Aftereffects of Stress on Human Performance and Social Behavior: A Review of Research and Theory

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A review of experimental and correlational studies of the aftereffects of stress on performance suggests that these effects occur as a consequence of a wide range of unpredictable, uncontrollable stressors including noise, electric shock, bureaucratic stress, arbitrary discrimination, density, and cold pressor. Moreover, these effects are not limited to a restricted range of stressful situations that involve a lack of predictability and controllability over a distracting stimulus, but they can also be induced by increased task demand. Interventions that increase personal control and/or stressor predictability are effective in reducing poststressor effects. There is also evidence for poststimulation effects on social behavior that generally involve an insensitivity toward others following stressor exposure. Studies of exposure to environmental stressors in naturalistic settings report effects similar to those found in laboratory settings. Several theories (e.g., psychic cost, learned helplessness, arousal) are examined in light of existing evidence. Although some theories receive more support than others, it is suggested that the reliability and the generality of poststimulation effects occur in part because of a multiplicity of causes.

The notion that continued exposure to a stressor may produce effects that appear only after stimulation is terminated has been central to the stress literature for a number of years. This assertion is derived principally from an adaptive-cost hypothesis which suggests that although humans can often adapt to extreme conditions, there are cumulative costs of adaptation. An early form of this hypothesis, which emphasized the biological costs of the adaptive process, was proposed by Selye (1956). He asserted that after prolonged exposure to a stressor, one’s adaptive reserves are drained, resistance breaks down, and exhaustion sets in. Others (Basowitz, Persky, Korchin, & Grinker, 1955; Dubos, 1965; Milgram, 1970; Wohlwill, 1966) make similar points in regard to poststressor effects on behavior. In the words of Dubos, “Although man is highly adaptable and can therefore achieve adjustments to extremely undesirable conditions, such adjustments often have... indirect effects that are deleterious” (1968, p. 139).

The early empirical work on the aftereffects of stress focused on stressor effects on physical and psychological health. For example, there are a number of studies on the cumulative effects of disease, malnutrition, and toxic chemicals on normal bodily functions (see Dubos, 1965). There is also an extensive research literature on the association between subjects’ reports of recent life changes and subsequent changes in somatic and psychological health (cf. Dohrenwend & Dohrenwend, 1974).

It was only recently, however, that the first experimental studies of the postexposure effects of stressors on behavior were reported (Glass & Singer, 1972). The major emphasis
of Glass and Singer's research program was on determining whether the cognitive context of a stressor mediated performance on tasks administered immediately after stressor termination. Based on earlier research which demonstrated that the ability (or perceived ability) to predict or escape an aversive event reduced both the aversive quality of the stimulus (e.g., Corah & Boffa, 1970; Penlin, 1963) and the resultant physiological response (e.g., Champion, 1950; Corah & Boffa, 1970; Sotland & Blumenthal, 1964), they hypothesized that performance following stress exposure may be similarly mediated by stressor predictability and perceived control over stressor termination.

Glass and Singer's (1972) early work was strongly influenced by the adaptive-cost hypothesis. Specifically, they suggested that deleterious effects on performance following exposure to unpredictable, uncontrollable stressors should occur because the substantial effort required to adapt to these aversive events would leave one less able to cope with subsequent demands and frustrations. Since predictable and controllable stressors were viewed as considerably less aversive, adaptation to these stressors would presumably require less effort and therefore would be less likely to impair poststimulation performance. At the completion of their research program, Glass and Singer concluded that exposure to unpredictable, uncontrollable stressors produces poststimulation deficits in performance on a number of tasks and that the ability to predict and/or control the stressor ameliorates these effects. However, they also concluded that the adaptive process is not responsible for these poststress performance deficits.

Since the publication of the Glass and Singer (1972) book there have been over 30 published studies on the poststimulation effects of stressors on performance and social behavior. Moreover, a number of cognitive and motivational explanations for the aftereffects of stress have been offered and in some cases tested. This article reviews the existing laboratory and field research on the aftereffects of stress on performance and interpersonal behavior and outlines a number of possible explanations for these effects. The research review is divided into five major sections. The first section examines studies that have attempted to determine whether there are effects of unpredictable, uncontrollable stress on performance following stressor termination. The second and third sections examine those studies that attempt to ameliorate poststimulation effects by providing subjects with a predictable version of the stressor and/or with control over the stressor. The fourth section describes studies of the poststimulation effects of stress on social behavior, and the fifth section reviews naturalistic studies of stress aftereffects. Finally, the theory review examines each of eight alternative explanations for poststress effects on performance and social behavior in light of existing data and reevaluates the adaptive-cost hypothesis.

Research Review

Aftereffects of Unpredictable and Uncontrollable Stressors

Studies reviewed in this section compare performance after exposure to an unpredictable, uncontrollable stressor with performance in an experimental control condition in which there was either a less intense form of the stressor or no stressor exposure. A number of these studies also included conditions in which the stressor was predictable and/or controllable. These conditions are not discussed here but are presented in later sections.

