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Contingent *vs.* Noncontingent EMG Feedback and Hand Temperature in Relation to Anxiety and Locus of Control

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This study was designed to measure the effects of contingent and noncontingent EMG feedback on hand temperature, anxiety, and locus of control. Two groups of six subjects each were selected on the basis of high test-anxiety scores. The groups participated in a reverse design study in which Group 1 received five sessions of contingent EMG feedback followed by five sessions of noncontingent feedback. Group 2 received noncontingent feedback followed by contingent feedback. Results indicate a significant order of treatment effect. Subjects who received contingent feedback first produced lower EMG readings, lower test-anxiety scores, and higher hand temperatures during noncontingent feedback sessions. Receiving noncontingent feedback first may actually have interfered with utilizing contingent feedback.

There have been concentrated research efforts toward the use of EEG (electroencephalogram) and EMG (electromyogram) biofeedback for problems of anxiety and psychosomatic disorders (Budzynski, Stoyva, & Adler, 1970, 1973). Chronic anxiety has been found amenable to treatment by feedback-induced muscle relaxation (Raskin, Johnson, & Rondestvedt, 1973). Decreasing anxiety has also been linked to increased blood circulation in the extremities and thereby can produce increases in hand temperature (Danskin & Walters, 1974).

Some physiological psychologists have studied the use of EMG feedback and subsequent influence on test anxiety (Garret & Silver, Note 1).

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Several preliminary observations have implied that certain personality variables may indicate learning of greater self-control. Smith (1973) reported significant correlations between resting frontalis EMG levels for anxiety, neuroticism and locus of control. Matus's data (1974) suggest that personality dimensions may be related to specific physiological responses rather than to global responses. That is, he found relationships between resting frontalis EMG and introversion–extroversion, but this was not significant with resting forearm EMG levels. Field independence–dependence was related to resting forearm EMG but not significantly correlated for resting frontalis EMG.

In an attempt to identify the difference between contingent and noncontingent EMG feedback, Budzynski et al. (1973) and others have focused on pseudofeedback and the possibility of overgeneralized placebo effects. The method involved two control groups in addition to the experimental group in order to rule out the implicit possibility of suggestion effects. Their results indicate a marked improvement in contingent feedback groups and a lower frequency of headache episodes when compared to the noncontingent feedback groups. Overall results suggest that feedback treatments may be applied to stress-related disorders other than tension headaches.

These and other observations have prompted the experimental design of this study. The purpose of the present inquiry was to investigate the effects of contingent and noncontingent frontalis EMG feedback on measures of anxiety and locus of control. In addition, we were interested in the effects of EMG feedback in relation to hand temperature. Therefore, this design includes two physiological measures (EMG and hand temperature) and measures of test anxiety, manifest anxiety, and IE. Dependent variables were selected in order to observe the differences and relationships of these measures based on contingent and noncontingent feedback conditions. Numerous hypotheses were generated and are, therefore, outlined below.

1. Contingent feedback should result in lower frontalis EMG readings vs. higher frontalis EMG readings in the noncontingent feedback condition.

2. Hand temperature should increase with contingent feedback as compared to the noncontingent frontalis EMG feedback condition.

3. Test anxiety should be lower following the contingent feedback condition when compared to the noncontingent condition.

4. Manifest anxiety should be lower following contingent feedback condition when compared to the noncontingent condition.

5. Subjects should become more internalized following the contingent feedback condition vs. more externalized following the noncontingent condition.

METHOD

Subjects

Ninety-five female introductory psychology students participated in an initial testing session. Subjects received extra credit for their participation. Only females were used in order to avoid possible sex differences.

In this initial session, subjects completed the Suinn Test Anxiety Behavior Scale (STABS) (Suinn, 1969). On the basis of these scores, 12 subjects were selected and divided into two matched groups. Thus we had two groups of 6 subjects each. Group means on the STABS were 159.0 and 161.2 and were intended to reflect moderately high test anxiety. These 12 subjects were involved in the experimental conditions and received additional extra credit points for further participation. However, the experimental treatment was quite time-consuming and, in fact, required considerably more time than was necessary to receive the maximum number of extra credit points. Therefore, participation might be considered voluntary. Subjects did show a high degree of interest and motivation.

