Prior Task Failure as a Determinant of Biofeedback and Cognitive Task Performance

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In a study of the effects of controllability of outcomes upon behavior in a biofeedback context, 40 college students were assigned to four groups differing in pretreatment: (1) a success-failure group, given false feedback in a fictitious blood-vessel control task for two sessions designed to convey success followed by two sessions of failure feedback; (2) a failure-failure group, given false failure feedback throughout pretreatment; (3) a contingent failure group, receiving actual feedback in a temperature biofeedback task with criteria that assured failure throughout pretreatment; and (4) a control group, given no specific task during this phase. In a subsequent phase, all subjects received actual frontal (forehead) electromyographic (EMG) response training with biofeedback. In analyses of the results, during EMG training, the contingent failure group attained lower levels than the other three groups. By contrast, on a cognitive (anagram) task, interpolated between pretreatment and EMG training, the contingent failure group demonstrated relatively poorer performance than the other groups. The results are discussed in terms of reactance and learned helplessness theories of perceived loss of control in this context.

1Some of the data reported here were included in a thesis submitted by the second author in partial fulfillment of requirements for the master's degree in psychology, University of Hawaii, 1981. The entire paper was the basis for a presentation at the annual meeting of the Biofeedback Society of America, Albuquerque, 1984.
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Brehm has argued that the perceived loss of control over outcomes of one's behavior or over the behavior itself generates reactance—that is, "a motivational state directed toward the re-establishment of the free behaviors" (1966, p. 9). The direction of this effect appears to be diametrically opposed to the consequences of learned helplessness. In Seligman's (1975) theory, it is maintained that the expectation of uncontrollable outcomes, or helplessness, may result in reduced motivation to initiate voluntary acts, among other effects.

In an attempt to reconcile these two positions, Wortman and Brehm (1975) argued that with increasing exposure to uncontrollable reinforcers, a person's cognitions should gradually shift from expectations of control to expectations of no control. Where there are expectations of control, reactance should result. When expectations of no control develop, helplessness (reduced motivation) should follow. In short, when a person initially experiences the loss of previously held control over reinforcers, he or she will strive harder to regain control. Later, however, with continued absence of control, expectations will change and performance will deteriorate.

Wortman and Brehm (1975) cite a variety of studies that support the reactance phenomenon. Similarly, Carlson and Feld (1981) reported the results of manipulations in a biofeedback context that lend themselves to an interpretation in terms of reactance theory. The biofeedback setting was chosen for this research owing in part to the background of prior research in this context relating controllability of outcomes to behavior (Carlson, 1982). In addition, the considerable task involvement of subjects in self-control using biofeedback may enhance the role of variables that appear to limit control. In the Carlson and Feld study, college students were assigned to several conditions, in one of which subjects were trained in a credible but fictitious "blood-vessel control" task. In this group, subjects received a feedback signal that conveyed that they had failed at the task. After several sessions, all of the subjects were given training in a true bodily control task in which a feedback signal reflected muscle tension (electromyographic, EMG, responses). Relative to appropriate control groups, the group that believed they had failed in the prior task showed somewhat better performance in the EMG training task. The direction of this effect is consistent with a reactance interpretation of the uncontrollability of the feedback during the initial phase. That is, prior failure may have enhanced subsequent performance levels in a motivational fashion. Subject self-reports were also consistent with this view, reflecting more reports of frustration and lack of control during the failure training than in the other groups.

If this interpretation is valid, an additional prediction from the reactance hypothesis can be tested in this context. Specifically, following Wortman and Brehm's (1975) suggestion, when subjects experience uncon-
trollable outcomes of performance, those who begin with greater expectations of control should be more likely to show enhancement of performance than those who begin with lesser expectations of control in the setting. From this analysis, it was reasoned that training specifically designed to foster the expectation of control should facilitate the later development of reactance when loss of control is experienced.

As its main objective, the present experiment was designed to test this prediction. Two groups of subjects were given apparent biofeedback training in a pretreatment phase of the experiment in order to establish expectations concerning the controllability of a bodily process. The failure-failure group was given fictitious feedback designed to convey failure at the task throughout pretreatment. The success-failure group was given fictitious feedback that initially conveyed success at the task followed by feedback that conveyed failure. Following pretreatment, the subjects were given a true biofeedback task, EMG reduction training. Applying Wortman and Brehm's view, it was predicted that the success-failure group would demonstrate higher levels of performance—that is, greater reactance—in the EMG training task than the failure-failure pretreated group. Due to their apparent successful sessions, the success-failure subjects should have been more likely to initially expect controllability of feedback during the sessions in which feedback became apparently uncontrollable, whereas the failure-failure subjects, having experienced only apparently uncontrollable feedback, should already have come to expect that outcomes were uncontrollable in these sessions.

