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Perceived control of aversive stimulation and the reduction of stress responses[1]

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Recent experimentation has demonstrated that if subjects believe they have control over the onset or offset of aversive stimuli, deleterious aftereffects of stress arousal are reduced (e.g., Glass & Singer, 1972). In one of these studies, subjects received a series of 18 electric shocks while they were attempting to solve graphic puzzles. They had all been told that successful solution of each puzzle would prevent the next scheduled shock. However, half of the cases worked on primarily soluble puzzles, whereas the other half were given insoluble puzzles. In fact, all subjects received the same number of shocks, but simply believing that negative reinforcement had been avoided led to expected differences in post-shock task performance. Subjects who perceived control (i.e., thought they had avoided some of the shocks) showed shorter reading times on a response competition task (i.e., the Stroop Color Word Test) and fewer errors on a proofreading test than subjects who did not have this perception.

Using somewhat different experimental paradigms, other investigators have shown that autonomic indices of stress are also reduced if subjects perceived control over aversive stimulation (e.g., Haggard, 1946; Staub, Tursky & Schwartz, 1971). In a study similar to the one just reported, Geer, Davison and Gatchel (1970) found that subjects who believed they had control over successive electric shocks produced lower skin conductance responses to shock onset than subjects who did not feel they had control. College student volunteers were given 10 trials in which they had

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to press a reaction time switch as soon as they felt an electric shock. The shock lasted 6 seconds and was always preceded by a 10-second warning signal. In a second part of the study, half the subjects (Perceived Control) were told shock duration would be reduced to 3 seconds if their reaction times attained a certain speed. The other half of the subjects were also told that shocks would be shortened, but nothing was said about its being contingent on speed of reaction time (No Perceived Control). Geer et al. report that skin conductance responses to shock during the second part of the study were smaller among perceived control than no perceived control subjects. In short, the perception of control through instrumental responding, even though not veridical, reduced autonomic reactivity during the aversive trials themselves. This finding provides a nice parallel to the Glass and Singer result of reduced stress response following aversive stimulation.

The magnitude of skin conductance responses during shock were not affected by perceived controllability in the Glass and Singer experiment. However, this lack of effect was to be expected since subjects in both control and no control conditions had been given to understand that they would be able to avoid some of the shocks. This perception effectively eliminated differential skin conductance responses to initial shocks, and all subjects had habituated to shock by the time the nonperceived control subjects realized they were unable to avoid negative reinforcement. The paradigm used by Geer and his associates avoids this problem by telling only the perceived control group that instrumental responding will reduce shock. The nonperceived control group simply receives less shock without being led to believe in a contingency between performance and amount of shock. Under these conditions, GSR differences are observed. It would be interesting to investigate autonomic effects and performance aftereffects within a single paradigm such as the one used by Geer and his associates. The present paper reports an experiment designed to implement this recommendation.

A second purpose of the experiment was to determine whether *mere* perception of control alters stress responses and post-stress aftereffects. It might be argued that the skin conductance effects reported by Geer resulted from joint impact of perceived control and actual reduction in shock duration. Suppose, however, that a condition was added in which perception of control was not reinforced by a subsequent decrement in shock duration. Subjects in this condition would either see themselves as responsible for their failure to reduce shock, or they might attribute blame for their plight to the experimenter. In each case we would expect stronger reactions to the shocks. On the other hand, perception of control, even without actual stress reduction, might reduce rather than increase stress reactions. Cognitive factors have, after all, been shown to ameliorate stress arousal and its consequences (e.g., Zimbardo, 1969). The conditions needed to explore these questions have been included in the experiment described below.

To give an overview of the study, subjects were told to react to the onset of a 6-second shock by pressing a reaction time button. Following 10 trials, half the subjects were told that faster reaction time during the next set of trials would reduce shock duration to 3 seconds (Perceived Control condition). The other half of the subjects were not informed of a contingency between their reaction times and shock duration (No Perceived Control condition). Within each of these conditions, half of the subjects received 3-second shocks during the second part of the experiment (Reduction condition), whereas the remaining subjects received 6-second shocks as in the first part of the experiment (No Reduction condition). The principal dependent variables were (1) a stress aftereffect measure (Stroop Color Word Test), (2) phasic skin conductance responses to shock onset, and (3) subjective indices of pain. It was expected that autonomic responding to the second series of shocks, adverse aftereffects, and pain ratings of the shocks would all be least in Perceived Control–Reduction and greatest in the two No Perceived Control conditions. As suggested above, there were no firm expectations for the Perceived Control–No Reduction condition.