Apparatus

We hoped to relate biofeedback to certain subjective experiences. We chose three subjective measures. These were the STABS, the Rotter Internal vs. External Scores of Control (IE) Test, (Rotter, 1966), and a test of manifest anxiety (MA) based on 48 items from the Taylor Manifest Anxiety Scale (Taylor, 1953).

Electromyographic feedback was provided by the Cyborg EMG, model J233. The effective band pass for this unit ranges from 100 to 1,000 Hz. This instrument provides auditory feedback in the form of a clicking sound that increases in rate as muscle tension increases. This instrument also provides visual feedback in the form of a dial that reads in microvolts. However, only auditory feedback was made available to the subjects. Three ½-inch-diameter (silver-silver chloride) sensors were placed on the frontalis muscles approximately 1 inch above the eyebrow ridge and about 1 inch apart.

We were also interested in possible placebo effects of biofeedback. Therefore, we provided noncontingent feedback during some sessions. This was accomplished by simply connecting the earphones to a cassette recorder. Tapes were prepared by recording the EMG feedback of two subjects not involved in this experiment. There was a separate tape or section of tape for each noncontingent feedback session, with no intended pattern of increasing or decreasing rate of clicks.

Hand temperatures were measured by a solid state resistive Texas Instruments device whose resistance is a nonlinear function of temperature. The error due to nonlinearity is ±3% from 77° F to 93° F, the range over which the temperature monitor is calibrated. This involved attaching a sensor to the middle finger of each subject's right hand. These readings were recorded but not made available to the subjects.

All sessions were conducted in a small, well-lighted room. Subjects sat in a comfortable reclining chair. Equipment, except for sensors and earphones, was concealed behind a screen divider.

Procedure

The study was presented to the subjects as an investigation of the relationship between test anxiety and biofeedback. All subjects completed the three subjective measures (that is, the STABS, the Manifest Anxiety Scale, and the Internal vs. External Locus of Control Test) prior to any experimental treatment. The groups then participated in a reverse design treatment program. Group1 first received five sessions of contingent EMG feedback. They then completed the subjective measures a second time. This was followed by five sessions of noncontingent EMG feedback and a final completion of the subjective measures. Group 2 received noncontingent feedback for the first five sessions and contingent feedback for the last five sessions.

Subjects in both groups received the same instructions prior to the first session. They were given a general description of the equipment and were told what was being measured and how to use the feedback. The only part of the instructions that might be considered leading or suggestive is a section that reads, "Training people to control these internal physiological processes apparently helps them learn to relax." Subjects were also told that they would hear either their own EMG feedback or else a prerecorded tape of the EMG feedback of another subject with approximately 1 hour of biofeedback experience. At the beginning of each session, subjects were informed which of these conditions would occur that day. Thus subjects were aware of whether the feedback was contingent or noncontingent. This was done simply because we believe subjects would have been able to differentiate contingent and noncontingent feedback anyway. All subjects regardless of feedback condition were instructed to try and maintain a relaxed state.

Feedback sessions lasted for 20 minutes. Subjects came in at approximately the same time each day (there was never more than 4 hours' difference) for 5 consecutive days, Monday through Friday. Immediately after the fifth session, they were given the subjective measures to complete. The next block of five sessions began the following Monday. The final subjective measures were completed immediately following the next Friday session. EMG readings were recorded in microvolts directly from the dial on the machine. The experimenter recorded readings from this dial every 2 minutes throughout the 20-minute session. Since there is no printout or averager on this machine, an effort was made to get readings as accurate as possible at the 2-minute intervals. The 10 readings in a session were then averaged to provide a mean EMG reading per session for each subject. The measure of hand temperature takes considerably longer to register changes in temperature. Readings were taken every 5 minutes and so provided four readings per session. They were also averaged to get a mean temperature for each session.

Six subjects were run each day. Thus it took 4 weeks to complete the data collection. Half of the subjects in each group were run during the first 2-week period and half during the second. Each experimenter ran half of the subjects in each group.

RESULTS

The physiological measures were averaged daily for each subject. Thus each subject provided a mean EMG and hand temperature reading for each session. These means were then averaged within contingent and noncontingent conditions and are summarized in Table I.

