DAVID ROSENBOOM: It's not necessarily getting control of the alpha feedback tone, it's getting control of yourself. Once your memory is strong enough about what you've learned, then you don't need the tone any more. Once you're there you become keenly

aware of your power and it's not an exertive power; a power which you exert on somebody else or on a machine or something else in the outside world, but it's your power over yourself.

(End of film)

Dr. Fehmi: I started research in the area of biofeedback five years ago. This was an outgrowth of my interest in perception. Throughout my training I had been particularly interested in perception as it relates to attention and consciousness. I will present my paper in conjunction with some slides. Please interrupt and ask me questions according to your interest. If I make a point that you'd like to hear more about, please indicate that to me in some way.

Question: The film talked about rewards because you're successful. When you're trying to dive, you know how to try to make it more successful. How would you control alpha waves?

Dr. Fehmi: In biofeedback research relating to brainwaves one can use a number of different types of feedback signals. In our laboratory we have used visual feedback signals, condition feedback signals and even vibrational or tactile signals. When one spontaneously produces alpha waves one is apprised of their occurrence simultaneously. Over time one learns to associate internal processes with their occurrences and ultimately learns control of these processes.

Now I'd like to begin the slide presentation. Then we will be able to discuss that question more fully.

(slide) This is a picture of a head - when we use brainwaves, we use as a reference the interconnected ears. We place a recording electrode in any one of five places which are shown here - midfrontal (the middle of the forehead, just below the hairline), mid-parietal (the middle of the top of the head), mid-occipital (the middle of the back of the head, about two centimeters above theinion, and right and left temporal lobes (an inch above the middle of the ears).

Once the electrodes are attached, we amplify the electrical signals from the recording sites. These signals are of very small amplitude, usually anywhere from one to fifty microvolts. It requires an amplification of about one million in order to be able to easily read and work with the signals.

Essentially that is all that the electroencephalograph (EEG) does - amplify the signals and record them on paper.

(slide) This is a diagram of a biofeedback system. In general, a bio-signal detector like an EEG, an electromyograph (EMG) muscle detector; or an electrocardiograph (EKG) is connected to various analyzing devices and a criterion detector. The adjustable criterion detector lets us know when a specified criterion of amplitude, frequency, or some other parameter of the signal has been satisfied. When the criterion is met, the criterion detector changes state and causes a feedback signal to be generated to the subject.

In the case of alpha waves, the subject hears a tone when he is producing alpha waves. This procedure lets the subject know immediately when he's producing alpha waves. (Slide)

Brain waves are classified according to their frequency. Delta waves are large amplitude, slow waves from one to four cycles per second. Theta waves are from four to eight cycles per second. Alpha waves, which we will be talking about most, are from eight to thirteen cycles per second, and usually occur in bursts

of several waves. Beta waves are more rapid, above thirteen cycles per second.

Delta waves are associated with certain stages of sleep. Theta waves are associated with hypnogogic and hypnopompic imagery - the kind of imagery that occurs when you have just woken up and are reliving or remembering part of a dream, when it is very vivid and real to you.

Traditionally, alpha is associated with relaxed wakefulness. Beta is associated with an active, problem-solving-type effort. "Effort" is the key word. Any time you are trying very hard to solve a problem, you are likely to be putting out beta waves rather than alpha waves.

QUESTION: Is it possible to simultaneously have different wave lengths at different recording sites?

Dr. Fehmi: Yes. What I have presented here is the ideal case. Usually there are a number of different frequencies present at the same and at different sites. The amount of energy or amplitude of any frequency band changes according to your state of mind and your activities.

In general, however, when you're producing large amplitude alpha waves, they can account for most of the EEG energy. I think that's also true of theta, particularly during meditation when large amplitude waves are produced.

A few years ago, Kasamatsu and Hirai found that Zen masters and monks, who had meditated for many years, produced very large alpha waves, with amplitudes of about 200 microvolts. Perhaps that number doesn't mean anything to you, but it's probably ten to twenty times larger than the amplitude of the alpha waves which most people produce.