Method

Subjects

Subjects were 48 undergraduate men recruited from the subject pool at New York University, and randomly assigned to one of the four conditions in the 2 × 2 design. Five additional subjects were actually recruited, but two disqualified themselves because they had been told about the experiment in detail by a previous subject, and three had visual disorders (i.e., color-blindness) which made it impossible to administer the Stroop Color Word Test. Inclusion of other data obtained from these latter subjects (e.g., skin conductance) would not have appreciably altered any of the results.

Apparatus

Electric shock was delivered through a disk electrode attached to the ankle of the subject's nonpreferred leg (Tursky, Watson & O'Connell, 1964). The circular pads used with the electrode were soaked in saline, but paste was not applied prior to electrode placement. The shock source was a Scientific Prototype AC-DC Isolated Shock Source (Model SS13) set in the AC mode. An ammeter attached to this instrument allowed us to monitor the amount of shock (in milliamps) delivered on each trial. The ready signal and reaction-time apparatus were locally constructed, and a specially prepared tape programmer controlled stimulus durations (both ready signals and shocks) and intertrial intervals. A Monsanto Electronic Counter Timer was used to record reaction times.

Palmar skin resistance was recorded on a Beckman Type R dynograph with a Type 9892A GSR coupler. A current of approximately 15 microamperes was imposed through the active electrode. Beckman biopotential electrodes and electrode paste were placed on the volar surface of the proximal phalanges of the first and third fingers of the subject's nonpreferred hand. A ground electrode was placed on the wrist of the same arm. These procedures were similar to those used by Geer, Davison and Gatchel (1970).

Physiological Data Processing

The dynograph recorded skin resistance, but the dependent measures actually employed in data analysis followed the method used by Geer. For phasic skin conductance (SC) changes (conductance was obtained by taking the reciprocal of resistance), we measured the log (base 10) of the change in conductance that began between 0.5 and 3.0 seconds after shock onset. The formula was the log of $[(SC_2 - SC_1) \times 10^9] + 1.0$, where SC_1 was skin conductance at the onset of shock, and SC_2 was the skin conductance at the point of maximal deflection. Measurements were also made of spontaneous skin resistance fluctuations. Such fluctuation was defined as a measurable decrease in skin resistance of over 500 ohms that occurred at a time other than when experimental stimulation (light or shock) was being administered.

Procedure

Subjects were tested individually. Upon arrival at the research facility, Experimenter 1 (DK) greeted the subject and escorted him to

the experimental room.[2] The subject was seated in a lounge chair, attached to the front of which was a reaction-time (RT) signal light and button. The experimenter proceeded to explain that the study was concerned with RT and physiological responses to electric shock. After attaching the shock electrode and SC leads, the subject was told that "because people vary in their sensitivity to electric shock, we must determine your own sensitivity at the beginning of the experiment . . ." Sensation threshold, discomfort threshold, and pain threshold were then obtained in essentially the same manner as reported in the Geer et al. (1970) experiment. Experimenter 1 went into the observation facility where the shock source was located. All communication between experimenter and subject during threshold determinations was conducted via a two-way intercom system. The experimenter increased shock level continuously from well below detection level until the subject first reported sensation. The milliamperage for that level was noted on the ammeter and recorded. The shock level continued to be increased until the subject reported discomfort. That level was noted and recorded, and the experimenter increased shock still further until the subject reported pain. The milliamperage associated with pain was recorded, and the shock turned off. The entire procedure was repeated four more times.

Following the threshold procedures, Experimenter 2 (HSL) entered the experimental room and told the subject that "the shock level to be used in the experiment will be at a level slightly lower than what you just indicated as painful." He then gave instructions which were a very slight modification of those used in the Geer experiment. They are as follows:

> Let me briefly describe what your task will be in Part 1 of the experiment. On the box in front of you, a light will appear which will be a signal for you to place your finger on the [reaction time] button. Your task will be to press the button, as fast as possible, as soon as you feel the shock. This shock will last 6 seconds. I urge you to react as quickly as possible since we are interested in the speed of your reaction time under shock conditions. However, your speed of reaction will in no way determine the duration of shock. It will always be 6 seconds. There will be a total of 10 trials. Are there any questions? The experiment will actually begin in 15 minutes.

