The Long, Intermediate and Short Term Effects of the Alpha Conditioning Process

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Abstract

The purpose of this thesis was to investigate the long, intermediate and short term effects of the alpha conditioning process. Twelve male and twelve female introductory psychology students were randomly assigned to one of three groups. The contingent feedback group (n=10) received tonal feedback when they were producing alpha; a brainwave pattern of between eight and twelve hertz. The noncontingent feedback group (n=10) received a tape recorded version of the tone pattern generated by a subject in the contingent group. The no feedback group (n=4) received no tonal feedback. Training occurred over four daily sessions and a fifth session seven days after the fourth. Each session except the first consisted of four segments: baseline (10 minutes), "try" (10 minutes), feedback (20 minutes), and "try" (10 minutes). During the "try" periods subjects were instructed to attempt to produce alpha activity without feedback. On the first session the baseline was 20 minutes with no initial "try" period. Alpha was recorded from an occipital-frontal electrode configuration using an Alphascan 600 filter and Alphascorer digital-time computer (Bioscan Corporation). No significant differences in percent time in alpha were found between the contingent and noncontingent groups over the five days revealing no evidence of alpha conditioning. Nor were there differences between the two feedback groups and the no feedback group. These findings prevented assessment of the duration of the effect of alpha conditioning. The results are discussed in relation to recent reports showing similar failures to increase alpha levels through feedback. It is concluded that alpha conditioning holds little promise as a clinical tool for inducing relaxation.

Within the past ten years research in the area of biofeedback has produced findings that could have considerable effect in the area of clinical psychology. The research seems to indicate that with the appropriate feedback a person is capable of voluntary control over a variety of internal processes, from cardiac function to brain rhythm. The implications of these findings for the clinical psychologist lie in the fact that certain physiological states, for example, lowered heart rate, and higher levels of alpha rhythm, are associated with states of relaxation. Therefore, one prospect is for using biofeedback training as a method of inducing relaxation. At the present time, the potential usefulness of biofeedback is a subject of uncertainty and controversy. The proposed research is designed to clarify two issues which bear on the possible therapeutic use of alpha biofeedback training.

First, can subjects learn to produce large increments in their levels of alpha production? Second, for how long after a training session can a subject retain what has been learned?

The Alpha Rhythm

The alpha frequency appears as a smooth eight to twelve hertz wave form of from twenty-five to one hundred microvolts. The alpha frequency was first reported and classified by Hans Berger in 1929 (Andersen and Andersson, 1968).

From the time Berger identified the alpha rhythm researchers have been trying to provide an explanation for its existence. Berger postulated that the beta wave was the main physiological activity of the brain and that the alpha frequency could be modified according to the level of consciousness.

Some researchers felt that the alpha frequency was purely an artifact and had nothing to do with the brain process. J.L. Kennedy (1959) attempted to show that the alpha rhythm was nothing more than an electrical artifact caused by the gelatinous nature of the brain. Kennedy demonstrated that the alpha frequency could be recorded from a gelatin filled sphere if an electrical potential and a mechanical stimulation were applied. Although there is little, if any, support for the Kennedy position, it illustrates that the explanations for the alpha frequency are many and varied. Most modern research seems to support Andersen and Andersson (1968) who have indicated that the alpha rhythm seems to be due to the repetitive synchronous polarization and depolarization of groups of thalamic neurons which have been called pacemakers.

Early studies (Adrian and Matthews, 1934; Mundy-Castle, 1957) demonstrated that alpha activity could be blocked by sensory stimulation and various cognitive activities. The most dramatic demonstration is the decreased alpha activity over the occipital cortex which occurs when the eyes are opened. However, it is clear that alpha can be blocked by non visual activities as well, for example, mental arithmetic and

auditory imagery (Mundy-Castle, 1957). These findings and others led to the view that the alpha rhythm reflects a relative absence of information processing (Doty, 1969).

Psychological Accompaniments of Alpha State

With the advent of more sophisticated electronic measuring devices and the increase in electroencephalographic (EEG) studies, researchers began to look for correlations between electrical activity of the brain and psychological and physiological states of the person.

Anand, Chhina and Singh (1961) noted that yogis, while in a deep meditative state, produced almost continuous alpha wave patterns. The meditative states were reported to be associated with feelings of calm, tranquility and being at peace with oneself.

One of the first researchers in this area was Joseph Kamiya (1962), who demonstrated that human subjects could learn to identify a particular brain state called the alpha state. A short time later, Kamiya (1968) reported that he was able to show considerable increase in alpha production in his subjects through instrumental conditioning procedures. He also reported that his subjects, while in this alpha state, experienced psychological effects similar to those reported by meditators. Kamiya's (1968) work seemed to indicate that one could be very easily conditioned to increase alpha production and that the concomitant psychological effects were desirable.

Alpha Biofeedback Paradigms

Several researchers since Kamiya, however, have not been as impressed with their subjects' increases in alpha production nor with the psychological benefits derived from increases that were found (Walsh, 1972; Strayer, Scott and Bakan, 1973; Orne, 1974; Lynch, Paskowitz and Orne, 1974a; Grynol and Jamieson, 1975; Kuhlman and Klieger,1975). Much of the discrepancy in the reported findings seems to stem from different designs being used.

Kamiya's paradigm was such that the subjects were required to discriminate between two states, state A (alpha) and state B (non-alpha). His subjects were told that a bell would ring from time to time, sometimes when they were in state A (alpha) and sometimes when they were in state B (non-alpha). The subjects were then asked to guess which of the two states they were in and were given information as to whether they were right or wrong. Kamiya found that his subjects learned relatively quickly to become extremely accurate at determining whether they were in alpha state or not. Clearly Kamiya's (1968) design is one of a discrimination task. The "control" of alpha evident in this paradigm could be due to the subjects learning to block the alpha pattern rather than enhance it. Moreover, the pleasant experience reported by the subjects may have been due, at least in part, to experimenter expectation effects (Rosenthal, 1956). The experiments were not run blind. The experimenter was clearly not impartial, for as Kamiya (1969) states, while describing

his subjects: " I noticed I generally tended to have a more positive liking for the individuals who subsequently turned out to learn alpha control more rapidly " (p. 527).