These meditators also produced theta waves. They would begin meditating by producing alpha waves, but would reduce the frequency down to the theta range, and begin producing "bursts" of theta activity with the largest amplitude recorded from the frontal lobe. Masters of Yoga also produce very large amplitude alpha and theta waves.

QUESTION: Is there any distinction between the waves put out by Yogis and Zen Masters?

Dr. Fehmi: The literature doesn't suggest any differences in the waves themselves but does suggest that their training causes them to cultivate different kinds of control over them.

(Slide) This slide shows the record of a person putting out alpha from the mid-occipital, midparietal, and midfrontal lobes. In most subjects, the largest amount of alpha is found in the occipital lobe, the area associated with vision in man.

The parietal lobe, which is associated with somesthetic activity, usually produces the next highest amount of alpha activity. Usually, according to our findings, even less alpha activity is found in the frontal lobe. The temporal lobes usually produce less alpha than any of the other lobes. This subject, for example, came into my lab with an abundance of midoccipital, midparietal, and midfrontal alpha, but very little alpha on the right and left temporal lobes.

After three days of training, much of the fast beta activity on the temporal lobes disappeared and he began producing more alpha in both temporal lobes.

It has been my observation that subjects do not report a significant effect until the whole head begins producing alpha. They don't really notice anything

if they have only learned to produce alpha waves at one site.

QUESTION: When you're training a subject, does the green light show alpha?

Dr. Fehmi: Yes. The green light just shows the experimenter when the subject is producing alpha. The sound is the feedback signal for the subject.

QUESTION: (Continued) When the tone comes on and the subject is in alpha, is he producing alpha all over his head, or only on part of his head?

Dr. Fehmi: This equipment generates a tone when one specified channel is recording alpha. In this case, it is the channel recording mid-occipital activity.

QUESTION: How many people have alpha in all areas at once?

Dr. Fehmi: In our laboratory, we have seen some people who can produce alpha all over their heads before receiving any alpha training. These are usually people who have been engaged in some discipline over a long period of time, e.g. artists, athletes, meditators, or musician-composers. If they regularly paint, compose, practice music, or dedicate themselves to an athletic endeavor they, somehow, in the process of disciplined practice, learn how to control their alpha production.

It only takes these people a few minutes to say, "Oh, I have it." For example, David Rosenbloom, a gifted musician and composer, learned rapidly. He wasn't aware of the associated dimensions of consciousness before. The feedback tone, in effect, just pointed a finger at what was happening. That was all that David needed in order to very rapidly learn quite a bit on his own.

QUESTION: It was curious to note that he was producing alpha while his eyes were open.

Dr. Fehmi: Some people, particularly visually oriented people, like artists and painters, can produce alpha with their eyes open. Most people, however, cannot without feedback training. They need to start training with their eyes closed. After some time they can also learn to do it with their eyes open. The visual system seems to be one of the most powerful sensory systems in the control of brainwaves. Producing alpha is a matter of learning a different way to see. Most of us learn to see or get in the habit of grasping our visual input rather tensely or effortfully. This kind of trying to see or making distinctions effortfully seems to be associated with beta activity. One begins to produce alpha after he learns to relax and to let the visual stimuli just come in without trying too hard to grasp them.

QUESTION: Do Zen Masters have alpha in just one area of the head? (**Dr. Fehmi:** No, they produce alpha and theta all over the head.)

QUESTION: Some people have claimed that in measuring people who follow the Maharishi method of meditation they have been able to record alpha, as in the case of the Zen monks. Do you think there is an identical ability? (**Dr. Fehmi:** It is true that the frequency is the same.)

QUESTION: Have you experienced a person who has an amplitude of 200 microvolts?

Dr. Fehmi: I have never personally recorded from a person who produced alpha of 200 microvolts amplitude. In the research by Keith Wallace, it has been shown that transcendental meditations produce a large amount of alpha. Most meditators produce alpha after meditating a short time. What distinguishes very experienced meditators is the amplitude of their waves and the presence of alpha waves, theta and other waves all over their heads.

