Alpha Activity, Anxiety, and Distraction

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by

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RDM

Abstract

To evaluate the effects of anxiety on alpha enhancement, 30 subjects were divided into high and low trait anxious groups and 27 of those 30 into high and low state anxious groups. The measures of trait and state anxiety were the Taylor Anxiety Scale and the Zuckerman Multiple Affect Adjective Checklist respectively. Seconds of alpha presence were recorded during four conditions: Baseline (no feedback was provided for 5 minutes); Acquisition (white noise feedback contingent on alpha presence was provided through earphones for 15 minutes); Distraction (an intermittent click of .1 second duration was provided through earphones for 5 minutes); and Reacquisition (identical to Acquisition). Analyses of variance indicated a significant increase over blocks during Baseline for the trait anxious subjects ($p<.005$) and for the state anxious subjects ($p<.01$). A difference approaching significance ($p<.10$) was found between the high and low state anxious subjects during the Acquisition condition.

Introduction

Alpha refers to a brain rhythm of 8 to 13 cycles per second with an amplitude of 5 to 15 microvolts. It is most frequent when the subject is awake, relaxed, and has closed eyes. By repeatedly pairing sound (CS) and light (UCS), classical conditioning of neural activity can be demonstrated when the sound blocks alpha. Such classical conditioning was demonstrated by Jasper and Shagass (1941a, 1941b) and many others in the 1940's and 1950's. Alpha research is currently concerned chiefly with the physiological mechanisms involved, operant conditioning, visual and subjective correlates, and therapeutic applications such as controlling cardiac arrythmia and preventative medicine. Maslow (1969) stated, "There are enough research projects here to keep squadrons of scientists busy for the next century. The mind-body problem, until now considered insoluble, does appear to be workable after all." (p. 728).

The focus of the present study is the operant control of alpha activity, whose history parallels the study of voluntary control of autonomic functions. Skinner (1938) stated the belief that classical conditioning procedures were necessary to condition involuntary responses, that is, responses mediated by the autonomic nervous system. The effect of operant procedures, he believed, was limited to responses mediated by the central nervous system. After reviewing experiments concerning operant modification of autonomically mediated responses, Kimmel (1967) took an opposing view. He stated, "At the present time it would appear that Skinner's assumption that autonomically mediated responses cannot be modified instrumentally was both premature and probably incorrect." While granting that instrumental conditioning of autonomic responses has been demonstrated by Miller (1967), Katkin and Murray (1968) suggested a series of conditions under which results would be improperly interpreted as representing instrumental conditioning of autonomic responses. Central to the discussion was the possibility of somatic mediation. Katkin and Murray suggested that instead of Galvanic Skin Reponses (GSR's) being instrumentally conditionable, an alternative explanation would be that muscular activity, which unconditionally stimulates GSR's, was instrumentally conditioned. Kimmel (1967) stated that somatic mediation was a reasonable argument, but that somatic responses producing a deceleration of response rate were not likely to be responsible for an accelleration. Reviewing Katkin and Murray's objections to instrumental conditioning of autonomic responses, Crider, Schwartz, and Shnidman (1969) stated that, "What is most striking about the mediation hypothesis... is the virtual lack of evidence that presumed mediators can produce the autonomic effects observed under contingent reinforcement regimes." They concluded that while the evidence is not incontrovertible, it is sufficient to assume that autonomic responses are instrumentally strengthened.

Similar conclusions have been reached for alpha activity. The current paradigm for the study of voluntary control of electroencephalographic activity consists of instructing a subject to maximize the presence of a tone presented by a feedback loop when alpha activity is present. Successful enhancement of alpha presence has been reported by Hart (1968), Kamiya (Note 1, Note 2; 1968, 1969) and many others. Beatty (1972) reported that subjects given an appropriate strategy for producing alpha (to feel calm, be pleasantly relaxed, and breath regularly), second

by second feedback, or both, all produced significantly more alpha than subjects provided feedback not contingent on alpha presence.