When these instructions were complete, the subject was given a 1-second sample of the shock level that was to be used throughout the experiment. It was the second highest milliamperage the sub-

2. Experimenter 2 was not aware of the subject's group assignment.

ject had rated as painful during the 5 threshold determinations. Experimenter 2 then told the subject to "relax for about 15 minutes" and left the room. The ensuing rest period was used to allow the subject to adapt to the experimental conditions, and to record a skin conductance resting level—the last 3 minutes of the 15-minute period.

After the rest period, Experimenter 2 reentered the experimental room and told the subject: "We are ready to begin. Remember, when the signal light appears on the box in front of you, place your finger on the button. As soon as you feel the shock, press the button as quickly as possible." Next, the experimenter returned to the observation facility and activated the programmer which began Part I of the experiment. The signal light for each trial was on for 10 seconds, and its termination was virtually contiguous with onset of the 6 seconds of shock. Ten trials were given with a 30-second intertrial interval.

Following completion of Part I, Experimenter 2 returned to the experimental room and gave instructions designed to manipulate perceived control. These instructions were taken almost verbatim from Geer et al. (1970).

No Perceived Control–Reduction condition. In this condition, Experimenter 2 said the following:

> Part II of the experiment will be almost exactly the same as Part I. The only difference will be that shock duration will be decreased in length from 6 seconds to 3 seconds. Thus, follow the same procedure as you have been following, and again please react as quickly as possible. There will be 10 trials.

Perceived Control–Reduction condition. In this condition, the following alternate instructions were given:

> Part II of the experiment will be essentially the same as Part I. The only difference will be that now, if your speed of reaction is as fast or faster than the average of your reaction times in Part I, shock duration will be decreased in length from 6 seconds to 3 seconds. Thus, if you can react quickly enough, you can significantly cut down the duration of shock you receive on each trial. Of course, if you fail to react quickly enough, you will receive the same shock duration as in Part I. The timer in the next room is recording your reaction times, and it is capable of measuring times as low as a thousandth of a second. So, even a slight decrease in reaction time will cut down the duration of shock you will receive. Again, there will be 10 trials.

No Reduction treatment. It should be emphasized that in Part II, both of the reduction groups received 3 seconds of shock regardless of the speed of a subject's RT. By contrast, subjects assigned to no reduction conditions received 6 seconds of shock on each trial in both Parts I and II. The Perceived Control–No Reduction subjects were given Perceived Control instructions as described above, but shock duration was not altered in any way. The No Perceived Control–No Reduction group also received 6 seconds of shock in Part II, but they had been told: "Part II of the experiment will be exactly the same as Part I. Shock duration will always be 6 seconds. Thus, follow the same procedure as you have been following, and again, please react as quickly as possible. There will be 10 trials."

Following appropriate instructions, Experimenter 2 returned to the observation facility and activated the programmer which began the second series of RTs and shocks. Throughout Parts I and II, SC was monitored continuously by Experimenter 2, and RTs were recorded for each of the 20 trials by Experimenter 1. At the completion of Part II, the first experimenter (still blind to the subject's group assignment) reentered the experimental room and told all subjects the following: "The experiment is about over. However, now that you have been through the series of shocks, we have to see if your sensitivity has changed. To do this, we are going to run through the gradually increasing shock series just as we did at the beginning of the experiment . . ." At this point, the experimenter reminded the subject of the procedure, and returned to the observation room to carry out the second determination of sensation threshold, discomfort threshold, and pain threshold.

Postsession measures. Immediately after the threshold determinations, Experimenter 2 returned to the experimental room, removed all electrodes from the subject, and then administered the Stroop Color Word Test (cf. Jensen & Rohwer, 1966). The rationale given to the subject was that stress sometimes affects color vision and the Stroop test was designed to assess his present ability to discriminate colors.

The Stroop was selected as our principal measure of stress aftereffects because we used it with some success in previous research (e.g., Glass & Singer, 1972), and because it presumably requires an alert organism capable of resolving competition between opposing response tendencies. An individual who has been exposed to uncontrollable electric shock is not likely to fulfill these requirements, and we therefore expected him to have difficulty in naming the colors of the word, a difficulty that would be manifest in longer reading times.