Noise. Glass and Singer (1972) reported five studies that examined poststimulation effects after exposure to unpredictable, uncontrollable noise (pp. 47, 50, 52, 55, 80). Their studies typically involved approximately 25 minutes of exposure to 108–110-dB (A) random-intermittent bursts of a broadband conglomerate noise made up of a number of fairly typical urban sounds. During noise exposure, the subject worked on simple cognitive tasks. Autonomic response was monitored during stressor exposure. Immediately after the noise exposure period, one or more of three measures were administered to the subject: the Feather (1961) tolerance for frustration task (studies reported in Glass & Singer, 1972, pp. 47, 52, 55), a proofreading
task (Glass & Singer, 1972, pp. 47, 50, 52, 55, 80), and the Stroop (1933) Color-Word task (Glass & Singer, 1972, p. 80).

The Feather measure requires a subject to work on two soluble and two insoluble line puzzles for 15 minutes. The subject can only work on one puzzle at a time and cannot return to a puzzle after moving on to the next. The puzzles are presented so that the first and third are insoluble and the second and fourth are soluble. The criterion measure (amount of tolerance for frustration) is the number of trials—puzzle cards—or amount of time spent on insoluble puzzles. The proofreading task involves correcting misspellings, grammatical mistakes, incorrect punctuation, transpositions, and typographical errors. Each subject is usually given between 8 and 15 minutes (although nothing is said about time), and the quality of performance is measured as the percentage of errors not found of the total number of errors that could have been detected at the point the subject was told to stop. In the Stroop task, task stimuli are the names of four colors (green, red, orange, and blue), each of which is printed in one of the other three colors. For example, the word green may be printed in red, orange, or blue. The four color words are presented randomly over a series of trials, and the subject is asked to name the color in which the word is printed. A control version of the task, in which subjects are required to name the colors of sets of asterisks or zeros, is also administered to each subject. Stroop interference scores (on accuracy and speed) are obtained by subtracting a subject's score on the control stimuli from the subject's Stroop score.

Poststimulation deficits in performance occurred in all five of the studies and on all three of the tasks. Except for a lack of effect on the proofreading task in one study (p 80), the effects were totally reliable. Moreover, Glass and Singer (1972, p. 47; see also, Glass, Singer, & Friedman, 1969, Experiment 1) reported poststimulation effects following exposure to 56-dB random noise as well as to the more intense 108-dB bursts.

There have been a number of successful attempts at replicating the poststimulation effects of unpredictable high-intensity noise on human performance. Thus Rotton, Olczewski, Charleton, and Soler (1978) reported less tolerance for frustration among subjects exposed to 80-dB (A) random-intermittent bursts of conglomerate noise than among subjects working in quiet. Likewise, Gardner (1978) found that subjects exposed to random-intermittent bursts of conglomerate noise at 100 dB (A) provided poorer poststimulation performance on a proofreading task than did subjects not exposed to noise. Percival and Loeb (in press, Experiment 1) found less tolerance for frustration among subjects exposed to random-intermittent, 95-dB (A), conglomerate noise than among subjects exposed to a continuous, soft (46-dB) broadband sound. Percival and Loeb did not, however, find poststimulation effects on proofreading performance.

Studies of the impact of variable continuous noise, when there are unpredictable components of the noise (e.g., aperiodic bursts of static or office noise), also report poststimulation effects. Thus Wohlwill, Nasar, DeJoy, and Foruzani (1976) found less tolerance for frustration among subjects exposed to 30 minutes of continuous 80–85-dB (A) conglomerate noise than among subjects working in quiet. Sherrod, Hage, Halpern, and Moore (1977) found similar effects for 18 minutes of continuous exposure to 94-dB (A) conglomerate noise. Finally, Rotton et al. (1978) found that those exposed to 15 minutes of meaningful speech (two lectures on phobias) at 80 dB (A) had less tolerance for frustration following stimulus termination than did a no-speech (quiet) control group.

Attempts by Harris (Note 1) to replicate the poststimulation effects of unpredictable noise were less fruitful. Harris reported three studies, one in which he used noise [85–105 dB (A)] from an automobile horn and two in which he used a conglomerate noise of similar intensity. All three of the studies included both fixed and random-intermittent noise conditions and a quiet control group. Harris failed to find postnoise performance decrements on either proofreading (Experiments 1 and 2) or a serial search task (Ex-
periment 3). It should be noted, however, that the average level of proofreading performance for his subjects was very low in all conditions, which suggests a floor effect.

A failure to replicate the postnoise effect was also reported by Frankenhaeuser and Lundberg (1974). After exposure to 40 minutes of aperiodic bursts of 65-85-dB (A) conglomerate noise, subjects did not show less (or more) tolerance for frustration than after working on a task without noise or after relaxing. The tolerance for frustration score in this study was the time that a subject was willing to spend on an insoluble task after an obligatory period of 80 minutes on that task. It is likely that because of the long period of required work, this measure is considerably less sensitive than the Feather measure, which has no obligatory work period.

Two studies reported by Moran and Loeb (1977) similarly failed to find a noise aftereffect. Participants were exposed to recordings of aircraft overflights [peaking at 90-105 dB (A)] that were either continuous or random-intermittent. A quiet experimental control group was also included. There were no effects of the noise (continuous or random-intermittent) on either the tolerance for frustration or the proofreading task. The authors pointed out, however, that it is possible that neither of the noise conditions in these two studies was actually unpredictable, since aircraft noise peaks were always signaled by onset of the overflight noise. This explanation is supported by later work from Loeb's laboratory (Percival & Loeb, in press, Experiment 2) in which decreased persistence on the tolerance for frustration task was found to occur after exposure to random-intermittent bursts of conglomerate noise and after exposure to random-intermittent bursts of aircraft noise peaks (eliminating the gradual onsets and offsets) but not following exposure to recorded normal aircraft flyovers (which include gradual onsets and offsets). There were no effects of any of the noise exposure manipulations on poststimulation proofreading performance.