In an attempt to determine the factors that affect alpha presence, Paskewitz and Orne (1973) argued that when an initial alpha baseline, i.e. seconds of alpha (SA) presence before feedback, is compared with SA after several trials with feedback, a significant difference should not lead to the conclusion that alpha enhancement is dependent on feedback. They believe this difference to be significant only because the subject's apprehension initially suppresses alpha and that this apprehension dissipates over time as he becomes more comfortable in the laboratory. Paskewitz and Orne controlled for this possible disinhibitory effect by comparing SA during feedback trials with SA during no feedback trials introduced between feedback trials. When the subjects had their eyes open in total darkness, no significant alpha enhancement was found, but when the subjects had their eyes open in a dimly lighted room, there was a significant difference in SA for feedback versus no feedback. Their conclusion was that the apparent ability to enhance alpha presence may actually represent the ability to disregard stimuli that suppress alpha activity, such as light, physical distress, or anxiety.

Although Paskewitz and Orne suggested that subject stress and anxiety may be significant mediators of alpha activity, no evidence was offered to substantiate the claim. Progressive relaxation of subjects does not, by itself, account for biofeedback acquisition, because contingent feedback produces more alpha than noncontingent feedback (Beatty 1971, 1972). However, anxiety might be influential in relation to subject arousal, which, as a motivational state, might influence subject reactivity to individual, distracting stimuli. If one assumes that attention to the feedback stimulus is a key mediator, distracting stimuli should be expected to interfere with alpa performance.

Performance of an anxious individual seems to depend on whether he is state or trait anxious. Matarazzo (1972) differentiates between state and trait anxiety by saying, "State anxiety is conceived of as an acute and transitory situationally induced anxious state, whereas trait anxiety is defined as a more enduring or chronic trait which typifies the person as a basically quite anxious person independent of situational stimuli. Considerable research, both empirical (Siegman, 1956a, Matarazzo, Guze, and Matarazzo, 1955) and theoretical (Spielberger, 1966), suggested that the 50-item Taylor Anxiety Scale (TAS) was primarily a measure of trait anxiety, as this latter would come to be differentiated from state anxiety." He further states that the Zuckerman Multiple Affect Adjective Check List (MAACL) is currently used as a measure of state anxiety.

The purpose of this present study is to investigate the relationship of tested subject anxiety to acquisition of alpha activity. Comparisons will be made within two groups of subjects: (a) high and low state anxious and (b) high and low trait anxious. During the initial baseline period the high anxious Ss are expected to show less alpha activity and slower or lower levels of acquisition. Later aperiodec introduction of a distracting auditory cue (clicks) should produce greater reductions of alpha activity in high state anxious Ss than in low state anxious Ss. This reduction should be only minimal for trait anxious Ss. Low

state anxious Ss should recover from this distraction more quickly during a subsequent reacquisition period than high state anxious Ss. These predictions all follow logically from the assumption that (a) acquisition of alpha control depends heavily on learned focusing of attention on the feedback cue, (b) that an aroused (anxious) S should show shifts of attention to competing cues with higher probability than relaxed (low anxious) Ss, and (c) the distractability of high trait anxious Ss is chronic and more independent of situational stimuli than that of state anxious Ss.

Method

Subjects

Fifty male and female subjects were recruited from psychology courses to participate in an experiment involving "voluntary control of brain activity." They were offered extra credit in their psychology classes for participation. All 50 were given the Taylor Anxiety Scale (TAS). The 15 scoring highest and the 15 scoring lowest were assigned to the high and low trait anxious groups respectively.

Apparatus

A Grass Model 79B Polygraph and an Autogen 70 Feedback Encephalograph were used as recording and feedback systems. The Autogen 70 produced continuous event recording of alpha presence on the Grass 79B by way of a logic output. Feedback was provided through Telex earphones as white noise when EEG activity was between 8 and 13 cycles per second with an amplitude of at least 5 microvolts. An adapter for the Autogen 70 was used to allow turning the white noise on and off and to introduce clicks in the ear not receiving the white noise. Clicks were produced by a .1 second closure of a relay. The random mean interval between clicks was controlled by a tape timer. Communication with the subject was by way of a speaker in the subject's room.

Procedure

The procedure was identical for each of the 30 Ss selected on the basis of his TAS score. The S was seated in a quiet, but not soundproof, room. Three electrodes were attached with a headband: one to the forehead above the left eyebrow (the ground lead), one above the left ear, and one in the center of the back of the head approximately 2 inches above the beginning of the hairline. Electrical interference was then checked. Then the subject was given the MAACL and asked to circle each adjective describing how he felt at that moment. These tests were scored after the experiment and the S was retrospectively assigned to the high state anxious or low state anxious group on the basis of his score on the MAACL.