The version of the Color Word Test used in this study required the subject to read aloud the names of four colors (green, red, orange, and blue), each of which was printed in incongruent color names. For example, if the word "red" was printed in blue ink, the subject was to read "blue." The four color words were repeated randomly for a total of 110 color names. Two other reading tasks preceded the critical color naming task, which was designated Part III. Part I consisted of a single page of color names printed in black, and Part II was composed of a page of 86 sets of 5 colored asterisks. Each set was printed in one of the same four colors used in Part III. The experimenter timed each subject's performance on all three parts of the test, though only Parts II and III are used in computing a final test score (see results section below). Since subjects were told to correct themselves, errors were sufficiently infrequent to make an error score meaningless.

Upon completion of the Color Word Test, the subject was asked to fill out a short postexperimental questionnaire. Following this, the subject was escorted to an adjacent room where he was given a thorough postexperimental interview and debriefing.

Results

Effectiveness of the Experimental Manipulations

There is reason to believe that we induced in Perceived Control subjects the belief that they were responsible for altering the length of the shocks administered during the second part of the experiment. We were partially successful in inducing feelings of potential control in those subjects assigned to the Perceived Control–No Reduction condition. Evidence for these conclusions comes from several sources, including a postexperimental rating of control, mean RTs calculated for Parts I and II of the experiment, and mean sensation threshold data collected at the beginning and end of the study. Table 1 reports the average ratings made by subjects to the following item in the postexperimental questionnaire: "How much control did you feel you had over the duration of the shock you received during Part II of the experiment?" where 6 = "complete control" and 1 = "no control." It is obvious from an examination of Table 1 that Perceived Control subjects felt they had more control over shock duration than No Perceived

Table 1. Mean ratings of perceived control.

	Reduction	No reduction
Perceived control	4.33	1.25
No perceived control	1.83	1.08

Control subjects ($F = 51.72$, $1/44$ df, $p < .01$), and that the No Reduction manipulation appreciably reduced this effect [F (interaction) $= 19.16$, $1/44$ df, $p < .01$; F (Reduction vs. No Reduction) $= 25.03$, $1/44$ df, $p < .01$]. Relative to the mean for No Perceived Control–Reduction (1.83), the somewhat lower mean for Perceived Control–No Reduction (1.25) probably reflects the disappointment of subjects who eventually realized they were unable to reduce shock through instrumental responding.

Additional data assessing the effectiveness of the Perceived Control manipulation comes from an analysis of reaction-time results. Table 2 contains mean RTs calculated for Parts I and II.[3]

Table 2. Mean reaction time (in seconds).

Experimental group	Section of experiment: Pt. I	Pt. II
Perceived control–reduction	.283	.206
No perceived control–reduction	.238	.227
Perceived control–no reduction	.275	.212
No perceived control–no reduction	.226	.224

A 2×2 repeated-measures analysis of variance yielded a significant Trials effect ($F = 7.10$, $1/43$ df, $p < .025$), and a significant Perceived Control × Trials interaction ($F = 4.91$, $1/43$ df, $p < .05$). All subjects reduced their RTs in Part II, but the magnitude of the reduction was greater for the Perceived Control treatment than for the No Perceived Control treatment.[4] Following Geer who also obtained a reliable interaction effect, we interpret the result as suggesting that "perceived control subjects reacted more quickly in Part II because . . . they believed that faster RTs would pay off in shorter shocks" (Geer et al., 1970).

It is somewhat surprising that RTs also decreased in the Perceived Control–No Reduction condition, for these subjects did not experience an actual reduction in shock duration. However, they

3. Apparatus failure reduced usable RT scores from 48 to 47.

4. The mean RT for Part I in Perceived Control conditions was marginally greater ($p = .10$) than the corresponding mean in No Perceived Control conditions. In order to check on this possible artifact in the significant Perceived Control × Trials interaction, we computed RT difference scores between Parts I and II of the experiment. These scores were then subjected to analysis of covariance, where the covariate was the RT scores for Part I. There was the expected main effect for the Perceived Control variable ($F = 14.00$, $1/43$ df, $p < .01$), which would seem to eliminate an artifactual interpretation of the interaction effect.

did expect to receive such reduction and their faster RTs in Part II probably reflect a repeated effort to attain speeds that would presumably shorten individual shocks. There is no doubt that No Reduction subjects recognized that they were receiving 6-second shocks in both Parts I and II. The postexperimental questionnaire asked, "How long do you estimate the durations of the shocks in Part I? In Part II?" The means for the No Reduction treatment were 6.3 seconds and 6.3 seconds, respectively. For the Reduction conditions, the respective means for Parts I and II were 6.4 and 3.4.