DeJoy (Note 2) failed to find poststimulation effects of either random or fixed-intermittent 85-dB (A) print shop noise on either a proofreading or an insoluble anagrams task. Since the anagrams task was affected by task load during noise (discussed later), it appears that this task was sensitive to a poststimulation effect but that the noise failed to produce the effect.

Although the Glass and Singer (1972) work suggests that poststimulation effects occur only following unpredictable noise, two studies reported similar deficits following exposure to high-intensity, steady-state (no unpredictable components) continuous noise. Thus Hartley (1973) found deterioration of performance on a five-choice reaction time task following a 20-minute exposure to 100-dB (A) continuous broadband noise, as opposed to exposure to the same noise at 70 dB. Broadbent (1979) similarly exposed subjects to a broadband continuous noise of either 55 or 85 dB (C). The interference score on the Stroop Color-Word task was not affected by the sound level of the previous noise exposure. However, after noise, but not after quiet, subjects named patches of colored inks relatively faster than they read color names printed in black. Since both the Broadbent and the Hartley studies were primarily concerned with variations in sound level (there were no no-noise control groups), the effects they reported may depend on variations in intensity rather than on stimulus predictability (cf. Broadbent, 1977). This argument receives inferential support from Broadbent's (1979) failure to find effects of the high-versus low-intensity sound on Stroop interference, which has been reliably affected in those studies that compared an unpredictable noise condition to a quiet control group.

As is apparent from Table 1, nearly all of the studies that used steady-state continuous and variable continuous noise found poststimulation deficits in performance. As mentioned previously, it is possible that the effect of steady-state continuous noise depends on variations in intensity, whereas that of variable continuous noise depends on variations in predictability. As is apparent from Table 2, results of studies of random-intermittent exposure are less consistent. Possible reasons for the failure of a number of these studies to replicate the Glass and Singer
<table>
<thead>
<tr>
<th>Study</th>
<th>Description of noise</th>
<th>Performance aftereffects measure</th>
<th>Duration of noise</th>
<th>Sound level</th>
<th>Mode of delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadbent (1979)</td>
<td>Broadband, steady state</td>
<td>Stroop interference</td>
<td>20 min.</td>
<td>85 dB (C)</td>
<td>Speakers</td>
</tr>
<tr>
<td>Hartley (1973)</td>
<td>Broadband, steady state</td>
<td>Color naming/reading names of colors*</td>
<td>40 min.</td>
<td>100 dB (A)</td>
<td>Speakers</td>
</tr>
<tr>
<td>-ton, Olszewski, Charleton, &amp;</td>
<td>Meaningful speech</td>
<td>Five-choice reaction time*</td>
<td>40 min.</td>
<td>100 dB (A)</td>
<td>Speakers</td>
</tr>
<tr>
<td>Soler (1978)</td>
<td>Conglomerate (with aperiodic bursts of electronic static)</td>
<td>Tolerance for frustration*</td>
<td>15 min.</td>
<td>80 dB (A)</td>
<td>Earphones</td>
</tr>
<tr>
<td>Sherrod, Hage, Halpern, &amp; Moore</td>
<td>Conglomerate (with aperiodic bursts of office noise)</td>
<td>Tolerance for frustration*</td>
<td>18 min.</td>
<td>94 dB (A)</td>
<td>Speakers</td>
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<tr>
<td>(1977)</td>
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<tr>
<td>Wohlwill, Nasar, DeJoy, &amp; Foruzani (1976)</td>
<td>Conglomerate (with aperiodic bursts of office noise)</td>
<td>Tolerance for frustration*</td>
<td>30 min.</td>
<td>80-85 dB (A)</td>
<td>Speakers</td>
</tr>
<tr>
<td>Moran &amp; Loeb (1977) Experiments 1 and 2</td>
<td>Aircraft sounds</td>
<td>Tolerance for frustration, proofreading</td>
<td>14.34 min.</td>
<td>90-105 dB (A) peaks</td>
<td>Not reported</td>
</tr>
</tbody>
</table>

* The noise described was associated with a deficit in performance on that aftereffect task.
AFTEREFFECTS OF STRESS

(1972) work (particularly, Frankenhaeuser & Lundberg, 1974; Moran & Loeb, 1977; Harris, Note 1) have been presented earlier and are noted in Table 2. There appear to be no consistent differences between those intermittent noise studies that found aftereffects and those that failed to find aftereffects on the number of noise bursts, duration of noise exposure, percentage of the total period that they were exposed to noise, sound level, and whether the noise was delivered through earphones or speakers.

In sum, the data on poststimulation effects of noise on performance are consistent for variable continuous and steady-state continuous noise and mixed for intermittent exposure. The relative reliability of the poststimulation effect following continuous as opposed to intermittent sound may be attributable to the greater exposure time (noise on) in continuous noise studies. Nevertheless, if we confine ourselves to those studies that used clearly unpredictable noise and reasonably sensitive aftereffects measures, even the intermittent literature provides considerable support for the reliability of the postnoise effect.