Beatty (1971, 1972) also used the discrimination task paradigm. Unlike Kamiya, Beatty (1971) included a yoked control group in his study. He found as expected that the yoked controls were unable to show a significant differential response between the alpha and the beta trials. Subjects receiving the appropriate feedback did show significant differential response. However, in this research it is still possible that the correct feedback subjects were merely learning to differentiate the alpha state per se. The fact that the subject is no longer suppressing alpha may appear as if the subject is producing an increase in alpha. In any event, the research does not show that the subjects are able to produce systematic increases in alpha production.

A second paradigm which has been used in the alpha research area looks at increases in alpha production over a baseline measure. Several researchers using this paradigm have used a within subjects control design. The within subjects control design is such that each subject is given alternating periods of feedback and no feedback. This design would begin with a two to five minute rest period during which a baseline would be determined. The subject would then be given a segment of feedback from five to ten minutes in length followed by a two to five minute segment of no feedback. The level of production during

the no feedback period may also be considered a baseline measure. The segments of feedback-no feedback are generally carried on for from thirty to sixty minutes. The problem with the within subjects design for assessing an increase in alpha production above a baseline is that the baseline is being measured immediately after a period of training. Therefore, any short term effects of the training segment will be influencing the baseline measure. As Kamiya (1969) indicates while discussing the phenomena of the rising baseline "the experimental task set them (the subjects) into certain preferred modes of waiting, and the preferred mode was the higher alpha state" (p. 525). This obviously makes the within subjects design difficult to interpret when trying to determine an increase in alpha production above a baseline measure.

A better design appears to be the between subjects design with a yoked or noncontingent feedback control. The yoked control design in alpha feedback research is such that each subject in the control group is matched for baseline alpha production with a subject in the experimental group. The feedback produced by the experimental subject is then tape recorded and used as feedback for the matched mate in the control group. In this way the control group is similar to the experimental group except for receiving non-contingent feedback. This paradigm was used by Strayer, et al. (1973). It was found in this instance that the yoked subjects showed as much increase in alpha production as did the experimental subjects. Even though Strayer's

(1973) yoked controls increased their alpha production, they seemed to realize that they had no control over whether they received feedback or not. Eleven out of the twenty yoked subjects "felt control was not possible", while none of the experimental subjects were reported in that category. Eighteen of the twenty experimental subjects reported a method of controlling the feedback while only four of the yoked subjects reported a method. The fact that several of the yoked subjects realized fairly early that they were not receiving correct feedback, and that they had no control over the feedback, could produce considerable frustration in subjects in such a group over a long period of time. This frustration might result in lower levels of alpha production than would otherwise be expected. One method that might be employed to diminish these unwanted side effects would be to give the subjects periodic positive verbal feedback. Such feedback might be "You are doing a good job", "Things are going as they should", "I think the experiment is going very well". Of course periodic positive reinforcement would also have to be given to the experimental group.

While some researchers have found significant increases in alpha production it seems many have not. Strayer, Scott and Bakan, (1973), using a yoked control design, found that both the experimental subjects and yoked control subjects showed increases in alpha production. They also found that there was no signficant difference between the experimental group and the control group. From this it was concluded that: "Since

all groups increased alpha production regardless of the type of feedback alpha enhancement cannot be attributed to the presence of contingent feedback" (p. 251).

Lynch, Paskewitz and Orne (1974a) reporting on a yoked control design experiment indicated that there was no significant difference in alpha densities between the contingent and noncontingent groups during feedback. Lynch et al concluded that: "The results from the noncontingent Ss, however, suggested that increases in alpha activity are not necessarily contingent on accurate feedback" (p. 403). Lynch et al (1974a) also reported that: "The maximum density during feedback trials, in other words, reached but did not exceed the density seen during the highest minute of the eyes open baseline period" (p. 408).

Kuhlman and Klieger (1975) divided their subjects into three groups; Loop 1, Loop 2 and no treatment control. Loop 1 received a feedback tone contingent on the presence of alpha while Loop 2 received a feedback tone contingent on the absence of alpha. The Loop 2 subjects were asked to keep the tone off. The Loop 1 subjects showed an increase in alpha across the trials but did not exceed their baseline level. The Loop 2 subjects showed insignificant increases in alpha across trials but did not exceed baseline. Kuhlman and Klieger concluded that even though the Loop 2 subjects showed a small increase in alpha above baseline their results "do not verify claims of large magnitude changes in alpha density with feedback training" (p. 459).

Some researchers have suggested that perhaps part of the reason subjects show little or no increase in alpha is that the training time is too short. Travis, Kondo and Knott (1974b) indicated that: "Our training time was relatively short and given longer periods of practice it is possible that Ss receiving binary feedback might also significantly increase emitted occipital alpha" (p. 678). Their training trials consisted of ten practice periods, each five minutes in length.

Kuhlman and Klieger (1975) using eight four minute training trials also indicated that longer training trials may be important. They proposed that empirical evidence sufficient to demonstrate the presence of alpha conditioning would require increases both over baseline level and over trials in the same subjects. To accomplish this they state: "It is likely that long term training would be necessary to document such an effect" (Kuhlman and Klieger, 1975, p. 459.) A cross section of the literature indicates that subjects are generally run for one session of about one half hour duration.

Beatty (1971) used eight trials of two hundred seconds duration for a total running time of 26.6 minutes. Strayer et al (1973) used twelve training trials of two minute duration for a total of twenty-four minutes. Lynch et al (1974) had their subject go through ten trials of two minutes duration for a total of twenty minutes. Prewett and Adams (1976) used five trials, each two minutes long for a total of ten minutes, while Brolund and Schallow (1976) used five trials

of four minutes. Perhaps it is unreasonable to expect subjects to accomplish a task as foreign, and undoubtedly as complex,as identifying and increasing a particular brain state, in such a short period of time.