The S was then told:

> This is an experiment to study how people learn to control their brain activity. During the experiment the electrodes will measure your brain waves and when they are just right you will hear a rushing-hissing noise in your earphones. During the experiment your only task is to learn to keep the noise on as much as possible. To do this you have to keep your eyes shut and it also helps to be as relaxed as possible. Otherwise, there are no special rules except to listen to the tone. Any questions so far? OK. In a minute I will go into the next room to adjust the equipment. When the experiment begins I will say, "Begin producing the noise" over this speaker and you will try to produce the sound. It will take about 5 minutes until you hear my voice. When I leave, shut your eyes and relax so that I can check out my recording equipment. The equipment sometimes makes clicking noises in the earphones, but just ignore these and keep listening for the rushing noise. The experiment will take about 40 minutes. I'll come back to get you when it is finished.

The light was then turned off and the door closed.

Alpha presence was recorded continuously for the following 40 minutes, which was divided into 4 periods: Baseline (5 minutes); Acquisition (15 minutes); Distraction (5 minutes); and Reacquisition (15 minutes). During the Baseline period no feedback was provided. Feedback contingent on alpha presence was provided in one ear during Acquisition and the following 2 periods. During the Distraction period clicks were provided in the ear not receiving feedback at a mean rate of 1 each 18 seconds.

Results

Due to the practical impossibility of manually measuring from polygraph records all bursts of alpha activity regardless of their short duration, an averaging technique was used to determine the amount of alpha prsence. Alpha presence of less than or equal to .50 seconds duration was scored as .25 seconds. This averaging technique was thought justified due to the equal probability of an alpha occurrence of less than .25 seconds duration and one from .25 to .50 seconds duration. Thus, it was considered that alpha occurrences of less than or equal to .50 seconds duration would average .25 seconds. In order to simplify the necessary statistical computations, alpha presence of this length were assigned the value 1. Likewise, alpha presence of less than or equal to 1 second but greater than .50 seconds were assigned the value 2, representing .75 seconds. This process of using integers for successive blocks of .5 seconds was continued for longer occurrences of alpha. The assigned values were used in the analyses of variances presented in Table 1 and Table 2. Figure 1 and Figure 2 were contructed after the means based on blocks were converted to mean seconds.

Figure 1 shows the mean seconds of alpha presence for each block of two 50-second periods for the high and low trait anxious groups. The low trait anxious group had a mean score of 10.2 on the TAS. Higher scores on this scale indicate higher trait anxiety. The high trait anxious group had a mean score of 28.3. As can be seen in Figure 1, the low trait anxious group began the Baseline period with more alpha presence than the high trait anxious group and maintained a greater duration of alpha through the Baseline period. The alpha presence of both groups increased markedly during the Baseline period. The level of alpha activity seen at the close of the Baseline period is as high as that seen during almost all of the remaining blocked periods. The difference between the amount of alpha presence of the two groups increased soon after feedback was introduced at the beginning

of the Acquisition period, but that difference soon disappeared. When clicks were introduced at the beginning of the Distraction period, the relationship seen in the Baseline period was reversed and the high trait anxious group showed more alpha presence at first. The Reacquisition period was similar to the Acquisition period in that the low trait anxious group began the period with more alpha, but the difference again became minimal.

Figure 2 shows the mean seconds of alpha presence for each of the blocks of two 50-second periods for the high and low state anxious groups. Three Ss who received the same middle score of 13 on the MAACL were assigned to neither state anxious group in order to separate the two groups, leaving 13 Ss assigned to the high state anxious group and 14 assigned to the low state anxious group. The high state anxious group had a mean score of 9.8 on the MAACL. A low score on this scale indicated high state anxiety. The low state anxious group had a mean score of 16. The high state anxious group began the Baseline period with more alpha presence. The alpha presence of both groups increased markedly during the Baseline period and, again, the level seen at the close of the Baseline period was as high as that seen during almost all of the remaining blocks. The difference between the amount of alpha presence of the two groups increased markedly when feedback was introduced at the beginning of the Acquisition period. The relatively greater amount of alpha presence for the high state anxious group continued through the Distraction period and the clicks did not seem to decrease the alpha level noticeably for either group. When clicks were ended at the beginning of the Reacquisition period, the difference between the two groups that had been apparent until then disappeared. There was no consistent difference between or pattern within the two groups during the Acquisition period.