Crowding. Those who study the effects of crowding on human behavior have found it useful to distinguish between two kinds of density—social density and spatial density (cf. Loo, 1973). Social density is manipulated by varying the number of people occupying a fixed quantity of space, and spatial density is manipulated by varying the available space but keeping the number of people constant. Since there is evidence that the effects of density are to some degree dependent on this distinction (e.g., Baum & Koman, 1976), the following review of the effects of high levels of density on poststimulation performance will similarly distinguish between these two kinds of density.

In an early study of the aftereffects of spatial density, Sherrod (1974) had groups of eight female high school students perform a number of tasks in either a large or a small room. After 1 hour of exposure, subjects were moved into a large reception area. Each student, at her own desk, was administered the tolerance for frustration and proofreading tasks. Those subjects who had been working in high density (small room) showed less tolerance for frustration than did their low-density (large room) counterparts. There were no differences on the proofreading task.

Similar postcrowding deficits on the Feather tolerance for frustration task are reported by Evans (1979) with mixed-sex groups of 10 persons by Nicosia, Hyman, Karlin, Epstein, and Aiello (in press) for both male and female groups with 4 persons.

The latter study, however, failed to find any poststimulation effects of high density on a visual search task and a problem-solving task. In a final study, Aiello, DeRisi, Epstein, and Karlin (1977) reported that following 30 minutes of sitting in a room with 3 other subjects, female undergraduates who were crowded (small room) scored lower on two measures of creativity than did their uncrowded (large room) counterparts. In sum, all four of the existing studies of the aftereffects of spatial density reported poststimulation effects.

There are two studies of the poststimulation effects of social density. The first was conducted by Saeger, Mackintosh, and West (1973, Experiment 2) in a railroad station in midtown Manhattan. Male and female subjects were asked to do a number of tasks during a crowded or uncrowded time of day. After task completion, the subject was brought to a quiet secluded place and administered the Stroop Color-Word task. Whereas females who had been exposed to high levels of density performed more poorly on the Stroop than did their low-density counterparts, males performed better after high- than after low-density exposure. Although other studies have found interactions between density and gender on a number of dependent measures (see Sundstrom, 1978, for a review), the relationship between one's gender and whether one experiences stress in a particular high-density setting is still unclear. As a consequence, we do not know whether it is the males or the females who are experiencing stress in this situation, and thus it is impossible to determine whether these data indicate a poststress effect.

In a study by Dooley (1978), groups of
Table 2
Nature of Noise Stimulus and Aftereffect Measures in Studies That Used Random-Interval Noise

<table>
<thead>
<tr>
<th>Study</th>
<th>Description of noise</th>
<th>Performance aftereffects measure</th>
<th>No. of bursts</th>
<th>Duration of noise</th>
<th>Percentage of time on</th>
<th>Sound level</th>
<th>Mode of delivery</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gardner (1978)</td>
<td>Conglomerate</td>
<td>Proofreading*</td>
<td>24</td>
<td>3.6 min.</td>
<td>15</td>
<td>100 dB (A)</td>
<td>Earphones</td>
<td></td>
</tr>
<tr>
<td>Glass &amp; Singer (1972)</td>
<td>Conglomerate</td>
<td>Tolerance for frustration*</td>
<td>23-25</td>
<td>3.6-5 min.</td>
<td>15-20</td>
<td>55 and 108 dB (A)</td>
<td>Speakers</td>
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<td></td>
<td></td>
<td>Proofreading*</td>
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<td></td>
<td></td>
<td>Stroop*</td>
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<tr>
<td>Percival &amp; Loeb (in press)</td>
<td>Conglomerate</td>
<td>Tolerance for frustration*</td>
<td>24</td>
<td>3.6 min.</td>
<td>15</td>
<td>95 dB (A)</td>
<td>Speakers</td>
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<tr>
<td>Experiment 1</td>
<td></td>
<td>Proofreading*</td>
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<td>Tolerance for frustration*</td>
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<td></td>
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<td>Proofreading</td>
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<tr>
<td>Experiment 2</td>
<td>Aircraft overflights</td>
<td>Tolerance for frustration*</td>
<td>16</td>
<td>7.13 min.</td>
<td>29</td>
<td>95 dB (A)</td>
<td>Speakers</td>
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<tr>
<td></td>
<td>Aircraft overflight</td>
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<td>peaks</td>
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<td></td>
<td>White noise</td>
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<td></td>
<td>Conglomerate noise</td>
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<tr>
<td></td>
<td>Conglomerate</td>
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<tr>
<td>Rotton, Olszewski, Charleton,</td>
<td>Conglomerate</td>
<td>Tolerance for frustration*</td>
<td>60</td>
<td>9 min.</td>
<td>60</td>
<td>80 min.</td>
<td>Earphones</td>
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<td>&amp; Soler (1978)</td>
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<tr>
<td>Lüty (Note 2)</td>
<td>Printing shop noise</td>
<td>Proofreading</td>
<td>60</td>
<td>10 min.</td>
<td>33</td>
<td>85 dB (A)</td>
<td>Speakers</td>
<td></td>
</tr>
<tr>
<td>Frankenhaeuser &amp; Lundberg (1974)</td>
<td>Conglomerate</td>
<td>Tolerance for frustration</td>
<td>20</td>
<td>40 min.</td>
<td>50</td>
<td>65-85 dB (A)</td>
<td>Speakers</td>
<td></td>
</tr>
<tr>
<td>Harris (Note 1)</td>
<td>Auto horn</td>
<td>Proofreading</td>
<td>30</td>
<td>3.8 min.</td>
<td>12.5</td>
<td>85-105 dB (A)</td>
<td>Not reported</td>
<td>Possible floor effect on proofreading in Experiments 1 and 2</td>
</tr>
<tr>
<td>Experiment 1</td>
<td>Conglomerate</td>
<td>Proofreading</td>
<td>30</td>
<td>3.8 min.</td>
<td>12.5</td>
<td>85-105 dB (A)</td>
<td>Not reported</td>
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</tr>
<tr>
<td>Experiment 2</td>
<td>Conglomerate</td>
<td>Serial search</td>
<td>30</td>
<td>3.8 min.</td>
<td>12.5</td>
<td>85-105 dB (A)</td>
<td>Not reported</td>
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<tr>
<td>Experiment 3</td>
<td>Aircraft overflights</td>
<td>Tolerance for frustration</td>
<td>14</td>
<td>4.6 min.</td>
<td>29</td>
<td>90-105 dB (A)</td>
<td>Not reported</td>
<td>Aircraft noise peaks were always signaled by the onset of overflight noise</td>
</tr>
<tr>
<td>Moran &amp; Loeb (1977)</td>
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<tr>
<td>Experiments 1 and 2</td>
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* The noise described was associated with a deficit in performance on that aftereffect task.