QUESTION: I remember seeing in that report that the hundred and some subjects included subjects with epilepsy and other very serious disturbances. The statistics group all the subjects together so that one cannot really tell what happens in individual cases. Do you think there is any defect in such a statistical report?

Dr. Fehmi: Certainly, when the data are lumped together one cannot make statements about individuals. There were probably individuals who didn't change their alpha production in the direction reported by Keith Wallace, but perhaps there are relatively few of these subjects. Investigators usually direct their efforts toward being able to make statements which have general validity. I think in general it's true that many kinds of meditation produce alpha.

QUESTION: But the Zen experience in amplitude is much higher?

Dr. Fehmi: I do not wish to limit the production of large amplitude brain waves only to Zen. I feel that after twenty years of meditation or twenty years of doing anything requiring singlemindedness, e.g., even picking your nose (laughter) the subject's alpha production and amplitude increases.

QUESTION: Has there been any study of brain waves associated with emotional states like anger, sexual arousal, or depression?

Dr. Fehmi: In general, depression is associated with lowered amplitude. Arousing states like anger, excitement, and perhaps sexual arousal are often associated with relatively high amplitude waves or their opposite, very low voltage waves.

Not everyone learns to produce alpha waves in the biofeedback setting. For example, we ran a hospitalized schizophrenic for more than fifty sessions. Forty of them are shown on the next slide.¹ On the vertical axis are shown minutes, and sessions are on the horizontal axis. The data are in seconds per minute. For example, in one minute this person on this trial (pointing) put out twelve seconds' worth of alpha waves.

You can see there's very little variability between sessions. What distinguishes "normals" from hospitalized schizophrenics, according to some literature, is that hospitalized schizophrenics produce some brain patterns consistently without much change over a long period of time. "Normals," although they might be capable of producing exactly the same pattern as the hospitalized schizophrenics, show greater variability in frequency and amplitude over a period of time.

Although hospitalized schizophrenics may produce waves of any single or narrow frequency spectrum, they usually are more consistent in the production of that wave than are normals. Thus mental health appears to be associated with flexibility and control of EEG amplitude and frequency....

QUESTION: What about people who are extremely up and down schizophrenics - manic depressives?

Dr. Fehmi: I have no information on that. If I may conjecture, I would expect them to produce alternately high and low amplitude waves. Notice that in this first session the subject's alpha production ranges from eleven to fifteen seconds per minute. In the second session, the range is five to nine seconds of alpha per minute.

¹Research with this subject was performed in collaboration with Dr. F. Levine, Psychology Dept., SUNY, Stony Brook.

If you look at the data within each session you can see that the amount of alpha produced does not change significantly.

We took pains to make the subject comfortable and to optimize the experimental conditions, in order for the subject to learn. We felt that if we could break her brainwave rigidity, it might lead to her becoming more functional. However, she failed to show any change in abundance, frequency, or control of alphas.

(Slide) Some other persons who have come into the laboratory can learn to turn the tone on and off very rapidly. It has, on occasion, only taken ten or fifteen minutes of practice for these people to learn to control their brainwaves.

This subject's EEG was monitored from the mid-frontal lobe. We asked the subject to turn the tone on and to turn it off. After a base rate session with no feedback, the subject began to receive feedback which informed him of the state of his brainwaves. (Indicating) For seven sessions, the subject failed to increase his alpha over the base rate level. In fact, the amount of alpha was depressed a bit below the base rate. This is a common occurrence which happens when the subject becomes self-conscious about his success in turning on the tone. He begins to listen too hard for the tone. At that point, he does exactly the reverse of what he is trying to do - he turns the tone off. How long the self-consciousness lasts depends on the subject. Sometimes within one session the subject can get through this stage and go on to realize that he can't focus upon the tone; he must just let the tone come along with other information, without making an effort to produce the tone. Here, the subject increased his alpha production after the first seven sessions.

The subject received another training session five months after the last of his original sessions. After these five months, his alpha production was down to the base rate level. In order to maintain the ability to produce alpha, it appears that periodic practice is necessary.