Long and Short Effects of Alpha Conditioning

An aspect of alpha conditioning which has received little investigation has to do with the longevity of the effects of the conditioning process. One study which did address itself, at least in part, to the "extinction" of the conditioned alpha state was done by Travis, Kondo and Knott (1974a). In their study, Travis et al noted that their groups, during the no feedback periods, "failed to show graded decrements in performance as would be predicted in a classical extinction situation" (p. 170). In a further study by Kondo, Travis and Knott (1975) which was mainly concerned with motivation on alpha production, it was noted that during a twenty-five minute period following the formal conditioning trials there was no significant decrease in alpha production. The subjects were offered no incentives during the twenty-five minute post conditioning period, but were "instructed to continue what they had found to be most successful in keeping the pitch of the tone high" (p. 388).

Short term effects similar to those reported by Travis et al (1974b) and Kondo et al (1975) have been found in a one subject pilot study in our laboratory. During the course of our pilot study which lasted over a period of five training sessions, we noted that although

the alpha level remained high for the twenty minute extinction period, it had dropped to a base level on the following day's session. These data indicate the possibility that the short term effects, which seem to resist extinction, do in fact extinguish over a longer period of time. The question of long and short term effects of the conditioning process seems to be of central importance if alpha conditioning is to be used as an effective clinical tool.

Upon inspection of the few studies that have been done over a period of days one finds that the initial period on successive days has been a resting baseline period (Brown, 1970; Walsh, 1972). A resting baseline period followed by feedback training is adequate if one is only looking at the subject's increase in alpha production. If, however, there is an interest in determining whether there are any long term effects, i.e., from one sesssion to the next, than a resting baseline is clearly not adequate. During a resting baseline the subject is presumably not trying to produce alpha, therefore, it will not be evident whether he is retaining any strategy for continuing the increased alpha level. On the other hand, if the subject is instructed to try to produce alpha without feedback after the initial rest period of each session, a more accurate assessment could be made. This comparison would be made between the extinction period at the end of one day's session and the "try" period at the beginning of the next day's session.

The purpose of the present research was to evaluate the duration of the effects of alpha feedback training. To do this the subject's ability to produce increased alpha levels was examined immediately, one day and seven days after training.

Subjects. The subjects for this research were drawn from the population of introductory Psychology students of Lakehead University. Fourteen male and fourteen female subjects were used. Each subject was assigned randomly to one of three groups.

Design. The contingent feedback group was made up of ten subjects, five male and five female. They received tonal feedback contingent upon their production of the alpha brain wave frequency.

The subjects in the noncontingent feedback group (five male and five female) heard a tape recording of the feedback produced by a subject in the contingent feedback group with a similar baseline level of alpha production. In this way each subject in the noncontingent control group was yoked to a subject in the contingent experimental group. The yoked control is a preferred form of control because it most closely approximates the experience of the experimental group while still providing a noncontingent feedback.

The no feedback group (two male and two female) was treated in the same manner as the previous two groups except that they received no tonal feedback and their instructions did not mention the tonal feedback.

Apparatus. Three silver-silver chloride electrodes were attached with an elastic headband at O_2, T_4 and Fp_2 of the 10-20 international electrode system (Jasper, 1968). This configuration provided access to the right occipital alpha activity. The filtering and feedback

were provided by an Alphascan 600 (Bioscan Corp., Houston, Texas). The digital filter was set to exclude frequencies above 12 Hertz and below 8 Hertz. The amplitude (sensitivity) was set to include waves of at least 50% of the higest baseline alpha amplitude. These values ranged from 8 to 20 microvolts and were held constant for each subject over the 5 sessions.

The analog EEG signal was taken from pins on the back of the Alphascan and fed into the A-C coupler of a Beckman type R S dynograph. One purpose of this recording was to measure the alpha amplitude at the beginning of the initial session to obtain the value for the filter amplitude criterion. The second purpose was to check each session that the electrodes were attached properly and yielding a record free of artifact and signal noise. The digital signal from the Alphascan, indicating alpha frequency activity meeting the amplitude criterion, was fed into an Alphascorer percent time computer (Bioscan Corp.). The Alphascorer was set to average percent alpha over 100 second intervals.

Procedure. Subjects were brought into the experimental room and seated in a comfortable lounge chair. The equipment was housed in a room adjoining the experimental room. The subject was then given a sheet of information to read while the electrodes were being attached. The information sheet was made up of statements about the types of experiences which have generally been reported to be associated with the alpha state, such as feelings of relaxation, a floating sensation

and a lack of concentration (Kamiya, 1969). Information was also given as to what strategies have been found useful in producing alpha, as well as what has been found to block it (see Appendix A).

When all the electrodes were attached, and the subject had completed reading the information, the room was darkened. The subjects were also asked to close their eyes in order to cut down on eye movement and blink responses therefore eliminating, as much as possible, eye muscle artifact.

The experiment consisted of four consecutive daily training sessions and a fifth session, seven days after the fourth session. Except for the first session each session was divided into four segments. During the first twenty minute segment of the first session a baseline measure was taken. On subsequent days, the first twenty minute segment was divided into two ten minute segments. The firstten minutes was a baseline, while the second ten minutes as a "try" period before feedback. It was hoped that this segment would be useful in determining the intermediate effects of the conditioning process. If the subjects were able to show a consistent increase over baseline alpha levels during this period, it was felt that the increase would be an indication that they had learned a method by which to transfer the effects of one day's session to the next day's session. The third segment was a twenty minute treatment period during which the subjects received either contingent feedback, noncontingent feedback or no feedback, depending on their treatment group. The final ten minutes was a second "try" segment

during which the subject was again asked to produce alpha without feedback. This segment provided a chance to examine the short term effects of the conditioning process. Between each segment in each session there were two minute activation periods. During the activation periods the experimenter entered the treatment room, engaged the subject in conversation and gave positive verbal reinforcement. The activation periods were provided to sustain the subjects' interest over sessions. This seemed particularly important for the noncontingent group, who might have become somewhat frustrated because of the noncontingency of feedback and for the no feedback group who might have become bored or drowsy due to their inactivity.