There were two additional objectives of this experiment. First, in an effort to more closely simulate methods used in related research in the helplessness and reactance areas (cf. review by Miller & Norman, 1979), a group was included in this study, the contingent failure group, that was given training on an actual temperature biofeedback task during pretreatment with a criterion too difficult to attain. Thus, the contingencies operating for these subjects were actual ones, whereas those for their counterparts in the failure-failure group were merely perceived. The contingent failure group provided a control for the possibility that aspects of the false-failure feedback might be detectable that lessened the credibility of the task and the expectation that outcomes of performance were uncontrollable.

The third objective of this study was to assess the generalized effects of failure pretreatment to a nonbiofeedback task. An anagram task was given to subjects immediately following pretreatment that was identical to one used in research by others demonstrating performance decrements (helplessness) due to prior exposure to uncontrollable outcomes (e.g., Hiroto & Seligman, 1975; Gatchel, McKinney, & Koebernik, 1977).
METHOD

Subjects

Forty students in an introductory psychology class were assigned at random to four groups of equal size. Participants received course credit in the form of one “bonus point” (Minke & Carlson, 1985) for each experimental session.

Apparatus

An Autogenic Systems Model 1700b feedback myograph, a Model 5100 digital integrator, and a Model 2000 feedback thermometer were housed in a control room adjacent to an experimental room. The experimental room was 200 cm by 250 cm, sound- and light-attenuated, and contained a reclining chair and intercom. Two Panasonic Model RQ 413AS cassette tape recorders provided for instructions to the subject and presentation of false feedback signals. All feedback signals were delivered to a subject binaurally via Koss headphones (Model K-6). Red and green signal lights were mounted on the wall opposite the front of the reclining chair in the experimental room.

Three biopotential surface electrodes were used for forehead (frontal) EMG measurements, positioned with the ground electrode 2.5 cm directly above the nasion and the active electrodes placed 4 cm laterally to either side. A thermistor was taped to the palmer surface of the right forefinger, 1 cm from the end.

Procedure

There were 3 sessions per week, at approximately the same time each day, for a total of 10, consisting of 2 baseline sessions, 4 pretreatment sessions, and 4 training sessions, in that order. Each session was approximately 30 min in duration, including a 10-min habituation period at the beginning. (See Table 1 for a summary of the procedures.)

In session 1, each subject was seated in the semireclined chair and was played a set of taped instructions concerning the fundamental details of the study, including the measuring devices, scheduling of appointments, and bonus point credit. In addition, subjects were asked to keep their eyes closed during each of the 10 sessions. All measuring instruments were then attached. During the baseline sessions, all subjects were treated identically and no sound was presented on the headphones.
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Table I. Summary of Procedures

<table>
<thead>
<tr>
<th>Group</th>
<th>Sessions</th>
<th>Pretreatment</th>
<th>Training</th>
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<tr>
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<td>Baseline</td>
<td>3 – 4</td>
<td>5 – 6*</td>
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<td>Success – failure</td>
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<td>Failure – failure</td>
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<td>Contingent failure</td>
<td>Monitor</td>
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<td>Control</td>
<td>Monitor</td>
<td>&quot;Failure&quot; tape</td>
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*At the end of session 6, all subjects were administered an anagram task.

At the beginning of the first pretreatment session, session 3, subjects in three of the groups were informed that they were entering a new phase of the experiment. Two of these groups heard a taped analogue feedback tone. There were two sets of tapes that were played to the subjects. One set of tapes consisted of “success” feedback, in which the tone steadily decreased to low levels by the end of the session. The other set of tapes were of “failure” feedback, in which the tone was variable and at approximately the same level by the end of the session as at the start. (See Carlson & Feld, 1981, for a more complete description of the false feedback and instructions to the subject.)

For one of these three groups, the success-failure group, in sessions 3 and 4, the tape provided “success” feedback. The green light was turned on at the end of these sessions, signaling mastery of the task. During sessions 5 and 6, the failure condition was in effect. The tape provided “failure” feedback and the red light was turned on at the end of these sessions.