Now we ask our subjects to practice the alpha state at home every night between sessions for 15 minutes. This practice seems to positively affect their ability to produce alpha during the training sessions.

(Slide) Another subject who needed eleven sessions before he learned to increase his alpha. His alpha production then increased in a see-saw pattern. By the end of his training sessions, he was producing 10 to 20 times as much alpha as when he began training.

There is another rather consistent finding which becomes apparent when the test period is very brief, for example, ten seconds. In that case, for many people the effects of the "tone-off" period will linger on in the following ten seconds. When you immediately ask them to turn it on, many subjects can't quite let go and get back into the alpha state in that short amount of time. In other words, for many people there is an inertia attached to the beta state. For a smaller number of other people there is an inertia attached to the alpha state. We call them alpha people and beta people.

(Slide) Heretofore it had only been shown that subjects could control alpha produced on the occipital lobe. The research from our lab suggests that alpha from any brain locus can be controlled by the subject. We have recently attempted to train subjects to control alpha produced on the temporal lobes.

(Slide) A control group was run under the same conditions as the experimental group, except they received bogus, rather than real, feedback. They received feedback which was taped from the experimental subjects. The control group

obviates the possibility that something other than the feedback is responsible for the experimental subjects learning to turn the feedback on and off. It has been suggested that after sitting in a comfortable chair for thirty minutes and relaxing, a subject's alpha production will increase even though he has received no feedback. Although I think that suggestion has validity, learning to control alpha production, turning the alpha both on and off, is facilitated by feedback.

(Slide) On the temporal lobe conditioning experiment, the subjects received ten experimental sessions. The first three sessions were base rate sessions. We recorded the amounts of alpha the subjects produced while receiving no feedback. The following seven sessions were training sessions. During each of these seven sessions, the experimental group produced significantly more alpha during the "on" periods than during the "off" periods, while the control subjects did not. The experimental subjects learned to turn the tone off during the first training sessions. By the end of the second sessions, they had learned to turn the tone on. The alpha production of the control group during the different test periods does not vary consistently in either direction.

(Slide) Here are the data. The data are "significant" at the .05 level. That is, these findings would not have been expected by chance more than once in 20 times. The experimental group produced significantly more alpha during the "on" periods and significantly less alpha during the "off" periods than during base rate periods.

(Slide) An interesting observation is that the subject's posture affects the amplitude of his brainwaves. In the data of a slouching subject shown here, you can see that the amplitude of the alpha is considerably depressed, in comparison to the EEG data from the same subject in an erect posture.

QUESTION: Are they both sitting positions?

Dr. Fehmi: The same subject is sitting - either slouched or erect, but not tense.

Dr. Haronian: Does that have any implications for attention?

Dr. Fehmi: All the traditional meditation practices, except those of the Maharishi, ask that one learn how to sit in a relaxed, but relatively erect position, with vertebra in line on the vertical axis, sternum high, chin in, which maintains a straight spine. The various kinds of attention associated with high amplitude waves, especially those involving creativity, free expression and unification would be reduced in efficacy or made impossible by poor posture.

(Slide) This slide shows the EEG of one person who was instructed to look critically and for detail at his environment. You can see that there is a lot of fast activity in that record. When the subject received the instruction, "Hold your eyes steady and don't look for the detail; in fact, let the edges fade," his EEG record shows much more rhythmic activity than before. These instructions also produce less blinking activity, as does meditation. Simply relating differently to his eyes and the way he sees is enough to make a remarkable change in the subject's EEG.

(Slide) This record shows the EEG of another subject who was asked to do four different things. First he was asked to focus on something internal; nothing in particular but not to look out. This produces a fair amount of alpha. Second, look out, employ critical focus; be sharp about the divisions and discriminations

between things; again, much lower amplitude, much less rhythmicity of the waves.

Third, external, appreciative focus; that is, look at things but look at them acceptingly, rather than critically; there is more amplitude, more rhythmicity. Finally, recall a painting that the subject (an artist) lost himself in, and again there's quite a bit of alpha.