In order to evaluate the long term effects of the conditioning process, subjects were required to return approximately one week after the last of the four training sessions and were asked to go through a session identical to the training sessions.

At the end of the last session on the fifth day subjects in the correct feedback and the noncontingent feedback groups were asked to fill out a short questionnaire (see Appendix B). The main purpose of the questionnaire was to see if the subjects felt they could control the tone and if they found the experience pleasant or frustrating.

The percent time in alpha was averaged across 100-second intervals throughout each segment for each subject. These data were then analysed using analyses of variance and, where appropriate, Newman-Keuls comparisons.

Results

The mean percent time in alpha of the three groups for the baseline and feedback periods over the five days are plotted on Figures 1 to 3. Sex differences in biofeedback training or alpha prodcution have not been reported, and the following analysis did not include sex as a factor. However, a separate analysis comparing males and females was done, and no significant differences were found.

Contingent versus Noncontingent Feedback. No evidence was found to indicate that conditioning had occurred. There was no significant difference between the contingent feedback and the noncontingent feedback groups over the five feedback trials, $F(1, 18) = 0.26$. Analysis also indicated that there was no group by trial interaction, $F(3, 72) = 0.14$. Further analyses also failed to reveal significant differences in percent alpha between these two groups during the baseline or "try" periods.

The primary analysis revealed that conditioning did not occur, therefore, further analyses will add no information regarding short, intermediate or long term effects of conditioning. Nevertheless, the planned analyses were done in an attempt to illustrate what did happen during the experiment.

The first analysis was to examine the short term effects of conditioning. To do this a three way analysis of variance was performed, the factors being Group (contingent vs noncontingent), Period (feedback

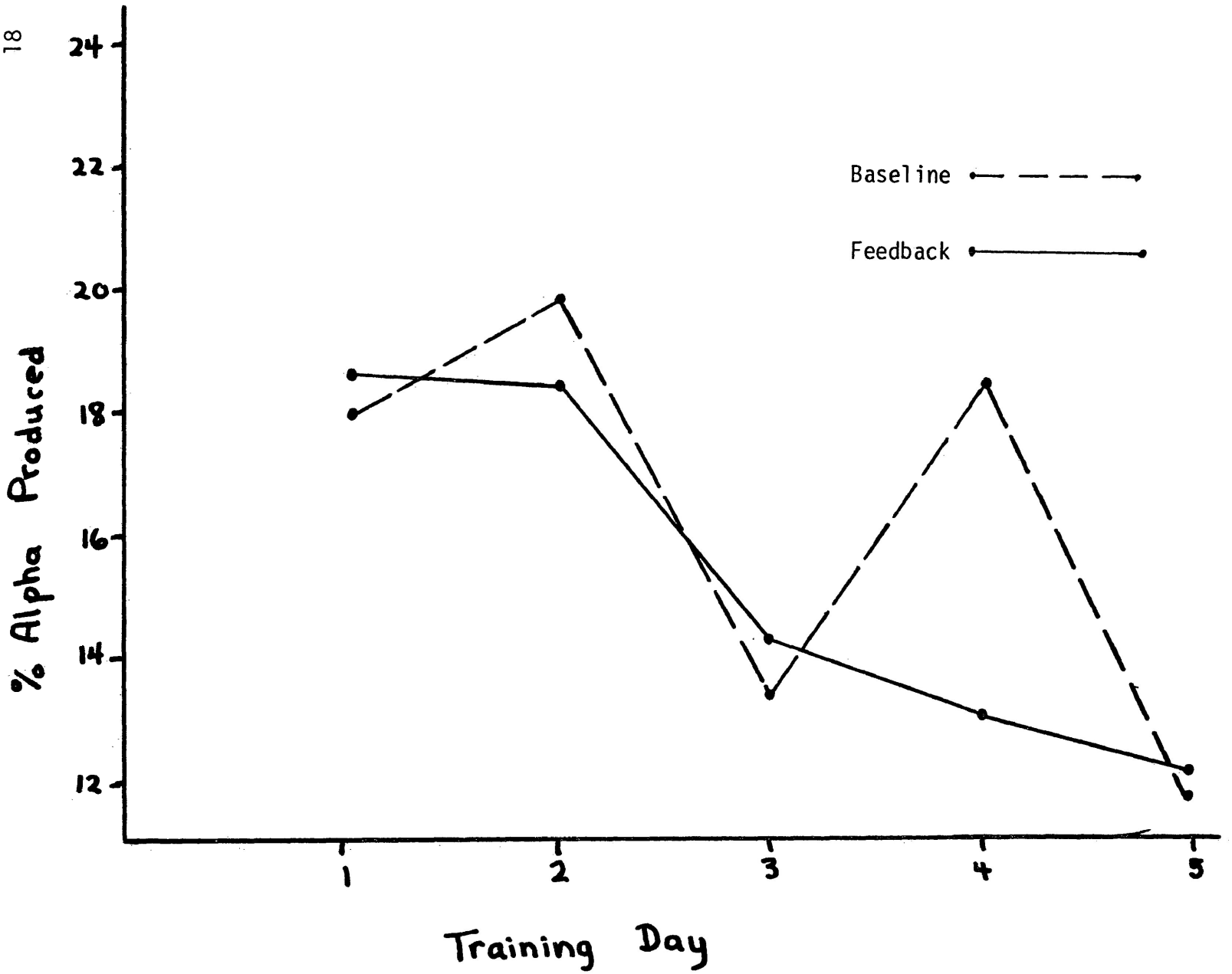

Figure I : Mean percent alpha during baseline and feedback periods for the non-contingent feedback group