Other data relevant to the impact of perceived control are the mean sensation thresholds following the entire experiment, as compared to preexperimental scores. Table 3 presents these data,

Table 3. Mean sensation threshold (in milliamps).

Experimental group	Time of data collection: Before experiment	Time of data collection: After experiment
Perceived control–reduction	.75[a]	.98
No perceived control–reduction	.68	1.33
Perceived control–no reduction	.89	1.47
No perceived control–no reduction	.86	1.37

[a]The numbers represent the minimum amount of shock detected. The higher the number, the greater the intensity of the least detectable shock.

and analysis of variance revealed a significant Reduction effect ($F = 4.32$, $1/44$ df, $p < .05$). It would appear that No Reduction subjects "sensed" shock later than Reduction subjects in both preshock and postshock threshold tests. Separate analyses of each column of data in Table 3 showed that this effect was significant for the second column ($F = 4.15$, $1/44$ df, $p < .05$), but not for the first ($F = 2.46$, $1/44$ df, $p > .10$). Moreover, the main sources of the effect were between the mean for Perceived Control–Reduction and the means for the other three conditions. Lower sensation thresholds following the experiment may reflect the perception of Perceived Control–Reduction subjects that they would be rewarded by early detection of shock. That is, if they noticed when shock was beginning, they could quickly react with a button press and reduce duration of painful stimulation.

To sum up, the Perceived Control manipulation appears to have induced a nonveridical belief in a contingency between RT

performance and shock duration. However, the evidence does not necessarily support the conclusion that Perceived Control subjects experienced control over shock. Indeed, the self-rating and sensation-threshold results suggest that both the Perceived Control and Reduction variables contributed to the induction of feelings of control.

Behavioral Aftereffects of Controllable and Uncontrollable Shock

It was expected that Perceived Control subjects would experience less stress from the electric shocks and, therefore, would show less adverse behavioral aftereffects. Specifically, it was predicted that Perceived Control subjects would have less difficulty in coping with the Stroop Color Word Test—our principal aftereffect measure—than No Perceived Control subjects. A customary procedure for scoring the test (cf. Jensen & Rohwer, 1966) is to subtract the reading time for Part II (color word naming) from the reading time for Part III (color naming). A more reliable version of this scoring procedure is to conduct an analysis of covariance on Part III reading times using Part II speeds as the covariate. Accordingly, we analyzed Stroop data by covariance methods, and the resulting adjusted means are presented in Table 4. The analysis itself yielded a significant effect due to the

Table 4. Mean adjusted reading times (in seconds) on the Stroop Color Word Test.

	Reduction	No reduction
Perceived control	96.95	104.74
No perceived control	111.58	108.79

Perceived Control factor ($F = 7.30$, $1/43$ df, $p < .01$). Subsequent comparisons by the Duncan Multiple Range Test showed that the main sources of this effect were (a) the significant differences between Perceived Control and No Perceived Control under the Reduction treatment ($p < .01$), and (b) the difference between Perceived Control–Reduction and Perceived Control–No Reduction ($p < .05$). All other comparisons failed to reach acceptable levels of statistical significance. It would appear that the belief that one is reducing shock ameliorates negative aftereffects of shock-induced stress. In previous work with noise as a stressor, the subject never tested that perception; his belief in control was sufficient to reduce negative aftereffects (Glass & Singer, 1972, ch. 5). However, the present experiment makes it clear that if this perception is tested, the belief alone is not sufficient to reduce stress aftereffects.