In these records, and more generally in the subjects I have observed a critical focus, making sharp distinctions, tends to produce beta waves. Alternatively, appreciative focus, wide gestalts, and immersion in the visual process is associated with alpha activity.

Now I'd like to discuss some other research with brain waves which has to do with phase relations between brain waves. We were interested in whether we could train a person to put the waves on the right and left side of his head in phase, that is, to produce waves on either side of the head whose crests and troughs coincide in time of occurrence.

(Slide) The experimental group received twenty minutes of practice period during which a tone came on only when their right and left occipital waves were in phase, or within fifteen degrees of being in phase with each other. The subjects then received ten test trials, during which they were requested to either "turn the tone on" or "turn the tone off" for ten seconds. The data clearly indicate that subjects spent more time with their brain wave activity in phase during the "on" periods than during the "off" periods.

A control group received exactly the same treatment as the experimental group, except that the feedback they received was taped and was therefore not related to their real brain wave activity. The control subjects didn't learn to turn the tone on and off.

The findings are statistically significant. Subjects say that it's a very difficult task to learn to hold the waves in phase. We gave training to 87 pilot subjects before we finally got a clear picture of the subjective states associated with in phase brain waves.

Most subjects indicate that concentration, or single-minded attention on a visual image makes the tone come on. Because we were recording from the visual cortex, other kinds of concentration were less effective than concentration on a visual image.

QUESTION: Who are your subjects?

Dr. Fehmi: When I run an experiment like this one, since it requires ten sessions of training, I use students who volunteer and are available most of the time.

QUESTION: Did you run a group who received no feedback?

Dr. Fehmi: Whenever I have tried running groups with no feedback, the subjects have just fallen asleep. It seemed of little value to continue to run such groups. I think there is some experimental justification for running a group receiving no feedback, as a comparison to the experimental group. However, since the results are consistent, it doesn't seem necessary to spend the time and effort any longer.

QUESTION: Your control group is negatively grouped, since you're feeding them a lot of false signals?

Dr. Fehmi: Yes, it's true that many of the control subjects are annoyed by the whole situation. They never get hold of anything relevant to what's going on. However, a group receiving bogus feedback is necessary to show that simply attending to a tone, and attending to the task of controlling the tone, as well as sitting in the experimental chamber is not enough to produce the results shown by the experimental group.

Alternatively, we might give the controls some other task in which they can succeed. It may occur in this case that success enhances alpha abundance and amplitude. However the learning of ON-OFF control of alpha would still be expected to require veridical information concerning EEG events.

QUESTION: I was just trying to bring up the point that if you do put people in that situation and they don't fall asleep, you could be producing a situation causing frustration.

Dr. Fehmi: That's very true.

QUESTION: Did you ever vary the environment? For example, instead of training them in a comfortable chair in a semi-darkened room, you could train them in bright sunlight.

Dr. Fehmi: Yes. When we first began biofeedback training in our laboratory, we trained subjects in a very comfortable chair. It was very difficult to teach these subjects to control the tone because they were so comfortable that they did not pay attention to the task.

We have also tested other aspects of the environment like negative ion concentration and music. People who really enjoy music produce more alpha when music is introduced, while the presence of music doesn't affect the brainwave activity of subjects who are not as interested in the music. The concentration of negative ions also has different effects on different people.

QUESTION: What seemed to be the optimum environment, then?

Dr. Fehmi: A soundproof, air-conditioned chamber, which is semi-darkened. Subjects should sit initially with their eyes closed, sitting upright in a chair which is not too comfortable.

QUESTION: What are your principal techniques to increase a subject's production of alpha or theta?

Dr. Fehmi: In our original experiments, we gave subjects careful instructions about what states of mind are associated with different brain waves and the associated tone. They were told exactly how to achieve the states. However, we discovered that receiving those instructions have seldom helped subjects to learn to control their brain waves.