A A proofreading effect was found in all but one study (Glass & Singer, 1972, p. 80).

* Decreased tolerance for frustration occurred following aircraft overflight peaks and conglomerate noise but not following aircraft overflights and white noise.
either three or nine male undergraduates performed a simulated marketing task in a small room. In an experimental control group, a single subject performed the same task alone. After task completion subjects were moved to individual cubicles in which they were administered a proofreading task. Results indicated that the poststimulation effects in this study were mediated by individual differences in personal space needs. Both high- and low-density conditions (as opposed to the alone condition) had a negative impact on the proofreading quality of subjects with far (need more) personal space but not on those with close (need less) personal space. It appears that the mere presence of others in the small room, rather than the manipulated level of high density, acted as the stressor in this study. Moreover, those subjects who were most likely to experience stress when involved in close interactions with others (i.e., those with far personal space) showed aftereffects. Those less likely to experience stress (i.e., those with close personal space) did not show the effects. In sum, there is evidence for a postdensity effect in cases in which the close presence of others is likely to be experienced as stressing.

Task load. Three studies have indicated that subjects who experience a high task load perform more poorly following task completion than those assigned a low task load. Thus Cohen and Spacapan (1978, Experiment 1) found in a four-choice reaction-time experiment that those required to respond to 100 lights per minute had less tolerance for frustration following task completion than those responding to 50 lights per minute. There were, however, no effects of task load on proofreading performance. (This experiment controlled for subjects’ perceptions of success-failure and thus is not explicable in those terms.) Hartley (1973) reports that those required to perform a serial reaction time task for the first 20 minutes of the experiment performed more poorly on the same task in the last 20 minutes than those who read during the initial stage of the study. (This effect may, of course, be attributable to boredom on the part of those required to perform the same task twice.) Similarly, Rotton et al. (1978) found that the expectation that one would be required to recall a speech, even though one was never actually required to do so, resulted in lower tolerance for frustration following task completion than for those not expecting a recall test. DeJoy (Note 2), however, found no differences in tolerance for frustration (insoluble anagrams task) or proofreading following performance of a high-versus a low-load coding task.

Other social and nonsocial stressors. Glass and Singer (1972) also reported that poststimulation deficits in performance occur following electric shock, a frustrating experience with a bureaucracy, and an experience of arbitrary or sex discrimination. In the electric shock study (Glass & Singer, 1972, p. 110) those subjects exposed to unpredictable and uncontrollable shock performed more poorly on both the Stroop and proofreading tasks following exposure. A later study (Glass et al., 1973), found similar poststimulation effects of electric shock on the Stroop. Experiences of bureaucratic harassment (Glass & Singer, 1972, p. 124) similarly resulted in poorer proofreading for the harassed than for the nonharassed groups after the experience had ended, and the study of the effects of discrimination in the amount of pay received for participating in the experiment (p. 132) found that those who experienced discrimination performed more poorly on the Stroop following the experience than those who did not experience discrimination.

Conclusions. The previously cited studies provide evidence for both the reliability and generality of the poststimulation effect of stress on performance. These effects have appeared in the vast majority of studies, and these studies have used a wide range of stressors. The data suggest that the effect is most likely to occur when the stressor is clearly unpredictable and when a sensitive aftereffects measure is used. Moreover, factors that might mediate the stressfulness of the situation (e.g., subject gender and need for personal space in the social density studies) are important determinants of whether a particular manipulation will produce an aftereffect. The most reliable mea-
asures appear to be those used by Glass and Singer (1972), although the proofreading task has proved less reliable (e.g., Cohen & Spacapan, 1978; Glass & Singer, 1972, p. 80; Sherrod, 1974) than the Feather and Stroop tasks. The inconsistency of the proofreading measure may be attributable to the large variation among subjects' literary skills that often results in substantial error variance on proofreading scores. Although other measures have only been used in individual studies, poststimulation effects have been obtained on a serial reaction time task (Hartley, 1973) and a creativity task (Aiello et al., 1977). Altereffects measures that have failed include visual search tasks (Nicosia et al., in press; Harris, Note 1) and a problem-solving task (Nicosia et al., in press). Since in all of the Glass and Singer studies and replications, the poststimulation tasks were administered shortly after stressor termination, there are no data on the time course of the effect.