In order to verify the apparent differences noted in Figure 1 and Figure 2, analyses of variance (mixed two factor) were performed on each phase. Table 1 and Table 2 summarize the results of these analyses. In Table 1 the only statistically significant finding for the high and low trait anxious groups was a blocks effect (p.<.005) during the Baseline period, which verifies the reliability of the apparent increase. For none of the anlyses was there any significant difference during the Distraction or Reacquisition periods. In Table 2 it can been seen that the high and low state anxious groups also showed a signficant blocks effect (p.<.01) during the Baseline period. During the Acquisition period there was an overall difference between groups that approached signficance (p.<.10).

Discussion

There were two main areas in which predictions were made with regard to the alpha activity of the high and low trait anxious Ss. First, it was predicted that high trait anxious Ss would show lower alpha activity during the Baseline period and either slower or lower levels of acquisition. The high trait anxious Ss did have lower alpha activity during the Baseline period, though their level was not significantly lower than that of the low trait anxious Ss. Neither the high or low trait anxious Ss demonstrated a significant increase in

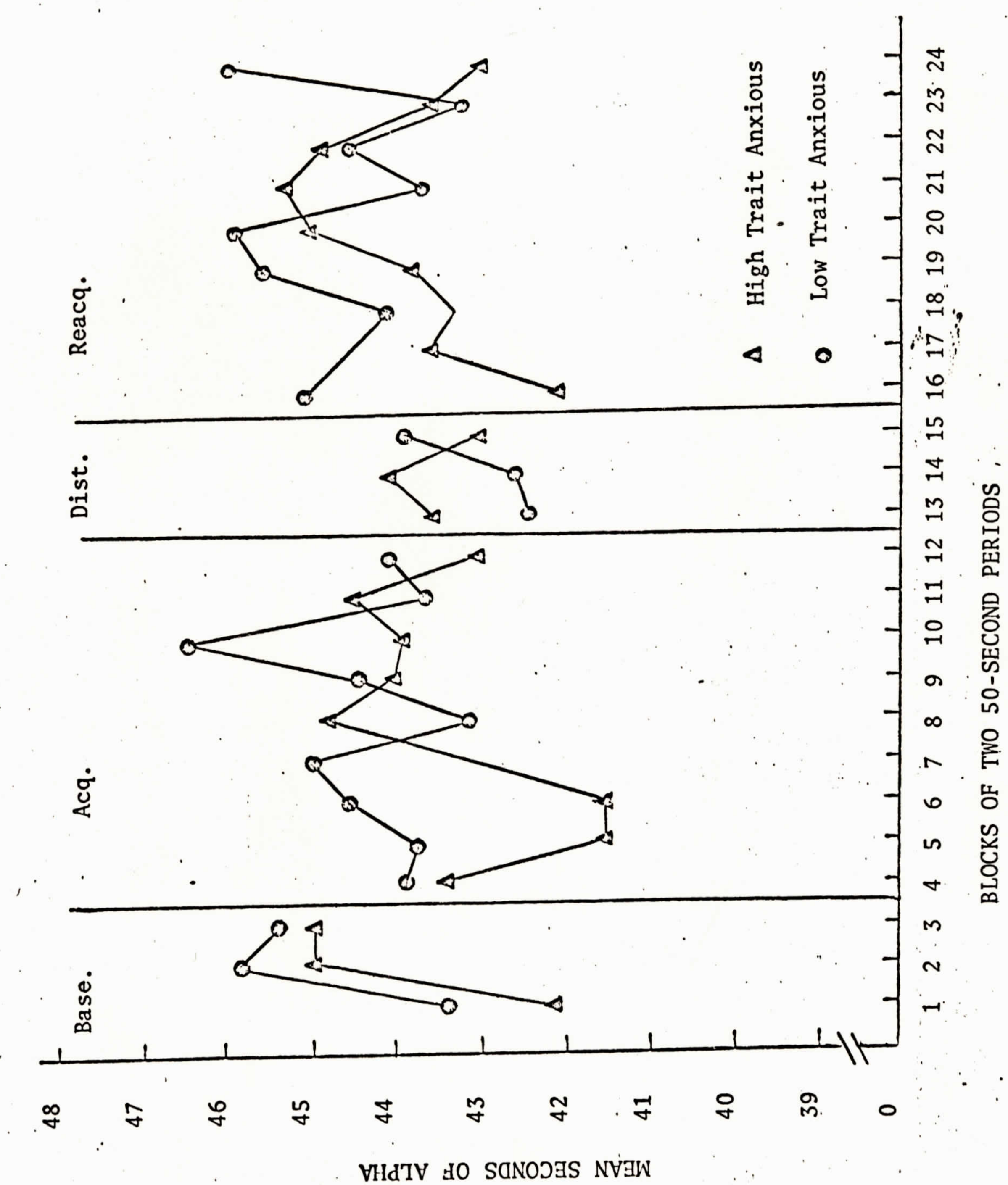

Figure 1. Mean seconds of alpha presence per 50-second period during Baseline, Acquisition, Distraction, and Reacquisition conditions for the high and low trait anxious groups.

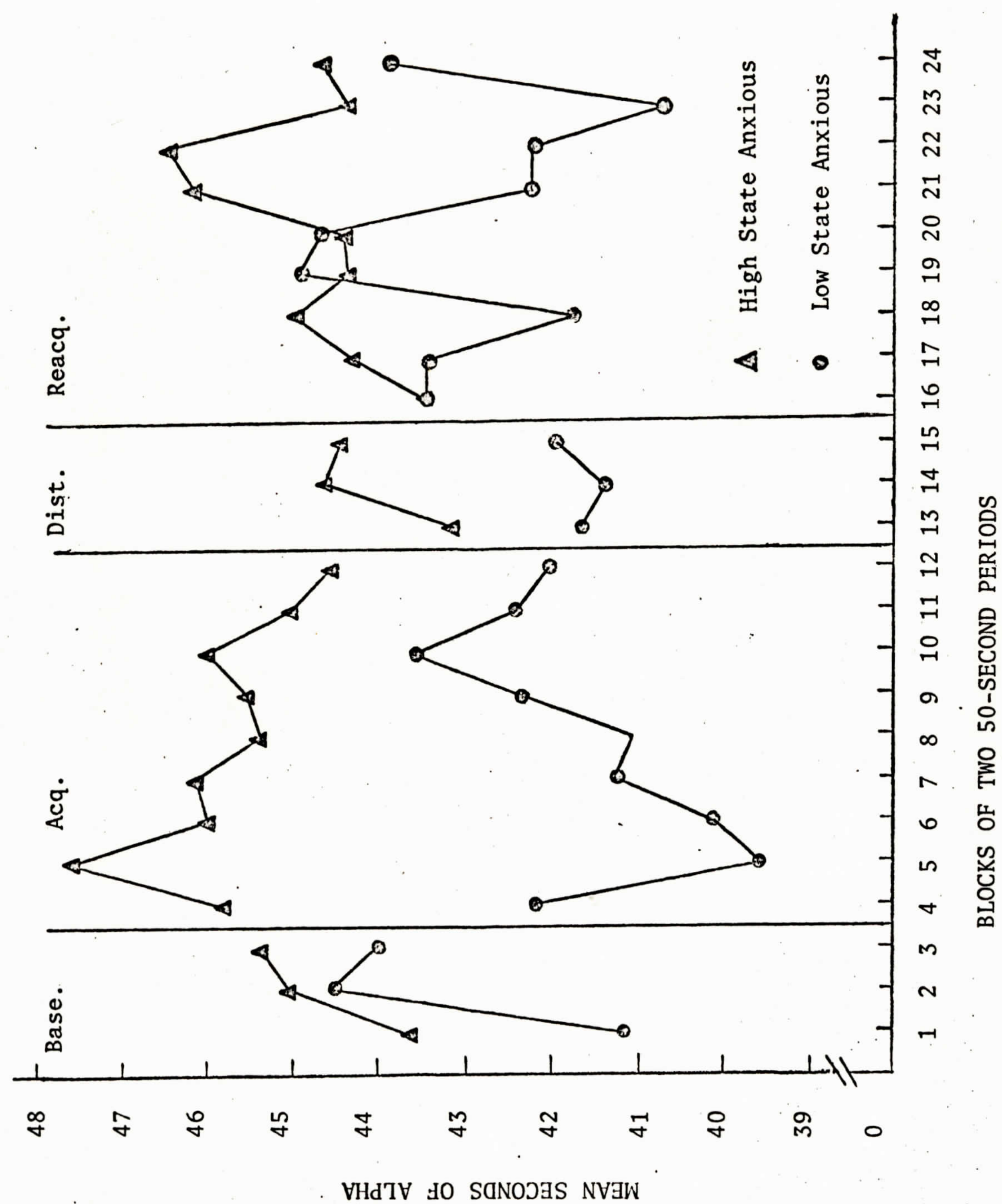

Figure 2. Mean seconds of alpha presence per 50-second period during Baseline, Acquisition, Distraction, and Reacquisition conditions for the high and low state anxious groups.