The second of these three groups, the failure-failure group, experienced the “failure” condition throughout all of sessions 3–6, including the failure feedback tapes and the end-of-session red light.

The third group, the contingent failure group, received actual feedback throughout the treatment phase for fingertip temperature increases. Every attempt was made for the temperature training procedure to be within established guidelines set forth by Taub and School (1978). (It was anticipated that the performance criteria in the four sessions of temperature training would virtually ensure failure in the relatively few sessions of treatment.)

The fourth group, control, was told that they were entering a phase of the experiment in which they would hear a varying tone (in actuality, the failure feedback tape) over the headphones. This condition was in effect throughout sessions 3–6, with no other manipulations.

At the end of session 6, all groups were administered an anagram test (Hiroto & Seligman, 1975) to assess potential cognitive deficits produced by
the uncontrollable events. This session was extended by the amount of time it took the subjects to complete this extra task, approximately 20 min.

In sessions 7–10, all subjects were given identical treatment. They were told that they were entering a new phase of the experiment and that the tone they now heard reflected their forehead muscle tension. The more they “relaxed,” the lower the pitch of the tone. In this phase, actual analogue feedback from the electromyograph was provided for frontal EMG responses.

Finally, all subjects were given a postexperiment questionnaire concerning all stages of the experiment and then were thoroughly debriefed concerning the details of the experiment.

RESULTS

The results of this study were in terms of frontal EMG levels, peripheral temperatures, performance on the cognitive (anagram) task, and responses on the postexperiment questionnaire. All data were subjected to analyses of variance (ANOVAs) and subsequent individual comparisons or contrasts in accordance with predictions (Winer, 1974). A .05 rejection level was used in all of the statistical tests.

Frontal EMG Levels

Frontal EMG responses were cumulated in 30-sec intervals, or “trials,” and recorded in terms of integral averages. The initial 10 min of each session were considered a habituation period and were excluded from all of the analyses. An ANOVA was conducted on EMG levels for the remaining trials in the baseline sessions, with groups and subjects as between-subjects factors and sessions and trials as within subjects factors. There were no significant differences on any of the factors, including groups. Therefore, to simplify some of the comparisons, EMG levels after the first 10 min in sessions 3–10 were converted to proportions of baseline for each subject. Each trial was expressed as a proportion of the mean of the corresponding trial on the two baseline days. (A rationale for this procedure is discussed by Carlson, Basilio, & Heaukulani, 1983).

Figure 1 shows proportional EMG levels in the pretreatment phase and EMG biofeedback training phase for each group. The figure displays means of the final two pretreatment sessions (sessions 5 and 6), during which the success–failure and failure–failure groups received the same false–failure feedback, and during the final two training sessions (sessions 9 and 10).
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The figure shows that during pretreatment, the EMG levels of the success-failure and failure-failure groups were considerably elevated above baseline, and that the EMG levels of the contingent failure and control groups were about at baseline (that is, the 1.00 level, in terms of proportions). The exceptionally high levels of the success-failure group were primarily attributable to a large increase in EMG levels in session 5 (mean = 1.89), when these subjects were first given failure feedback. By contrast, during biofeedback training, EMG levels of all three failure-pretreated groups declined considerably and were lower than those of the control group.

An ANOVA was performed on these proportions, with groups and subjects as between-subjects factors, and phases (pretreatment vs. training), sessions, and trials as within-subjects factors. Reflecting the effects of training on performance, the analysis yielded a large phase effect ($F = 22.97$, $df = 1/36$, $p < .0005$) and group x phase interaction ($F = 6.66$, $df = 3/36$, $p < .005$). In a subsequent contrast on the pretreatment means, the mean of the two false-failure pretreated groups was significantly higher.

Fig. 1. EMG levels of the four groups in pretreatment and training, expressed as a proportion of baseline.
than the mean of the contingent failure and control groups, which did not differ from one another \( t = 3.90, df = 36, p < .0005 \). In a subsequent contrast on the training means, the mean of the contingent failure group was found to be significantly lower than the means of the other three groups, which did not differ from one another \( t = 2.04, df = 36, p < .05 \).