**Predictable Versus Unpredictable Stressors**

Glass and Singer reported five studies that compared the poststimulation effects of predictable versus unpredictable noise. The first two studies (Glass et al., 1969, Experiment 1; see also, Glass & Singer, 1972, pp. 47, 52) compared fixed versus random-intermittent exposure to a broadband conglomerate noise made up of a number of fairly typical urban sounds. In both of these studies, those exposed to unpredictable noise performed more poorly than did the predictable noise group on both the tolerance for frustration and proofreading tasks. There was no difference between poststimulation performance of the predictable noise group and a no-noise control group. The first study also indicated that predictability of the noise was a more important determinant of poststimulation effects than was the intensity (56 vs. 108 dB) of the sound. In a third study (Glass & Singer, 1972, p. 55) predictability was manipulated by the use of signaled (by a light) versus unsignaled (light occurrence is random) noise bursts. Again, those exposed to unpredictable noise were less persistent on insoluble puzzles administered after noise termination. The effect of unpredictable noise on proofreading was, however, not replicated.

Predictability was manipulated in two other studies that were primarily designed to assess the effect of inhibiting adaptation on poststimulation effects. (See the section on Adaptive-Cost Hypothesis under Theory Review.) The first study was the only one in which Glass and Singer (1972, p. 141) reported a clear reversal of the predictability effect. For subjects working on difficult math problems during exposure, higher frustration tolerance and better proofreading occurred in the random-intermittent condition than in the fixed-intermittent condition. This was not true for those working on simple problems. The second study (Glass & Singer, 1972, p. 147) resulted in the usual predictability effect with those who were exposed to random-intermittent noise, whether the interburst intervals were 51 sec or 96 sec, performing more poorly on the proofreading task than those who were exposed to fixed-intermittent bursts.

Gardner (1978, Study 1, Table 1) similarly presented subjects with fixed or random-intermittent conglomerate noise of 100 dB. A proofreading task performed after noise exposure was performed more poorly by those exposed to unpredictable than by those exposed to predictable noise. Likewise, Percival and Loeb (in press) reported that subjects exposed to 24 minutes of 95-dB random-intermittent conglomerate noise showed less tolerance for frustration following exposure than either those exposed to equivalently intense fixed-intermittent sound or those exposed to a soft (46-dB) broadband sound. Studies by Harris (Note 1), Moran and Loeb (1977), and DeJoy (Note 2) described earlier also manipulated the predictability of the noise. As mentioned earlier, none of these investigations indicated aftereffects of either predictable or unpredictable sound.

In sum, the role of predictability in producing stress aftereffects has not received considerable attention since the publication of the Glass and Singer book. Existing evidence does, however, suggest that aftereffects are more likely to occur following exposure to the unpredictable rather than a predictable-stressor.
Controllable Versus Uncontrollable Stressors

Glass and Singer (1972) reported a number of studies which indicated that the aftereffects of stress occur following uncontrollable but not controllable stressors. First, there were two identical studies (pp. 64, 65) that used 108-dB aperiodic noise in which half of the subjects were instructed how to terminate the noise by pressing a button (perceived control). In fact, the perceived control subjects did not actually terminate the noise. In both studies, following noise exposure, those provided with perceptions of control over stimulus termination had more tolerance for frustration and performed better on the proofreading task than did their counterparts without perceptions of control.

In a third study, Glass and Singer (1972, p. 69; see also, Glass, Reim, & Singer, 1971) tested the proposition that indirect control (i.e., having access to another person who could terminate the noise) would be similar to having direct control over noise termination. Their hypothesis was confirmed. Following exposure to the 108-dB conglomerate noise, those with indirect control performed better than those lacking the perception that they (or their partner) could control the termination of the noise. In a final study, Glass and Singer (1972, p. 74) found that knowing that someone else was able to terminate the noise (for themselves) during the experiment but that one's own exposure could not be terminated (relative deprivation) did not increase poststimulation effects. However, as in previous studies, a proofreading task administered after stimulus termination was performed more poorly by those lacking perceived control than by those with control.

A replication of the aftereffects of noise that used a slightly different operation of perceived control is reported by Gardner (1978). An inability to replicate Glass and Singer when using an informed consent form that explicitly informed the subject that he or she could leave the experiment without loss of pay led Gardner to use the informed consent form as a way of manipulating control. Gardner reported that although it was impossible to replicate the aftereffects of unpredictable, uncontrollable noise with informed consent, the effect was replicable when informed consent was not required. Unfortunately, those who received the informed consent were not only given the perception of control over termination of the stressor (i.e., they could leave at will) but also were making an explicit choice (to the extent of signing their names) to participate in the study prior to noise exposure. Thus, it is unclear whether the ameliorative effects of informed consent in this study are attributable to increased control or to increased choice and commitment.

Perceived control over the termination of the stressor was also examined in the previously described study of spatial density by Sherrod (1974). Besides the high-density (small room) and low-density (large room) conditions, an additional condition was included in which subjects were assigned to a high-density setting but were told that they could leave the room and work in a larger room if they so desired (density with perceived control). As in the noise studies, the perceived control subjects did not actually use this option. The high-density group showed the least persistence on the insoluble puzzles, followed by an intermediate level of persistence by those high-density subjects with perceived control, and finally, the most persistence was shown by the low-density group. As mentioned earlier, there were no effects on the proofreading task.