Now we give the subjects less detailed instructions, after which they are able to increase their alpha production. We tell them not to try too hard to produce the tone. We say something like, "I'd like you to turn on the tone more often." When we asked the subject to "try" they would make an object out of themselves or their experience. Thus, the attending tension, which is associated with beta activity, destroyed flexibility. The act of trying involves taking an objective stance toward one's self or one's experience. One has made a subject-object discrimination which requires the establishment of internal tension which in turn immobilizes attentional flexibility.

The alternative to this subject-object orientation is unification of mind and is associated with increased amplitude and abundance of alpha waves.

Mr. Shames: Have you tested hypnotised subjects?

Dr. Fehmi: I haven't tested them myself. There is some research that suggests that the hypnotic state is not related in any way to brainwave activity. However, an abundance of alpha is associated with hypnotizability. That is consistent with subjective reports that alpha abundance is associated with an open, suggestive state. Since someone who was producing alpha all the time would be in a very suggestible state, in our laboratory, we emphasize that the subjects learn to gain flexibility in control over their brainwaves to be able to turn the alpha on and off, not that they just learn to produce alpha.

QUESTION: What correlation would you see between the control of the involuntary system under alpha and the control of the involuntary system under hypnosis?

Dr. Fehmi: You mean controlling the heart rate? (QUESTION: Or the blood pressure.) I have seen the records of one Yogi who could stop his heart. He showed a very low amplitude EEG record at that time. Whenever you are doing something specific to yourself, like controlling an organ, you probably have an objective orientation toward yourself. This seems to be associated with beta activity. Since no particular brainwave state is associated with hypnosis there is no wave to make parallel statements about it in relation to control. Such comparisons deserve more study.

QUESTION: Have you attempted to monitor the alpha of people who are undergoing ESP experiments?

Dr. Fehmi: No, I haven't. Dr. Chuck Honorton at Maimonides Hospital recently did a study which associated alpha activity with a greater ability to more correctly send and receive messages in an ESP experiment. That doesn't surprise me. If I believed in ESP, I would expect an enhanced ability to be associated with large amplitude alpha activity.

QUESTION: I wanted to get back to that Yogi who showed beta records while stopping his heart. The achievement of stopping the heart was done by controlling the flow of the blood from the heart, and in that sense the voluntary control in any definite sense was not involved. It was a pure diaphragm action. I found that out because I carried out the same experiment on my own self, and could do it. There was no involuntary thing involved; it was pure diaphragmatic action.

Are you using your groups and control groups by blind selection; do you standardize them by mass study or by dynamic study? Do you structure the groups in some way?

Dr. Fehmi: The first subject that comes in is placed in the experimental group; the second subject that comes in is placed in the control group and so on.

QUESTION: Do you mean to finalize your results by dynamic interpretation, and are you already structuring your groups by statistical methods, so that there is already an interpretation of the groups? Or do you intend to use mass techniques?

Dr. Fehmi: For statistical purposes we group the data together. That, to most westerners, is a convincing statement that the phenomena reported have general validity?

QUESTION: Dynamics?

Dr. Fehmi: I don't know the terminology you are using. I'm interpolating here. It's true, however, that in any given experiment there are a few subjects who don't perform quite the same as the rest of the group. In this particular experiment, there was only one subject who really learned as well as I expected. That does not mean the phenomenon, this high level of learning, is not real learning. Although there may be a great many people who can't or don't learn to swim or ride a bicycle, that doesn't mean that swimming or bicycle riding are impossible, or that these phenomena are unreal. However, when only one or a few subjects learn control there is a lingering doubt that in fact the data does indicate learning. The data may have occurred by chance or some error when only one or a few subjects respond as expected.

We in the West have a mass approach to science. We try to get a number of people performing the same way, or one person performing the same many times.

QUESTION: I was comparing this technique with the already existing techniques which have been used in psychological experiments, where they already structure the groups by examining traits and such things.

Dr. Haronian: I think what you're referring to is matching experimental and control groups on certain personality or physical traits in advance.

In this case Dr. Fehmi hasn't been doing anything like that. That would be what you call a dynamic study and would be a more involved study than has been done so far. What he did was odds and evens - the first one in the experimental group and the second in the control group without looking at the individual differences or trying to group them according to physical, psychological, historical, or anything of that sort.