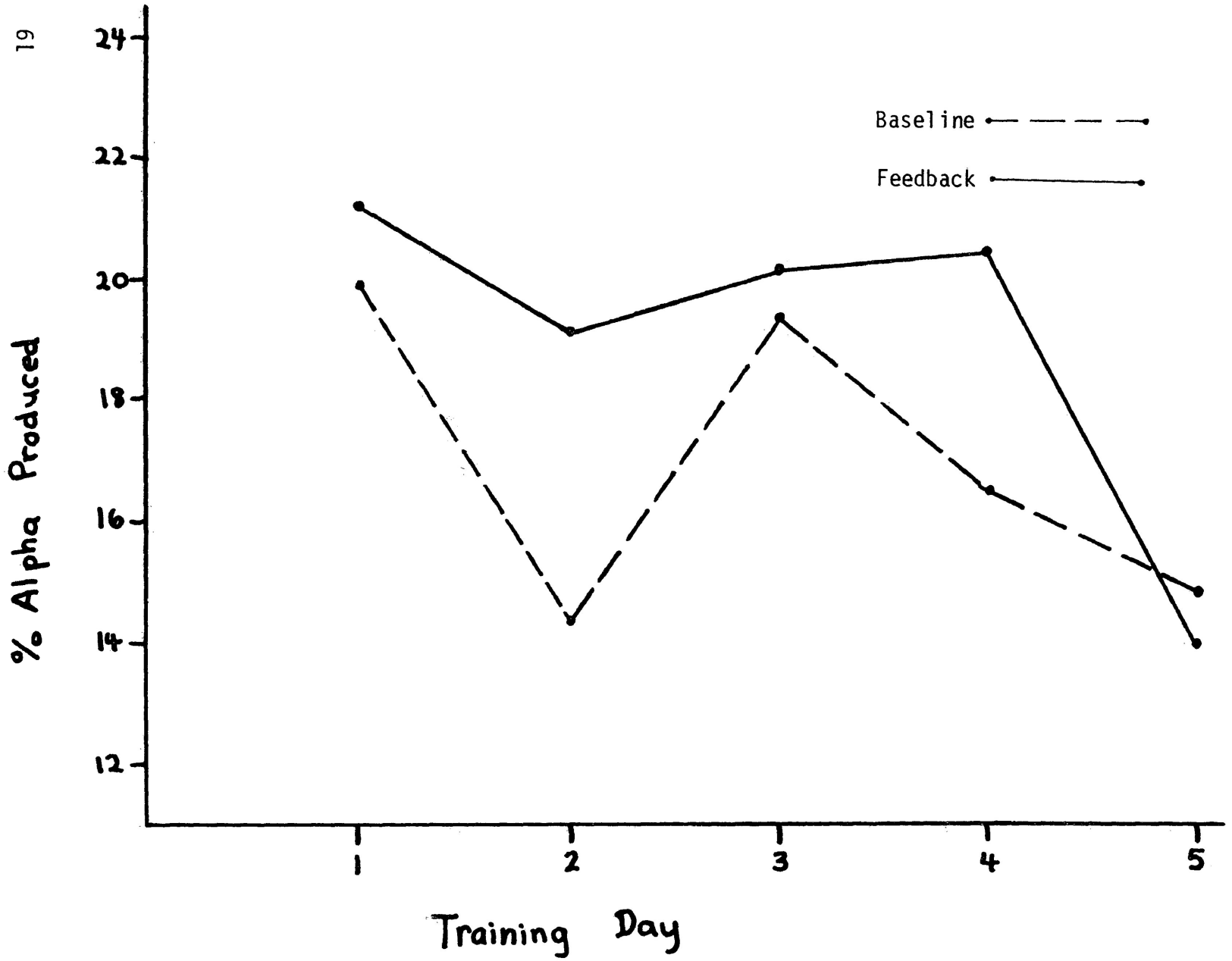

Figure II : Mean percent alpha during baseline and feedback periods for the contingent feedback group