Table 1

Analyses of Variance of Data of Trait Anxious Subjects

High and low trait anxious subjects during the baseline period

Source	SS	df	ms	F	p.
Total	59,619.0	89			
Between Subjects	48,510.3	29			
Conditions	440.0	1	440.00	.256	N.S.
Error Between	48,070.3	28	1,716.80		
Within Subjects	11,108.7	60			
Trials	2,035.5	2	1,017.75	6.308	<.005
Trials x Conditions	37.9	2	18.90	.117	N.S.
Error Within	9,035.3	56	161.40		

High and low trait anxious subjects during the acquisition period

Source	SS	df	ms	F	p.
Total	40,287,639.2	269			
Between Subjects	168,529.4	29			
Conditions	1,414.5	1	1,414.53	.237	N.S.
Error Between	167,114.9	28	5,968.39		
Within Subjects	40,119,109.8	240			
Trials	2,736.9	8	342.12	.002	N.S.
Trials x Conditions	2,949.7	8	368.71	.002	N.S.
Error Within	40,113,424.8	224	179,077.78		

High and low trait anxious subjects during the distraction period

Source	SS	df	ms	F	p.
Total	58,233.7	89			
Between Subjects	47,657.0	29			
Conditions	127.2	1	127.20	.075	N.S.
Error Between	47,529.8	28	1,697.49		
Within Subjects	10,576.7	60			
Trials	84.1	2	42.05	.233	N.S.
Trials x Conditions	390.5	2	195.25	1.082	N.S.
Error Within	10,102.1	56	180.39		

High and low trait anxious subjects during the reacquisition period

Source	SS	df	ms	F	p.
Total	203,360.1	269			
Between Subjects	144,413.8	29			
Conditions	1,409.9	1	1,409.96	.276	N.S.
Error Between	143,003.8	28	5,107.28		
Within Subjects	58,946.3	240			
Trials	1,345.2	8	168.15	.681	N.S.
Trials x Conditions	2,284.3	8	285.54	1.156	N.S.
Error Within	55,316.7	224	249.95		

Table II

Analyses of Variance of Data of State Anxious Subjects

High and low state anxious subjects during the baseline period

Source	SS	df	ms	F	p.
Total	56,504.0	80			
Between Subjects	46,481.3	26			
Conditions	909.1	1	909.10	.499	N.S.
Error Between	45,572.2	25	1,822.88		
Within Subjects	10,022.7	54			
Trials	1,939.6	2	969.80	6.057	.01
Trials x Conditions	77.2	2	38.60	.241	N.S.
Error Within	8,005.9	50	160.12		

High and low state anxious subjects during the acquisition period

Source	SS	df	ms	F	p.
Total	229,882.3	242			
Between Subjects	155,819.9	26			
Conditions	16,561.7	1	16,561.75	2.973	.10
Error Between	139,258.1	25	5,570.33		
Within Subjects	74,062.4	216			
Trials	895.1	8	111.89	.319	N.S.
Trials x Conditions	2,968.2	8	371.03	1.057	N.S.
Error Within	70,199.1	200	351.00		

High and low state anxious subjects during the distraction period

Source	SS	df	ms	F	p.
Total	54,806.9	80			
Between Subjects	44,402.9	26			
Conditions	1,812.4	1	1,812.40	1.064	N.S.
Error Between	42,590.5	25	1,703.62		
Within Subjects	10,404.0	54			
Trials	135.4	2	67.70	.335	N.S.
Trials x Conditions	169.0	2	84.50	.418	N.S.
Error Within	10,099.6	50	201.99		