Subjective Reactions to Controllable and Uncontrollable Shock

Following Geer et al. (1970), we also examined the hypothesis that Perceived Control subjects would find shocks in Part II of the experiment less painful than No Perceived Control subjects. Two sets of data were analyzed. The first was subjects' postsession ratings of the intensity of the shocks they received in each part of the experiment. These ratings were made on 6-point scales ranging from "not at all painful" (1) to "extremely painful" (6). Table 5 contains the means of these ratings. A 2×2 repeated-measures analysis of variance of these data revealed a significant Trials effect ($F = 8.38$, 1/44 *df*, $p < .01$), which reflects the general decrement in rated painfulness from Part I to Part II of the study. Though we did not obtain a significant Trials $\times$ Perceived Control interaction ($F < 1$), there was a reliable interaction between Perceived Control and Reduction ($F = 4.59$, 1/44 *df*, $p < .05$). Subsequent analyses indicated that this was produced, in the main, by the fact that Perceived Control–Reduction was lower than the other three conditions at .10 level and beyond. Since pain ratings were retrospective, it is not surprising that Perceived Control–Reduction subjects failed to differentiate between painfulness of the shocks given in the two parts of the study. That these subjects rated both series of shocks as less painful is consistent with the notion that effective perceived control ameliorates shock-based stress effects.

Table 5. Mean ratings of the painfulness of the shocks.

	Section of experiment	
Experimental group	Pt. I	Pt. II
Perceived control–reduction	3.67	3.08
No perceived control–reduction	4.25	4.17
Perceived control–no reduction	4.50	3.92
No perceived control–no reduction	4.17	3.75

The other data for testing differences in subjective reactions to shock comes from the threshold test given prior to Part I and immediately following Part II of the experiment. As in the Geer study, changes in pain thresholds from preshock to postshock were not appreciably different in the various experimental groups. All conditions showed a significant increase in postshock pain thresholds ($F = 96.42$, 1/44 *df*, $p < .01$), but there was no evidence of a greater shift for Perceived Control subjects. An almost identical pattern of results was obtained for discomfort thresholds. It would appear that, unlike the pain ratings, perceived control exerted minimal impact on tolerance for electric shock—yet another type of subjective response to stress.

Autonomic Reactions to Controllable and Uncontrollable Shock

It was expected that autonomic responding to shock in Part I of the experiment (during which all subjects believed they could not control shock duration) would habituate to an equivalent degree in all four conditions. This effect was observed in the Geer experiment, and our own prior research also reported adaptation effects with electric shock (Glass & Singer, 1972). The relevant data are the mean log change in conductance scores for Part I of the study. Contrary to expectations, these data revealed that autonomic adaptation did not occur in any condition. Analysis of variance failed to yield a significant Trials effect over the first 10 shocks ($F < 1$). There was a reliable Trials $\times$ Reduction interaction ($F = 3.37$, 4/176 *df*, $p < .05$), which disappeared when SC reactivity scores to the first two shocks were eliminated from a subsequent analysis ($F = 2.00$, 3/132 *df*, $p > .10$). The No Reduction subjects (particularly in the No Perceived Control condition) responded more strongly to initial shock than did Reduction subjects, and this difference produced a greater decline in reactivity over 10 trials in the No Reduction group. It would appear that the interaction effect was primarily due to initial differences in SC response.

Of more direct interest was the prediction that phasic SC responses in Part II of the experiment (during which Perceived Control subjects—at least in the Reduction condition—believed they were shortening the shocks) would be reduced for those subjects, but not for No Perceived Control–Reduction subjects. This finding was reported in the Geer et al. (1970) paper. The relevant results from the present study did not show the anticipated effect. There was no divergence in the directions of the mean log change in conductance scores for Part II; phasic SC to individual shocks did not diminish more rapidly for Perceived Control subjects than for No Perceived Control subjects. Indeed, there is no evidence of decrements in SC in any of the four conditions. Analysis of variance failed to reveal a reliable Trials effect or Trials × Condition(s) interactions. It would appear, then, that perceived control and shock reduction had no effect on SC reactivity to aversive stimulation. Subsequent internal analyses (e.g., dividing subjects into groups according shock intensity or rated painfulness of the shocks) confirmed this conclusion. In each of these analyses, we did not obtain evidence of overall SC adaptation in Part I or differential adaptation in Part II.

It was also expected that Perceived Control subjects would experience Part II of the study as less generally arousing than No Perceived Control subjects. A test of this hypothesis was made by analyzing spontaneous SC fluctuations during Parts I and II, a procedure which Geer had used successfully. Analysis of variance of the total number of fluctuations for the 4 experimental conditions failed to reveal significant treatment terms or interactions ($ps > .20$). The only significant effect was a decline in fluctuations from Part I to Part II ($F = 51.40$, $1/44$ df, $p < .01$). We conclude, therefore, that Perceived Control and No Perceived Control subjects were equally aroused in both Reduction and No Reduction treatments.