But certainly what you're talking about would be a useful approach for further study, for example extroverts and introverts.

QUESTION: I think his approach is very valuable. It is very good because it goes with the data and so forth.

(End of Slide Section)

Dr. Fehmi: I'd like to say a few more things about ongoing research in our laboratory.

We've been trying for a long time to correlate the presence of different brainwaves and reaction time. We thought that one state may permit faster responding than other brainwave states. It was very difficult to arrange clearcut experimental conditions in which we found faster reaction times associated with a specific brainwave state.

Recently we've done the reverse. We have compared the EEG record of people who have fast reaction times and people who have slow reaction times. The people with fast reaction times have a lot more alpha than the people with slow reaction times. We have only done pilot work in this area, with only five subjects in each group. We are now going to try it with ten or fifteen subjects in each group, to see if the effect holds up.

We have studied one karate devotee for one year. He told me that when he does his karate, he waits in the alpha state for an event to occur. If he waits for the event in beta, he's not fast enough and he can't mobilize his movements in time.

He said that alpha is associated with all-around consciousness, while he is not focussing on anything specific. When he waits in this state and his opponent just begins to move, he is mobilized, as if by intuition, according to him, and responds before his opponent has actually gotten in motion.

Verbal reports of subjects have shown that while producing alpha, the subjects feel freer, more relaxed, and that they have a free, non-focussed, diffuse consciousness. After alpha training⁸⁹ David Rosenbloom mentioned in the film, the subjects feel they can somehow drop things they were at one time hung up on or unwillingly attached to; things that unavoidably attracted and held their attention; they were more stimulus bound and didn't have as much flexibility of attention before as they did after some training.

The beta state is just the opposite. Subjects report feeling more constrained, more focused.

Dr. Haronian: I wanted to ask a question with regard to this. You talk about the objective feelings of people who have trained for some time. That was something I wanted to ask about. But you also mentioned, in our conversations two years ago, that outside observers - people who watch people who are going through this - have noticed certain differences in their personality and their way of behaving which might be of interest, too, because of the objective - relatively objective - view of the outsiders. Could you tell us something about that?

Dr. Fehmi: Yes. When I first started this research, it was a source of some concern to me, to see changes in the appearance of the subject associated with changes in the amount of alpha he produced. After the session, the subjects would have more color in their face, and greater animation, especially of the eyes. They're obviously more relaxed; they walk differently. If they are asked, "What happened?", some answered (in an exhilarated tone of voice) "Oh, nothing happened! Nothing happened at all! Wow! Look at the way that light comes through the window!"

I wondered: how is it possible that they are often unaware of what has happened to them when it was so clear that they are very different after training. I have observed that effect many times. The only explanation that I came to which is also consistent with other observations, is that the subjects are so much less self-conscious when they produce a lot of alpha, that they don't recognize the changes. In the beta state, the subject actually makes an object of internal processes and himself (i.e., becomes self-conscious), while in the alpha state the reverse process occurs.

As I intimated earlier, perhaps it's not just the presence of alpha which is important. I've been using the term alpha this evening as if to say that their frequency is crucial. There are observations which suggest that for the two types of attention I have described, objectifying and unifying, it doesn't matter what the frequency is. It happens that under normal conditions the alpha frequency represents our so-called resonant frequency, the frequency which permits the largest amplitude waves. However, large amplitude waves occasionally appear at other frequencies. Large amplitude beta waves have been observed to be associated with creative experience in our own laboratory, e.g., the "AH-HA" phenomenon upon coming upon the solution to a problem.

When I've interrupted people who were putting out extremely large amplitude beta, they said things to me such as, "I just created a jazz symphony. I was there. I was living it." An administrator said to me, "I just solved a problem I've been working on for four months and the solution just flashed right before me." In both instances, the subjects were producing high frequency, high amplitude waves.