High and low state anxious subjects during the reacquisition period

Source	SS	df	ms	F	p.
Total	193,638.7	242			
Between Subjects	106,129.3	26			
Conditions	3,166.0	1	3,166.00	.769	N.S.
Error Between	102,963.3	25	4,118.53		
Within Subjects	87,509.4	216			
Trials	1,613.2	8	201.65	.488	N.S.
Trials x Conditions	3,284.4	8	410.56	.994	N.S.
Error Within	82,611.7	200	413.06		

alpha activity during the Acquisition period and there was no clear difference between the groups, so the prediction of slower or lower levels of acquisition by the high trait anxious group was not confiremd. Second, because the distractability of high anxious Ss was considered more chronic and independent of situational stimuli, it was predicted that these Ss would show only a minimal reduction of alpha activity as a result of the clicks. As predicted, this group did show little or no reduction of alpha activity during the Distraction period. In fact, during the Distraction period the high trait axious group had a minimally greater level of alpha activity than the low trait anxious group.

There were three main areas in which predictions were made with regard to the alpha activity of the high and low state anxious Ss. First, the high state anxious Ss were expected to show lower alpha activity during the Baseline period and either slower or lower levels of acquisition, but just the opposite was found. During the Baseline period the high state anxious group had an insignificantly higher level of alpha activity. There was no significant increase in alpha over trials during Acquisition, but there was a difference between groups that approached significance with the high state anxious group having a higher level of alpha activity. This was particularly suggestive because the two groups were small and the difference between their mean MAACL scores was minimal. Second, it was predicted that the high state anxious group would show a greater reduction in the level of alpha activity during the Distraction period than the low state anxious group. It did appear that their reduction was slightly greater, but they nevertheless remained at a higher level than the low state anxious Ss.

Third, it was predicted that the low state anxious Ss should recover from the distraction more quickly than the high state anxious Ss. This was not supported. There was neither a significant difference between groups during Reacquisition or a significant increase over trials for the low state anxious Ss.

Paskewitz and Orne (1973) state that a significant increase in alpha presence over trials should not lead to the conclusion that alpha enhancement is dependent on feedback. This study clearly supports that statement. During the Baseline period, when no feedback was provided, a significant increase was found for both the high and low state anxious Ss and the high and low trait anxious Ss.

So, alpha presence can increase significantly, but why was there no significant increase in alpha activity when the Ss were provided with feedback? Lynch and Paskewitz (1971) state, "Some authors have noted, however, that although Ss can very quickly learn to suppress their alpha activity, often within the first trial, increases during instructions to augment alpha densitites are far more difficult to achieve, and rarely rise above levels which naturally occur under optimal conditions." If this is correct, the Ss may have approached an asymptotic level of alpha activity during the Baseline period. Paskewitz and Orne (1973) state, "...it is likely that other stimuli such as anxiety or physical stress may, in some circumstances, also lead to suppression (of alpha activity) which persists." The present study suggests that if state or trait anxiety does indeed lead to a suppression of alpha activity, a few minutes of sitting quietly in a darkened room may be sufficient to extinguish both that suppression and the increased distractability that the high anxious Ss were presumed to have.

Another possible explanation for the lack of a significant increase over trials concerns the role of motivation. The Ss received extra credit for participation in the study, but that extra credit was not contingent on any aspect of performance during the experiment. The Ss may simply have not been motivated to attend to the feedback. This potentially important aspect of alpha acquisition is almost never controlled. Subjects are recruited for extra credit and it is assumed that they will attend to the feedback. This question deserves further study.

Most intriguing is the between group difference that approached significance during the Acquisition period for the high and low state anxious Ss. Why should high state anxious Ss have more alpha activity than low state anxious Ss? The present study raises this question but does not answer it. One possible explanation, again concerning motivation, is suggested. Perhaps the MAACL tapped motivation. After the instructions were read, several of the high state anxious Ss asked questions that suggested they may have been concerned with their impending performance. One asked, "Does this have anything to do with how smart I am?". Another asked, "What if I can't do it?". It is possible that, even though their extra credit was not contingent on their performance, the state anxiety measured by the MAACL was correlated with or served as a motivating factor.

According to Newlis and Kamiya (1970) alpha presence is consistently associated with subjective reports of relaxation, letting go, and a feeling of pleasure, but the high state anxious Ss nevertheless had more alpha presence than the low state anxious Ss. This finding and the questions raised above concerning the role of motivation in the process of alpha acquisition strongly suggest the need for further investigation before the relationship of anxiety and alpha activity is properly understood.

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