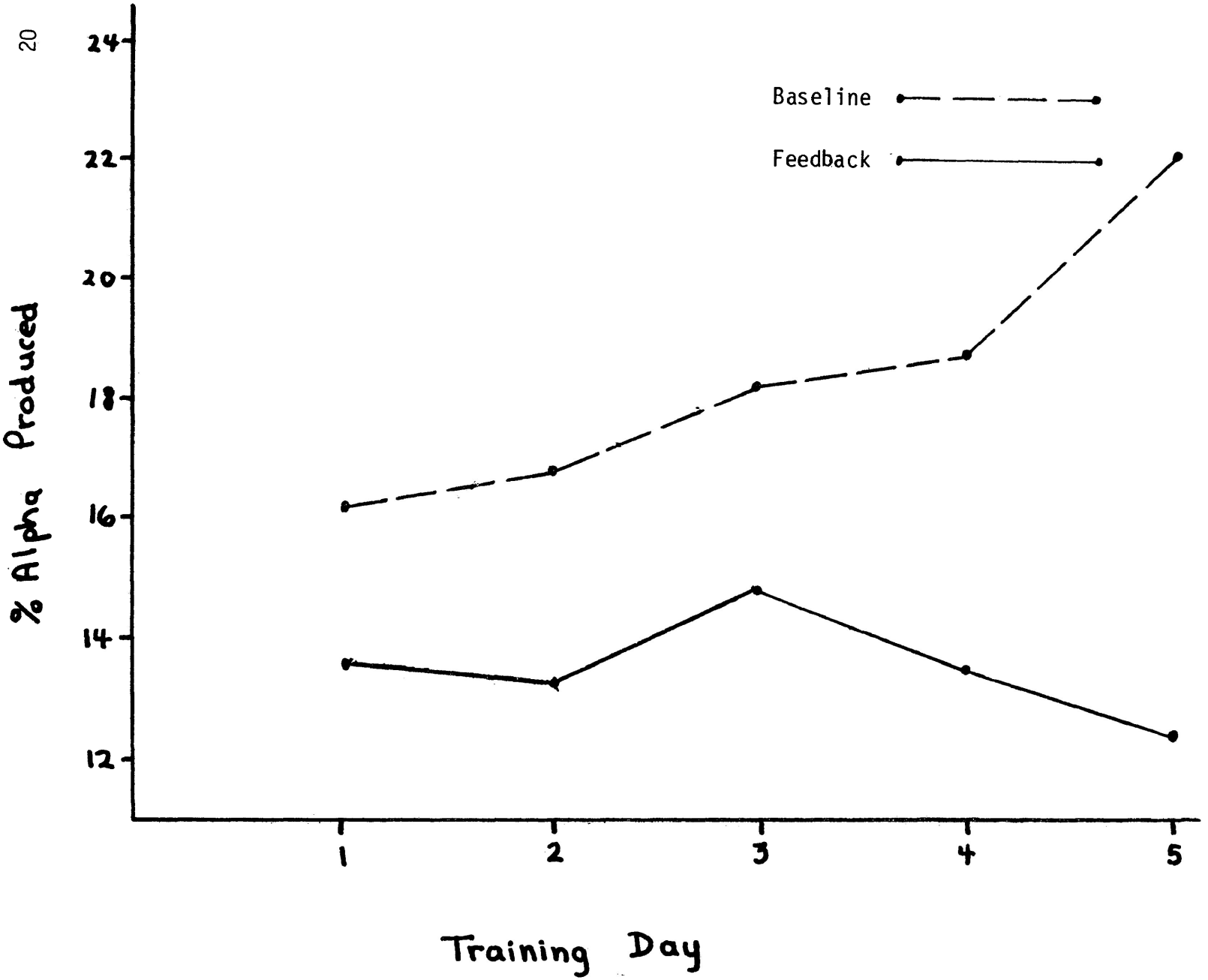

Figure III : Mean percent alpha during baseline and feedback periods for the no treatment group

vs "try" 2) and Days (1 to 5). The comparison of interest was the Group by Period interaction which was not significant, $F(1, 18) = 1.60$. However, the main effect of period approached significance $F(1, 18)=3.19$, $p = .09$. As can be seen from Table 1, where the two groups are combined, more alpha was generally produced during the second "try" period than during the preceding feedback period.

The second planned analysis was to examine the effects of the conditioning process after an intermediate lapse of time, i.e., from the end of one day's session to the start of the next day's session. To do this the alpha production during the second "try" period of one day was compared with the alpha production during the first "try" period of the next day. A three way analysis of variance was performed, the factors being Group (contingent vs noncontingent), Periods ("try" 2 vs "try" 1) and Days (2 to 5). The analysis showed a significant main effect $F(1, 18)=12.68$, $p = 0.002$ indicating that significantly more alpha was produced during the second "try" period than during the first "try" period of the next day; the group by periods interaction was not significant, $F(1,18) = 0.15$. The significant main effect in this case might be interpreted as indicating that the effects of "conditioning" did not carry over from one day's session to the next day's session. However, further analyses indicated that there was also a significant drop in alpha production between the baseline period and the first "try" period of the same day $F(1,18) = 8.01$, $p = 0.01$. Therefore, it appears

Table I

Mean percent time in alpha
for the combined feedback groups for
feedback and Try II periods over five days

Days	Feedback	Try II
1	21.480	23.400
2	20.680	22.395
3	21.285	22.095
4	19.255	21.565
5	13.750	13.590

that the significant difference between the last "try" period and the first "try" period of the next day reflects a suppression of alpha on the first "try" period, rather than the dissipation of effects of "conditioning".

The third planned analysis was to determine the long term effects, i.e., whether the alpha level would be maintained over the week delay between the fourth and fifth sessions. A two way analysis of variance was performed for the feedback periods, the factors being Groups (contingent vs non-contingent) and Days (1 to 5). The Groups by Days interaction was not significant $F(4,72)=0.14$ but the main effect of Days was, $F(4,72)=5.07, p=.001$. A Newman-Keuls analysis indicated no difference between days 1 to 4, with all of these days showing significantly ($p=.01$) more alpha than day 5 (see table II).

No Feedback Group. In the analysis described below, the no feedback group is discussed in terms of the same periods as the two feedback groups. This was done as a description of the time periods being compared and not as an indication of treatment being applied. Because of the small sample size of this group ($n=4$), significance tests were not performed. Instead, the data were simply examined for possible trends which might differ from those of the two feedback groups. Two trends are apparent in Figure 3 above which do not appear in the feedback groups. First, the percent alpha appears to decrease over the course of each daily session. Second, the percent alpha of the baseline periods appears to increase over consecutive days, in contrast to the decreasing baselines observed in the two feedback groups.

Table II

Newman-Keuls comparison of feedback means for five days

	21.285	20.680	19.255	13.750
21.480	.20	.80	2.22	7.73*
21.285		.60	2.02	7.53*
20.680			1.45	6.93*
19.255				5.50*
13.750				

* $p < .01$

Correlation over Days. The lack of significant differences among the three groups might be due to an inordinant amount of variability in the data. A correlational analysis, however, shows that there is not a great deal of variability in the data between sessions. (see Tables III and IV).

Questionnaire Data. One subject in the noncontingent feedback group did not complete the questionnaire, leaving nine from the noncontingent feedback group and ten from the contingent feedback group. As indicated in Table V most responders were non-meditators.

In the contingent feedback group most responders felt they had control of the tone coming on but not going off. While most of the responders in the contingent feedback group reported a pleasant experience half reported frustration. Some reported both experiences: pleasant when the tone was on, frustrating when the tone was off. Almost all of the contingent feedback responders reported feeling calmer or more relaxed after the feedback.

Those who responded to the questionnaire in the noncontingent feedback group gave responses similar to the contingent feedback group. None of the differences between the two groups were significant (Chi Square test).