Discussion

The results of this experiment show that nonveridical perceived control, when effective, reduces adverse aftereffects of shock-induced stress. The results also suggest that shock is experienced as less painful when the individual believes he has control over its duration, though this conclusion must be regarded with caution in view of the null interaction on the pain threshold test. We may also conclude that perceived control ameliorates stress aftereffects and subjective reactions to stress only under conditions where there is an actual reduction in shock duration. One is immediately reminded of recent work on coping responses in rats (e.g., Weiss, 1971), which showed that severe gastric ulceration developed when animals were given negative reinforcement each time they performed an escape or avoidance response. It would appear that negative feedback from the environment—shock in the rat study and unreduced shock in the present experiment—increases the likelihood of undiminished stress response, even where there is seeming opportunity to control aversive stimulation. Subjects are protected from stress not only by the ability to alter aversive stimuli, but also by the perception that control is effective.

The Stroop data confirm earlier research showing greater adverse aftereffects following uncontrollable as compared to controllable aversive events (Glass & Singer, 1972). These aftereffects can be viewed as an instance of the "delayed reaction" observed in field studies of psychological stress (e.g., Basowitz et al., 1955; Grinker & Spiegel, 1945). Korchin (1965, p. 260) has suggested, in this connection, that "this [i.e., the delayed reaction] might represent a release phenomenon from the control of feelings and associated stress behaviors which had been necessary for adaptive behavior . . ." during stress exposure. In other words, stress aftereffects, like impaired Stroop performance, may represent behavioral residues of cumulative stress which appear after the need to maintain effective functioning is no longer required.

But, why should the magnitude of these aftereffects be less where subjects believe they have shortened the duration of shock than where they believe they could not do anything about alleviating stressful stimulation? Though interpretable as other than a performance decrement, our preferred explanation of the aftereffect phenomenon is as follows. Exposure to uncontrollable shock produced feelings of helplessness which interfered with later functioning (Seligman, Maier & Solomon, 1971; Glass & Singer, 1972). Perceived Control subjects—at least those who effectively reduced shock—learned to label the situation as one in which they were not helpless. By contrast, No Perceived Control subjects did not develop such expectations. Subsequent performance on the stressful color naming task was therefore affected in a way that was consistent with prior experience, when control was or was not available. The No Perceived control subjects were less able to cope with the after task than subjects who had previous success in controlling stressful stimulation. The pain rating results also fit this interpretation. Subjects who felt they were able to control the shocks recalled them as less painful than subjects who did not have this perception. To quote Geer et al. (1970, p. 737), ". . . human beings tend to find less stressful those aversive situations over which they at least believe they have some degree of control."

Do we in fact have evidence that "Perceived Control subjects responded to shocks as though they were less stressful? There are, of course, the pain ratings, but these were retrospective self-reports given at the end of the experiment. The only measures of reactivity during shock were phasic SC and spontaneous SC fluctuations. Unlike the behavioral results, perceived control had no effect on either of these variables. Indeed, nothing we did to the subjects appeared to alter their physiological responses to stress, and we were even unable to detect habituation to shock over the course of the 10 trials in Part I of the study. Contrary to expectations, then, there was a clear dissociation between autonomic activity, on the one hand, and behavioral and self-report effects, on the other.

We have speculated among ourselves on possible reasons for this behavioral-physiological dissociation (cf. Lacey, 1967). In the absence of systematic evidence for one or another viewpoint, we are not inclined to present the various alternatives at this time. There is one possibility worth considering, however. The average number of spontaneous SC fluctuations for Part II of the study in the Perceived Control treatment was higher in our study (165.5) than in Geer's (152.0), despite the fact that we used a 500 ohm criterion and he used a 200 ohm criterion. Assuming this differential in spontaneous SC implies our subjects were more "anxious,"[5] it might be argued that anxiety arousal somehow inhibited the effects of perceived control on phasic SC responses to the shocks in Part II. The same reasoning might account for our failure to observe adaptation of SC during Part I of the study. For the average number of spontaneous fluctuations in Part I was 286.5 in this study and only 197.0 in Geer's.[6] Prior research has shown that high levels of arousal can interfere with adaptation to aversive events, and also impair the ameliorative effects of cognitive factors surrounding the stressor (cf. Cofer & Appley, 1964, ch. 9; Lazarus, 1968). The principal difficulty with this interpretation is that all of our subjects showed a decline in spontaneous fluctuations over the course of the study. Such an effect would imply lower rather than higher arousal. On the other hand, the overall level of spontaneous SC was greater in our study than in Geer's, which leads to the suggestion that our Perceived Control subjects were in fact more aroused.