**Peripheral Temperatures**

Finger temperatures, in degrees Fahrenheit, were recorded at the end of each 30-sec trial. Of greatest interest, there were no apparent differences between the groups in any phase, including the group that received contingent temperature training during pretreatment. The data were subjected to an ANOVA similar to that described for EMG levels. Consistent with the visual inspection of these data, neither the groups effect nor the interactions of groups with the other variables were significant.

**Anagram Task**

Anagram task responses were summarized in terms of mean trials to criterion, mean number of failures, and mean latencies, respectively. (Subjects who did not solve an anagram within 100 sec were given a latency score of 100 for that anagram and it was counted as a failure. Also, subjects who did not meet the trials-to-criterion standard, three consecutive trials under 15 sec, within the 20 anagrams, were given a failure score of 20.) Summaries of these statistics are shown in Figure 2.

It is apparent, in all three measures, that the contingent failure group exhibited poorer performance than the other three groups. Three separate ANOVAs were conducted on these data, with groups and subjects as between-subjects variables. The only test approaching significance was the group effect in the ANOVA on mean latencies \( F = 2.24, df = 36, p < .10 \). In a subsequent contrast, this effect was found to be attributable to the somewhat longer latencies of the contingent failure group relative to the other three groups combined \( t = 2.31, df = 36, p < .05 \).

**Postexperiment Questionnaire**

A 25-item postexperiment questionnaire was administered, which assessed the nature and effects of the experimental manipulations. Subjects answered each question by placing a hatch mark on a 10-cm continuum between two extremes. These answers were then assigned a numerical value by
measuring their distance in cm from the left side of the continuum. Separate ANOVAs, with groups and subjects as between-subjects variables, were performed on these items.4

The first 11 items of the postexperiment questionnaire pertained to gaining fingertip temperature control during pretreatment. (The responses of the success-failure, failure-failure, and contingent failure groups were analyzed, since only these groups were given this task.) The first of these items assessed the degree of perceived control in this task. The success-failure group indicated a moderate degree of control. There was a significant groups effect in the ANOVA for this item ($F = 7.93, df = 2/18, p < .01$). A subsequent contrast revealed that the success-failure group perceived themselves to be significantly more in control of their finger temperature than the other two pretreated groups ($t = 3.98, df = 8, p < .01$).

A significant main effect in the ANOVA for item 8 was also found ($F = 4.4, df = 2/18, p < .05$). This question was similar to item 1. The success-failure group again indicated a degree of perceived control, while the failure-failure and contingent failure groups again reported somewhat less control. A subsequent contrast was significant ($t = 2.65, df = 8, p < .05$).

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4Owing to a procedural error, questionnaire data from two subjects in each group were not obtained, leaving eight subjects per group in analyses.
Item 2 assessed the degree of importance that individuals placed on this task. No significant main effect in the ANOVA was found. However, a subsequent contrast, comparing the success-failure group to the failure-failure and contingent groups combined, was significant (t = 2.46, df = 8, p < .05). Item 9 asked the subjects to what degree they found the tone to be helpful. There were no significant main effects in the ANOVA for this item, but a subsequent contrast found that subjects in the success-failure group perceived the tone to be significantly more helpful than did subjects in the other two groups combined (t = 2.44, df = 8, p < .05).

There were no significant group effects in the ANOVAs on items pertaining to the task and EMG training phase of the experiment.

DISCUSSION

To summarize the main results. (1) During pretreatment on the fictitious blood-vessel control task, both the group given false success-failure feedback and the group given consistent false-failure feedback showed somewhat elevated EMG levels relative to the other groups. (2) When subsequently provided with true feedback for EMG level reduction, these two groups did not differ from one another, whereas the group given prior actual temperature training along with feedback to convey failure acquired lower levels. (3) By contrast, on the cognitive (anagram) task, interpolated between pretreatment and EMG training, the contingent failure group showed significantly impaired performance on one of three dependent measures. (4) On the postexperiment questionnaire, self-reports regarding pretreatment were somewhat consistent with the manipulations. Relative to the groups that received continuous failure feedback, success-failure subjects reported relatively greater control during the task and that the feedback was somewhat more helpful.