Table I. Means and Standard Deviations for Physiological Measures during Contingent and Noncontingent Feedback

	Contingent		Noncontingent	
Group	*M*	*SD*	*M*	*SD*
	Frontal EMG Readings (Microvolts)			
1	5.78	.21	5.85	.30
2	6.55	.47	10.50	1.48
	Hand Temperature Readings (F)			
1	89.16	1.34	90.39	1.97
2	90.65	2.87	88.57	1.82

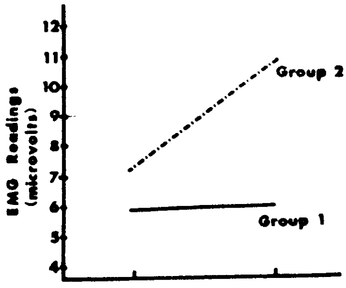

Fig. 1. Group mean EMG readings for contingent and noncontingent EMG feedback (1 = contingent first, noncontingent; 2 = noncontingent first, contingent).

A three-way analysis of variance was computed on EMG session means in order to determine possible Group, Treatment, and Group X Treatment effects. Here, Treatment refers to contingent and noncontingent feedback and Group refers to an order effect; contingent–noncontingent (Group 1) vs. noncontingent–contingent (Group 2). Both Group and Treatment produced significant main effects [$F(1,10) = 17.78$, $p < .01$, respectively]. In addition, there was a significant Group X Treatment interaction [$F(1,10) = 16.57$, $p < .01$]. Clearly, receiving contingent feedback first leads to lower EMG readings during noncontingent feedback (see Figure 1).

A similar analysis of variance was computed on hand temperatures. This revealed a significant Group X Treatment interaction effect [$F(1,10) = 10.38$, $p < .01$]. As can be seen in Figure 2, Group 2 showed a gradual decrease in temperatures during noncontingent feedback, while Group 1 temperatures progressively increased.

Table II. Means and Standard Deviations for the Subjective Measures

	Time of testing					
	First		Second		Third	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
			STABS			
1	159.00	16.36	154.83	34.03	142.00	41.86
2	161.16	9.89	172.33	25.13	160.16	36.54
			Manifest Anxiety			
1	23.50	7.84	20.16	8.18	19.66	7.66
2	18.83	5.98	18.33	4.03	16.00	3.95
			I E			
1	11.00	2.61	8.33	2.73	7.83	2.86
2	14.00	4.00	12.00	4.38	13.00	5.62

Group 2 scores increased following noncontingent feedback and later decreased following contingent. Thus, this suggests that the effect of type of feedback on STABS was influenced by the order of treatment (see Figure 3).

DISCUSSION AND CONCLUSION

Subjects were able to attain relatively low EMG readings quite quickly when given real EMG feedback first. Apparently, they were able to associate the EMG feedback with their own subjective experience as a guide. This is the basis of biofeedback theory and is clearly exemplified by Group 1. The second group's initial noncontingent EMG readings were significantly higher than all other EMG means. We can assume that Group 1 noncontingent EMG readings would have been comparable, had they received noncontingent feedback first. Group 2 subjects were able to attain lower EMG readings when given contingent feedback, but these readings were not as low as Group 1 contingent feedback readings. It is possible that receiving noncontingent feedback first interfered with Group 2 subjects' ability to utilize contingent feedback. These subjects may have experienced some frustration due to past reinforcement that was not contingent on their behavior. This could have become a conditioned emotional response that was incompatible with a relaxation response. Further research is needed to support this.

Mean temperature readings were not significantly different between contingent and noncontingent feedback conditions. However, during noncontingent feedback, there was a noticeable trend toward higher temperature readings across trials for Group 1 subjects, and toward somewhat lower readings for Group 2. This is seen in Figure 2. Hand temperature tends to reflect a more complete body relaxation. As the major muscle groups relax and blood circulation to the extremities improves, hand temperature rises. It seems likely that learning to lower tension in the frontalis muscles with EMG feedback does tend to generalize over time. Again, further research is needed to show if this trend would continue with additional sessions.