But, if differential arousal interferes with the effects of perceived control upon stress reactions, why did the expected results appear for both pain ratings and adverse behavioral aftereffects? Perceived control had a positive impact on both variables, despite the presumed high level of arousal among these subjects. We can only surmise that autonomic arousal has effects specific to phasic responding, and that it has minimal influence on the consequences of subject's perceptions of their circumstances as helpless or not helpless (cf. Shapiro & Crider, 1969). Given the former label, we may expect heightened stress and, consequently, more severe aftereffects. By contrast, if subjects label the situation as one over which they have some control, we may expect them to find the shocks less painful and to show less severe aftereffects. Level of arousal, in other words, had little to do in this study with behavioral consequences of stress exposure. Its impact was confined to physiological reactions to stress.

We cannot, however, explain why arousal has limited effects. Perhaps it has to do with an inverse relationship between spontaneous SC and magnitude of phasic response, but for the present, this hypothesis must remain in the realm of speculation. Unlike Geer's experiment, our study simply did not show a decrement in phasic SC as a function of nonveridical perceived control. And, we have also been unable to discover a corresponding change in level of arousal as measured by spontaneous SC fluctuations.

The present experiment may, nonetheless, be fruitfully placed in the general context of work on controllable and uncontrollable aversive events. Positive findings with respect to adverse after-

5. We recognize the confusion that exists among psychophysiologists regarding various autonomic measures of anxiety arousal (Martin, 1961). However, we use spontaneous SC fluctuations as index of arousal in the present discussion, since it has been used with some success for this purpose in previous research (e.g., Geer, 1968; Geer et al., 1970).

6. Spontaneous SC fluctuations for Part I in nonperceived control conditions were also higher in this study than in Geer's (248 vs. 198). However, the reverse occurred in Part II, with Geer's paper reporting 210 fluctuations and our data showing 128. This reversal does not detract from the line of argument presented above, for lower arousal in Part II of the No Perceived Control treatment should have, if anything, facilitated adaptation of phasic responses to shock. This effect did not in fact occur.

effects (i.e., the Stroop scores) and the pain ratings are consistent with the helplessness hypothesis proposed in earlier research on animals (e.g., Seligman, Maier & Solomon, 1971) and humans (Glass & Singer, 1972). These results also highlight the importance of positive reinforcement (e.g., shock reduction) following the exercise of control. For in the present experiment, only perceived control followed by shock reduction ameliorated stress effects. The fact that our principal findings were in the form of aftereffects takes on added significance when compared with research on analogues of urban stress (e.g., Glass & Singer, 1972). We reached the conclusion in this earlier work that stressors such as noise, shock, and bureaucratic frustration have disruptive aftereffects which depend on the cognitive circumstances in which stressful stimulation occurs. Sheer magnitude or intensity of stimulation is less important than contextual variables such as the belief that one has little control over stimulus occurrence. The current experiment provides additional support for this conclusion. Stress aftereffects are very much a function of antecedent cognitive states, and the perception of effective control appears to be among the more potent of these mediators.

Summary

In a replication of earlier research, subjects were told to react to the onset of a 6-second shock by pressing a reaction time button. Following 10 trials, half of the subjects were told that faster reaction time during the next 10 trials would reduce shock duration to 3 seconds (Perceived Control). The other half were simply informed that the next 10 shocks would each be 3 seconds (No Perceived Control). Within each of these conditions, half the subjects received 3-second shocks (Reduction), whereas remaining subjects continued to receive 6-second shocks (No Reduction). As predicted, subjective ratings of painfulness, and behavioral aftereffects of shock (i.e., Stroop Test performance time) were least in Perceived Control–Reduction and greatest in the two No Perceived Control conditions. Contrary to expectations based on earlier experimentation, autonomic responses to shock were not ameliorated by the Perceived Control variable. An arousal explanation was suggested to account for this null effect. Aftereffect and pain-rating results were discussed in terms of a "helplessness hypothesis."

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