Table III

Correlation[I] of the percent alpha between feedback periods for all subjects combined

Days	2	3	4	5
1	0.891	0.847	0.796	0.801
2		0.890	0.782	0.925
3			0.886	0.867
4				0.741

[I] All p's $<.001$

Table IV

Correlation[I] of the percent alpha between Baseline periods for all subjects combined

Days	2	3	4	5
1	0.779	0.766	0.814	0.806
2		0.695	0.925	0.877
3.			0.710	0.852
4				0.844

[I] All p's $<$ .001

Table V

Percent answering"yes"to questionnaire items

Question	Contingent feedback	Non-contingent feedback
1. Meditate?	20	22
2a. Control tone on?	78	56
2b. Control tone off?	30	44
3a. Feedback pleasant?	89	78
3b. Feedback frustrating?	50	14
6. Calmer after?	90	78

Discussion

The purpose of the research reported here was to determine if human subjects could learn to increase the amount of alpha that they produced through operant conditioning techniques. The paradigm was such that the long, intermediate and short term effects of the conditioning process could be evaluated.

The results failed to reveal any effects from the conditioning process. There were no significant differences between the contingent feedback and noncontingent feedback groups, nor were there any significant increases in alpha within the sessions or between sessions.

In conducting and analyzing the present research several problems in the area of brainwave research became apparent. One of the problems concerns the difficulties in comparing studies that use binary feedback triggered by alpha amplitude. While some researchers may use a relatively wide amplitude criterion, others may use a more stringent criterion. The subjects in the research with the wide criterion will be receiving more alpha information and therefore will undoubtedly have a better chance of learning to control alpha than those in the research with the narrow or more stringent criterion. The problem of comparing such studies becomes even more difficult when the researchers do not report what criteria they are using.

A second but related problem concerns how one sets the amplitude criteria for each session, when the research proceeds over several days.

If the amplitude criterion is based on the first day's baseline information and the same criteria are followed for subsequent days, the general EEG record might change on the subsequent days. In such a case the detectable alpha abundance for subsequent days would be different and independent of the conditioning process. On the other hand, if the amplitude criteria are set at the beginning of each session, the fact that the criteria are changed makes it difficult to statistically compare day to day changes.

Another possible problem area is that of resistance between the scalp and the electrode. Most researchers, it seems, use a surface type electrode. When the paste or cream is exposed to the air it begins to dry out and therefore increase its resistance. As the resistance of the paste or cream increases over the session the amplitude of the signal received by the filter will be decreased.

The resistance at the electrode could also be increased by an inappropriate attachment of the electrode to the scalp. The double sided adhesive collar has been a popular method of attachment of electrodes and is adequate for recording over a short period of time. For extended periods of recording, however, the subjects' hair has a tendency to push the collar away from the scalp and therefore causes an increase in resistance. A second method of holding the electrodes to the scalp is to attach the electrodes to a rubberized cloth band which fits around the subject's head. The problem with the rubberized cloth band, however, is that it is difficult to adjust proper tension. If

the band is tight enough to keep the electrodes in position over an extended period of time it tends to increase the pressure on the electrodes and cause discomfort to the scalp in the area where the electrode is pressing. If the band is loosened so that the pressure is not such that it causes discomfort, the electrodes tend to slip with the slightest movement of the head. Any movement of the electrode will cause the electrode paste or cream to be smeared or to be dislodged and again cause an increase in resistance for the signal. The third and, it seems, the most effective way to attach the electrodes for extended recordings is to use colloidian. The colloidian glues the electrode firmly in place without causing discomfort, while keeping the electrode conductor moist and relatively consistent in resistance. The problem with the colloidian method, however, is that it requires more time and effort in cleaning the material off of the scalp and out of the hair when the electrode is removed.

The type of power supply used in one's filter can also be a problem area. An unexpected finding in the present study was that the alpha production of the fifth day, which was held one week after the first four consecutive days, was considerably lower than any of the first four days. This lowered output was consistent for all subjects. When the means were plotted on a graph a smooth regression line appeared. This seemed to indicate that some constant factor was operating which caused a consistent decrement in alpha production.

The most plausible explanation for this observation seems to be a constant decay in the filter's power supply. In its original form the filter used in the present research was equipped with four nine volt batteries as a power supply. The nine volt batteries, however, would not last for more than eight hours running time. To overcome this short duration in power, six large commercial six volt batteries were substituted. When these batteries became low they were replaced. This gave the effect of having the same voltage with a much longer battery life.

The advantage of using the battery power supply is that the batteries eliminate the possibility of inaccuracies due to rapid changes in line voltage, as well as providing a safe apparatus. One must be aware, however, that the battery has a consistent voltage drop over time which must be accounted for. It appears that the Bioscan filter used was affected by this battery decay to produce lower percent alpha readings. Obviously this is an important source of artifact that should be considered in future research.

The largely negative tone of the present findings seem to be in keeping with much of the current alpha research. Leib, Tryon and Stroebel (1976) reported that twenty-two subjects who were put through an alpha conditioning procedure five days a week for four consecutive weeks produced "absolutely no evidence for any between session learning..." Hosford (1977) using tonal feedback for three ten minute training trials,

reported that none of the subjects significantly increased alpha production over their trainability (baseline) level. Hosford indicated that his findings supported Paskowitz's (1969) position that alpha will not significantly increase above a baseline taken under optimum conditions.

The results of the subjective reports in the present study clearly indicate that the majority of the subjects felt they had control of the tone coming on, that the feedback was a pleasant experience, and that they felt calmer and more relaxed after the feedback than before the feedback. These results were indicated by both the contingent and the non-contingent feedback group, even though neither group showed a significant increase in alpha production.

The subjective reports in the present research seem to be in keeping with what has been reported by other researchers. Plotkin, Mazer and Loewy, (1976) indicated that: "the present research clearly demonstrates that, in our experimental situation, the likelihood of an alpha experience is unrelated to the degree of enhancement of alpha strength during alpha feedback". Glaros (1975) also demonstrated that expectancy significantly influences the subjective report. He showed that S s given alpha loaded instructions and subjects given beta loaded instructions would report the experience related to their instructions regardless of the type of feedback received. Lowry (1976), when investigating alpha control and concomitant mood states concluded that neither the type of relaxation training nor contingent feedback,

reliably affected subject's alpha production. Mood reports showed no relationship to the training group or treatment day.