The previously described studies all provided subjects with the perceived ability to terminate the stressor, but in all cases subjects did not actually perform any coping responses. That is, they knew they could terminate the stressor but did nothing about it. A slightly different form of control was offered to subjects in a study of the aftereffects of electric shock reported by Glass et al. (1973). During an initial trial block, all of the subjects received a series of 10 6-sec shocks and were required to press a reaction time key at the onset of each shock. During a second block of trials, the perceived control group was told that they could decrease the duration of each shock (from 6 to 3 sec) by maintaining a fast reaction time to the onset of the shock. For half of these sub-
jects, all shocks were halved (perceived control with reduction), and for the remaining subjects none of the shocks were halved (perceived control without reduction). Two experimental control groups received shocks of either 3 sec (no perceived control with reduction) or 6 sec (no perceived control without reduction) but were given no indication that shock duration was related to their behavior. Thus in this case, subjects with control were actually implementing that control by attempting to maintain fast reaction time. Performance on the Stroop, administered after the two blocks of shock trials were completed, indicated that subjects who were told that they could control the duration of the shock and ostensibly succeeded in doing so (perceived control with reduction) performed better on the Stroop than both of the no-perceived-control groups and better than the group given the expectancy that control was possible who actually failed to control (perceived control without reduction).

A number of studies of the learned helplessness phenomenon have also examined the effects of implemented control over a stressor on poststress performance. Compared with those with the ability to escape or avoid loud noise, those lacking control subsequently performed more poorly on anagrams (Gatchel, McKinney, & Koebenick, 1977; Hiroto & Seligman, 1975), a concealed figures test (Krantz & Stone, 1978), and a proofreading task (Krantz & Stone, 1978). In contrast to the previously described studies, subjects in the unavoidable, unescapable stress conditions in these studies experienced failure as well as stress. (The unavoidable stress conditions in these studies are similar to the perceived control no-reduction condition in the study by Glass et al., 1973, described previously.) The fact that control and success–failure are confounded in these studies makes it difficult to assess whether the mechanisms involved are the same as in the other aftereffects work (cf. Cohen, Rothbart, & Phillips, 1976; Griffith, 1977).

Two recent studies of helplessness induced by exposure to uncontrollable bursts of noise (tones) provide data that are inconsistent with those reported in the aftereffects literature (Gatchel, Paulus, & Maples, 1975; Gatchel & Proctor, 1976). Both of these studies included an experimental control group in which subjects were instructed to merely sit and passively listen to loud tones (no success or failure). This condition is similar to an unpredictable, uncontrollable stresor condition in the aftereffects paradigm and thus would be expected to result in poststimulation deficits in performance. Although a learned helplessness group, who thought they could escape the noise but actually could not, showed poststimulation deficits on an anagram task, the group who passively listened to the tones did not show deficits. The noise dose in these experiments, however, was small in comparison with previously cited noise studies.  

The research discussed previously has been limited to studies that provided control over the termination of a stressor. A study of the aftereffects of noise by Sherrod et al. (1977) extended this work by investigating the relative contribution of control over initiation of the stressor as well as over termination. Subjects with initiation control were allowed to choose whether they would be exposed to noise. The experimenter stressed, however, that for the purposes of the study, he would prefer that they turn the noise on (they all did). Subjects without initiation control were given no such choice. Termination control was provided in the same way as in the Glass and Singer studies. Following noise exposure the Feather task was administered. Sherrod and his colleagues reported that the least

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1 At the beginning of both of these studies, the subject, after hearing a sample tone, was offered the opportunity to withdraw from the experiment. As we outline later in this article, such a choice, by providing a form of control over the situation, is likely to ameliorate any poststimulation effects (cf. Sherrod et al., 1977). If we assume that the learned helplessness effect in these studies was a response to failure and not to a lack of control, it is possible that the ability to choose whether to participate in the study ameliorated control-related effects for the passive listening group but did not affect the learned helplessness (failure) group. Admittedly, however, these studies constitute an additional failure to replicate postnoise effects, and this post hoc explanation must be viewed as only tentative.
Tolerance for frustration was shown by those who lacked any kind of control over the noise, intermediate tolerance was shown by those with initiation control, termination control caused an even greater increase in tolerance, and combined control (both initiation and termination) caused the greatest increase. Thus although initiation control was not as effective as termination control, increasing overall perceptions of control by combining initiation and termination was the most effective intervention.

In a field study of the stress involved in donating blood, Mills and Krantz (1979, Experiment 1) investigated the roles of providing information about a threatening event and of providing choices about that event in mediating poststress response. Information and choice were both conceptualized as forms of personal control because they presumably allow one to alter or affect their outcomes. In this study, blood donors were offered or not offered a choice of which arm blood would be drawn from. This manipulation offers some control over the procedure but not directly over either the initiation or termination of the stressor. Also, although all donors received some information prior to the procedure, in half of the cases (high information) this information dealt with the details of the procedure and the sensations the donor might expect, whereas in the remaining cases (low information) the information was limited to a general description of the Red Cross blood donor program. The Stroop Color-Word test was administered during the donor recovery period. There were no differences between conditions in Stroop performance. However, the authors pointed out that the nursing interventions during the procedure and the refreshments given to donors following the procedure precluded an adequate assessment of aftereffects in this setting. In addition, the time that elapsed between the stress experience and the aftereffects measure was long in comparison with previously discussed studies in which the aftereffects measures were administered either immediately or after a short respite.