Unfortunately, groups were not adequately matched on IE and MA scores. Group 1 subjects tended to become more internalized following contingent feedback, and scores remained low or decreased further following noncontingent feedback. Similarly, MA scores reflected a decrease in anxiety with contingent feedback and anxiety continued to decrease with noncontingent feedback for Group 1. Group 2 scores changed very little or suggested slight decreases with contingent feedback. These Treatment effects were not statistically significant. Since these measures often reflect

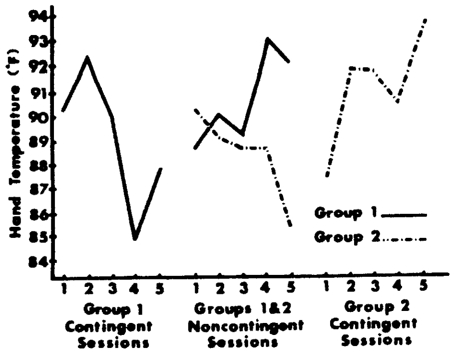

Fig. 2. Group changes in hand temperature during contingent and noncontingent EMG feedback sessions (1 = contingent first, noncontingent; 2 = noncontingent first, contingent).

A separate three-factor ANOVA with repeated measures was run on each of the subjective measures. These means are summarized in Table II.

The pattern of results for MA and IE were generally consistent with the physiological measures. However, significant effects were found only on the repeated measures [$F(2,30) = 6.376$, $p < .10$ and $F(2,30) = 2.587$, $p < .10$ for MA and IE, respectively]. For MA, repeated testing produced decreasing scores on both groups combined; moreover, each group consistently showed larger decreases following contingent feedback. On the IE variable, there was also a trend toward a more internal locus of control. Group 1 showed a substantial decrease following contingent feedback. Group 2, which received noncontingent feedback first, showed a slight increase in IE scores following contingent feedback. This lack of significant Group X Repeated Measures effect may have reflected initial group differences on the pretests.

Since subjects were selected on the basis of STABS scores, groups were matched on this measure. Posttreatment STABS scores were analyzed and demonstrated a significant Group X Treatment interaction [$F(1,10) = 7.501$, $p < .05$]. Group 1 scores decreased following contingent feedback and continued to decrease following noncontingent. On the other hand,

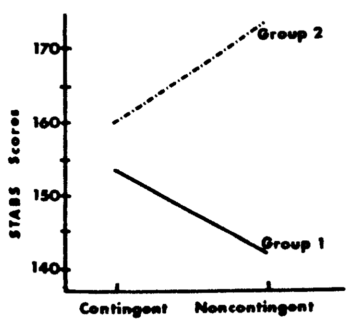

Fig. 3. Group mean STABS scores following contingent and noncontingent EMG feedback (1 = contingent first, noncontingent; 2 = noncontingent first, contingent).

relatively stable personality traits, and the total contingent feedback was less than 2 hours per subject, it is hardly surprising that there was little or no change. The pattern of results suggests that longer treatment may prove effective in manipulating such stable measures. Recall that Smith (1973) has shown that internal control is associated with lower frontalis EMG levels. However, the effect of long-term treatment or underlying personality variables is still open to question and speculation.

STABS scores did show a significant Group X Treatment interaction. For Group 1, receiving contingent feedback first was associated with lower test anxiety. After noncontingent feedback, STABS scores were even lower. Group 2 scores increased following noncontingent feedback, then decreased in the contingent condition. It seems that learning to control internal processes tends to decrease test anxiety.

It might be suggested that subjects should not have been informed of the specific feedback condition. Yet, the difference between contingent and noncontingent EMG feedback is quite noticeable. We wished to avoid the confounding of having subjects realize somewhere in the middle of the study that they had been deceived. Further research with informed and uninformed noncontingent feedback will be of interest. Although there are few areas of psychological research that lend themselves more readily to a placebo effect, it seems unlikely that a placebo effect is sufficient to explain the influence of biofeedback as a therapeutic treatment.

REFERENCE NOTE

1. Garret, B., & Silver, M. *The use of EMG and alpha biofeedback to relieve test anxiety in college students.* Paper read before the American Psychological Association meeting. Washington, D.C., 1973.

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