When the karate subject that I mentioned earlier responded with a fast reaction time, he said his whole body would respond. He said he put his mind at a spot below his navel. He reported that he pressed the button, not voluntarily, but letting the signal energy activate his body to press the button. When he made this type of response, his EEG record showed high frequency, high amplitude waves occurring at least on the temporal lobe, when they did not appear over the entire head.

QUESTION: Has anyone ever tested what happens when people are high on marijuana or other drugs?

Dr. Fehmi: Yes. Many of the opiates and narcotics are associated with the production of large amplitude alpha and theta waves, at least for a time. That may be why people take them. The psychedelics are somewhat different, according to what I can gather from various people, from the literature and a little first hand experience. They act more like psychic amplifiers. If someone is in a beta state, for example, and he takes LSD, he is likely to experience the most extreme beta state he has ever been in. He would feel anxious and may feel bound by his experience without a way of escape. His EEG would reflect enduring beta activity with little variation. In other words, this is an amplification of the beta state.

On the other hand, if he was in an alpha state when the psychedelic took effect, he might have the most positive experience he ever had. However, there appears to be a loss of flexibility associated with these drugs. The flexibility to change states is reduced at least in some people

QUESTION: The popular view in India concerning marijuana is the same. When he enters into any type of experience he remains in it and expands it and there's no flexibility.

Dr. Fehmi: If you're free and happy you don't need marijuana.

QUESTION: I was interested in your one study of a patient with schizophrenia. Could you enlarge on that? What were the conditions?

Dr. Fehmi: She had been hospitalized for a long time, and hallucinated frequently. The reason we chose her was she could communicate fairly well; she could say "I'm having hallucinations now." There was some rapport between us.

QUESTION: I see the same thing in art therapy with the same kind of patient. There's a certain rigidity; unable to go from the dining-room to the kitchen like normal people. They're locked in one situation.

QUESTION: Have you seen any correlation between theta production in normal subjects and personality traits? Have you attempted to make any?

Dr. Fehmi: No, I haven't; I haven't done much work with theta. The things I have reported about theta are the things I have read about.

One subject I have worked with had just gotten a job as a professor. He had been a very good subject previous to that time. He had large amplitude alpha waves and he could control the waves very well. After the first five weeks of being a professor he visited the lab. He said, "Let me just relax for awhile. This is the first time I've had to relax in five weeks." I watched his EEG while he was relaxing. He did what Kasamatsu and Hiraï report that Zen masters do when they meditate. First he began producing alpha waves. Then he reduced the frequency of these waves and began bursting theta waves. After about thirty minutes he began producing alpha again.

He then said, "Okay, I'm ready now." He then appeared more relaxed and centered than he was when he arrived. However, it took him two days of training in the experimental chamber receiving auditory feedback to regain some of the control flexibility he had previously had. Apparently the demands of an academic life reduce one's ability to vary one's brain wave state.

I think deep relaxation (unification) involves a process that Zen masters, yogis and other religious people have used for thousands of years. They achieve deep relaxation and tranquility by dissolving the subject-object dichotomy. This dissolution may be brought about directly by using the methods of Zen or by regularly enacting a ritual, one which is so oft repeated that it requires neither thought, self-consciousness, nor object-consciousness. The complete relaxation occurs when the ritual is so thoroughly penetrated that the actor loses himself in the acting. The actor and the action or role become unified. Subject and object become one. The majority of people in our culture have lost sight of the significance for mental health of ritual.

QUESTION: Do you see any correlation between controlling the rate of breathing and this work?

Dr. Fehmi: At times there seems to be a correlation between breathing and certain brain wave states. However, this effect changes from person to person and day to day.

QUESTION: Yogi breathing is controlled to produce a state of more peacefulness. Have you tried people consciously doing this?

Dr. Fehmi: Dr. Kamiya told me that people instructed to breathe heavily and rapidly ten times or so and then hold their breath produce very high amplitude waves. They report a psychedelic-like experience when they produce these waves.

I have observed others and I myself have tried breathing exercises. Within twenty minutes of just watching one's breathing - not trying to do anything with it - one can feel very peaceful, and experience an expanded consciousness.

END OF DISCUSSION