The implications of the pretreatment phase are mixed. The considerable elevation of EMG levels in the two groups pretreated with the false feedback tapes and related instructions is suggestive that "failure" at the task was disturbing. However, a similar pattern was not obtained in the group that experienced actual failure in the temperature task. Owing to the differences in the nature of the feedback signals in these groups, it is not clear just what is the basis for the disparity in pretreatment EMG levels. However, since all groups received failure pretreatments, the disparity does not appear to be in failure at the task itself. On the other hand, theoretically, the differences among these groups in this phase are not relevant to either the Seligman (1975) or Wortman and Brehm (1975) theories that were the bases for this research. That is, neither model is specifically concerned
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with the behavioral effects of uncontrollable reinforcers at the time of exposure, but rather following exposure.

Following pretreatment, the obtained pattern of results agrees, in some limited respects, with previous research in this laboratory and with predictions derived from the reactance theory of motivation (Brehm, 1966). The facilitated EMG performance of the group given prior failure training on the temperature task could be analogous to the reactance phenomenon observed in a variety of other experimental settings (cf. Wortman & Brehm, 1975) and in this laboratory, as cited earlier (Carlson & Feld, 1981). However, in our previous research, the effect was also observed in a group that received false feedback during pretreatment. Possibly, the contingent failure training in the present study made the task more believable, thereby optimizing the effect. Also, verbal statements at the end of each session in our previous study may have heightened the credibility of false task failure and its effects (see Carlson & Feld, 1981, footnote 4).

More important, however, contrary to predictions from the reactance concept, the group that received success feedback prior to failure feedback did not demonstrate enhanced reactance. That is, these subjects should have begun failure training with a perception of control induced by their success training. In fact, these subjects did report significantly greater perceived control on the pretreatment task than did the failure-pretreated subjects. Moreover, as noted earlier, the success-failure group displayed substantially elevated EMG levels, corresponding to their exposure to the false-failure feedback. In short, there were signs that the success-failure pretreatment itself had effects, but there was no apparent enhancement of reactance in the subsequent tasks, as expected from reactance theory. (On the other hand, the absence of performance decrements on the test tasks in this group may be attributable to the rather brief failure pretraining, an outcome consistent with either the Seligman, 1975, or the Wortman & Brehm, 1975, model.)

Also inconsistent with reactance theory, performance of the contingent failure group on the interpolated anagram task was apparently disrupted to a small extent. This effect, if replicable, resembles the results of various “learned helplessness” manipulations in a number of earlier uses of the same

Footnote: The recent analysis of helplessness effects by Kuhl (1981) was also considered for its implications for these data. Kuhl suggests that whether subjects assume a “state orientation” or an “action orientation” will determine whether performance decrements or increments respectively, will result from exposure to uncontrollable outcomes. In the present study, since we cannot say which orientation the subjects may have assumed, Kuhl’s analysis cannot be readily applied. Moreover, the apparently disparate results of the cognitive and biofeedback tasks do not seem to be addressed directly by Kuhl’s approach.
anagram problem (e.g., Gatchel et al., 1977). However, since the effect is opposite to that obtained in the biofeedback task with this group, some further attempt at explanation is demanded.

In one recent account, in a paper that appeared following the first report of some of the present results (Cassisi, 1981), Traub and May (1983) proposed that apparent facilitation of EMG performance as well as a decrement in cognitive performance in tasks such as the present one may be different manifestations of a single phenomenon, learned helplessness. At the basis of their analysis, the two different tasks, cognitive processing and autonomic control through biofeedback, differ in the degree to which "active striving" plays a role. In the former, successful performance is related to striving, whereas some theorists have argued that autonomic control is best attained through "passive attention" and a "letting go" of active attempts to control. Accordingly, in one study, Traub and May replicated the Carlson and Feld (1981) demonstration of enhanced EMG performance through biofeedback following false-failure pretreatment. In a second study, however, they found a decrement in an arithmetic task following prior failure training in the temperature biofeedback task. The authors conclude that "while learned helplessness interferes with cognitive performance, it actually facilitates performance at a biofeedback relaxation task...[in which] doing well...is facilitated by giving up" (Traub & May, 1983, p. 484).

To apply this analysis to the present study, the appearance of both anagram task disruption and improved EMG performance in the same subjects, following contingent failure pretreatment, may thus reflect different effects of learned helplessness, depending upon just how "successful performance" is defined. This analysis renders unnecessary the reactance interpretation of performance enhancement in the biofeedback setting due to prior uncontrollable outcomes. Further research should take into account the specific nature of the task in evaluating potential effects of learned helplessness treatment.

REFERENCES

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