One interesting finding which did occur in the present research, and which was not expected, was that the amount of alpha produced during the first try period was significantly lower than the amount of alpha produced during the baseline period. The significant drop in alpha production during the first try period occurred for both the contingent feedback group and the non-contingent feedback group. One possible explanation for this finding is that during the baseline period the subject was inactive, and apparently not doing anything. During the try period, however, the subject was instructed to try to produce the alpha frequency on his own. These instructions would require the subject to institute some strategy or method and therefore engage in a cognitive process which some researchers have indicated suppresses the alpha frequency (Andreassi, 1973). The questions might arise then as to why these subjects did not show the same decrement in alpha production during the second try period. Clearly, the subjects' cognitive process during the feedback period could not be compared to that during the baseline period. The subjects may in fact have been engaging in cognitive strategies during the feedback period which were similar to those used during the second try period and indeed during the first try period. In fact, one argument that may be used to explain why the present research showed no effective conditioning could be that

too high of a cognitive demand was placed on the subjects and therefore they could not "get into" the alpha state. On the other hand, Lynch, Paskowitz and Orne (1974b) indicated that "perhaps our subjects became 'too relaxed' during our baseline period and had fallen below the 'optimum levels' necessary to generate maximum alpha density".

The two trends shown by the No Feedback group are consistent with the above factors. One trend was for a decrease in the alpha abundance over the course of each session. The most probable explanation for this observation is that these subjects became too relaxed, i.e., drowsy, as a result of just sitting, doing nothing, for 50 minutes. The second observation, that the baseline alpha levels increased over days, is consistent with the notion that these subjects became more relaxed on subsequent days due to their familiarity with the experimental situation. A similar increase over days was not observed in the two feedback groups, presumably because they were entering a situation which required considerable cognitive effort, and which they were not achieving particular success at. In contrast, the No Feedback group were not required to perform a task, but were simply allowed to relax for the entire period.

Some light might be shed on this question if a frequency analysis was done on the subject's EEG record throughout the conditioning so that one could more accurately describe the process. A significant increase in the amount of beta frequency production could be indicative of

increased cognitive activity. However, if there was a significant increase in delta and theta frequencies, it might be concluded that the subjects were becoming too relaxed.

The hope that alpha brainwave biofeedback will become a strong clinical tool seems to be growing weaker. The evidence is rapidly mounting that even normal subjects under optimal conditions are not able to produce significant increases in alpha production.

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Appendix A

Information Sheets Given to Contingent and Noncontingent Groups

INSTRUCTIONS

You are about to experience alpha feedback training under controlled laboratory conditions. While you are reading these instructions, I will be applying small silver discs (electrodes) to your scalp with a water soluble paste. The disc will allow me to monitor and record the electrical activity of your brain (brain waves) during the experiment.

The particular brain wave activity in which we are interested is the alpha rhythm, an electrical signal having a frequency from 8 to 12 cycles per second. The alpha rhythm has been found in the past to be associated with certain feelings or special states of consciousness variously described as calm, drowsy, contemplative, dream-like, floaty, or even high. Experiments conducted in Japan have suggested that the special state of consciousness experienced by Zen meditators may in fact be a brain state in which the alpha rhythm predominates. While individuals differ in their descriptions of the alpha state, everyone seems to agree that it is a pleasant state to be in. Many volunteers for these experiments ask to return so that they can again experience the alpha state.

Your brain normally produces a certain amount of alpha even though you are not aware of it. The goals of alpha feedback training are to help you to learn when you are in the alpha state, and to learn to voluntarily increase the amount of time you are producing alpha.

In order to assist you in recognizing and increasing your alpha activity I will do two things. 1. When your brain is producing alpha

a tone signal will automatically turn on. 2. After an initial period of twenty minutes without feedback you will begin to hear a tone, and at this time I wi l ask you to try to keep the tone on. In some cases the tone might be activated if the jaw or brow muscles are tightened, that is, if you clench your teeth or wrinkle your brow. Please refrain from such activity as it does not give you true information about your brain wave activity.

Thank you for your cooperation.

Information Sheets Given to No Feedback Group

INSTRUCTIONS

You are about to participate in a brain wave experiment under controlled laboratory conditions. While you are reading these instructions, I will applying small silver discs (electrodes) to your scalp with a water soluble paste. The discs will allow me to monitor and record the electrical activity of your brain (brain waves) during the experiment.

The particular brain wave activity in which I am interested is the alpha rhythm, an electrical signal having a frequency of from 8 to 12 cycles per second. The alpha rhythm has been found in the past to be associated with certain feelings or special states of consciousness variously described as calm, drowsy, contemplative, dream-like, floaty and even high. Experiments conducted in Japan have suggested that the special state of consicousness experienced by Zen meditators may in fact be a brain state in which the alpha rhythm predominates. While individuals differ in their descriptions of the alpha state, everyone seems to agree that it is a pleasant state to be in. Many volunteers for these experiments ask to return so that they can again experience the alpha state.

Your brain normally produces a certain amount of alpha activity even though you are unaware of it. A goal of this experiment is to determine if there is an increase in the amount of time that you are producing the alpha frequency while you are relaxing. To do this I will ask you to just sit back, relax and try to think about nothing.

Thank you for your cooperation.

Appendix B

QUESTIONNAIRE

		Yes	No
1.	Do you meditate regularly?	___	___
2.	Did you feel you had control of the tone		
	(a) coming on	___	___
	(b) going off	___	___
3.	Did you find the feedback to be		
	(a) a pleasant experience	___	___
	(b) a frustrating experience	___	___

If "Yes" to either of the above can you describe the feeling?

4. Can you describe how you kept the tone on?

5. When you are thinking, do you see what you are thinking about or is it internal conversation?

6. Did you feel any calmer or more relaxed after the feedback than you did before? ___ ___