A laboratory study of cold stress by the same authors (Mills & Krantz, 1979, Experiment 2) similarly manipulated information about the stress experience and choice of hand to be placed in the cold water. In this case, however, those who were allowed to choose the hand to be used could also elect to remove their hand from the cold water if they chose to do so. The proofreading measure was administered following stressor exposure. Subjects with choice of hand and perceived control over stressor termination (high choice) were more accurate proofreaders than those given neither choice nor the perception of control (low choice). Also under low-choice conditions, providing information led to improved performance, whereas under high-choice conditions, providing information made little difference. It appears that in this case combining two forms of control did not further decrease poststress effects. It should be pointed out, however, that the high-choice condition itself involved two forms of control (hand choice and immersion time in cold water). Thus, it might be more accurate to conclude that the addition of a third form of control did not decrease poststress effects.

In a final study, DeJoy (Note 2) compared posttask performance of subjects who had some control over a difficult coding task (self-paced) with the performance of subjects who lacked task control (experimenter-paced). The two conditions were yoked (average stimulus exposure time of self-paced subject used for experimenter-paced subject) to equate conditions on time on task. Experimenter-paced subjects performed more poorly on an insoluble anagrams task (tolerance for frustration) administered immediately following completion of the coding task than did self-paced subjects. There were no effects on the proofreading task.

Conclusions. The data are almost unanimous in supporting the role of both perceived and implemented control over termination of a stressor in ameliorating stress aftereffects. In some cases those groups with control performed as if they were not exposed to a stressor (e.g., Gardner, 1978; Glass et al., 1973), whereas in others (e.g., Sherrod et al., 1977) control provided some improvement in poststress task performance but did not com-
pletely ameliorate the effect. The single study of initiation control similarly suggests a lessening in poststress performance deficits. Initiation control does not, however, appear to be as effective as termination control. There is also some mixed evidence that providing subjects with choice over an aspect of the stress situation and/or with information about the procedure and expected sensations similarly lessens the poststimulation impact of the stressor.

Is providing someone with more than one kind of control a more powerful intervention than providing them with a single mode of control? The combination of initiation and termination control does prove to be more effective than either of these modes alone (Sherrod et al., 1977). However, the combination of two kinds of choice and one kind of information control does not seem to be more effective than either of these modes alone (Mills & Krantz, 1979). It could be that combined modes of control do help to reduce poststress performance deficits until one reaches levels equivalent to performance following no-stress conditions (as in the Sherrod et al., 1977, study), but additional control is unimportant if that level is already reached (as in Mills & Krantz, 1979).

The research clearly demonstrates that providing one with increased control over a stressor or over a stress setting decreases deficits in poststimulation performance. None of the reviewed studies, however, have investigated whether increased control over a setting is beneficial when there is no stressor present. (This assumes that the demanding coding task used in the DeJoy, Note 2, study was experienced as a stressor.) That is, since none of these studies included a condition that provided control over a nonstressing setting (e.g., perceived ability to leave if the experiment is not fun or choice of task or task order on a simple task), it is unclear whether there is an interaction between stress and control or a main effect for control. Since there is some evidence that perceived control over a simple task setting may improve performance in that setting (Perlmutter & Monty, 1977), an over-"n" rather than stress-specific effect of control ...es seem possible.

**Aftereffects on Social Behavior**

Recent studies on the poststimulation effects of uncontrollable stress on social behavior have extended the scope of the original aftereffects research. For example, two studies have reported decreased poststimulation helping after exposure to unpredictable, uncontrollable stress. In an experiment by Sherrod and Downs (1974), subjects performed a task while listening to either a recording of a soothing simulated seashore or a stressing recording of dixieland jazz plus a male voice reading nonrelevant prose. In a third condition subjects listened to the stressing tape but were told that they could terminate the distracting stimulus if they wished (perceived control). After the completion of the 20-minute experiment, subjects left the laboratory and were confronted by a second experimenter who asked for voluntary help in pretesting some experimental materials. Subjects who listened only to soothing seashore sounds volunteered the most times, followed by subjects who listened to the stressing tape but who had perceived control, followed finally by stress-without-control subjects. Thus, exposure to uncontrollable stress decreased poststimulation helping with the addition of control over the termination of the noise partially ameliorating these effects.

Similar results were found in a study of the aftereffects of density and task load conducted in a large shopping center (Cohen & Spacapan, 1978, Experiment 2). Subjects were required to perform high- or low-information rate shopping tasks during periods in which the shopping center was crowded or uncrowded. After completing their task, subjects (on their way to meet the experimenter) entered a deserted corridor in which they encountered a woman who feigned dropping a contact lens. Those subjects who performed high-load tasks and/or were crowded helped less often and for less time than their low-task-load, uncrowded counterparts.

Increased aggressive behavior following exposure to uncontrollable stress was reported by Donnerstein and Wilson (1976). In their experiment, subjects completed a math task under either quiet, high-intensity noise or
high-intensity noise with perceived control over the termination of the noise. Following noise exposure, half of the subjects were angered (by the person they would later aggress against) and half of the subjects were not angered. Angered (but not nonangered) subjects with no control revealed an increase in aggression, whereas the level of aggression of perceived-control subjects was no different than that of no-noise subjects.

Three studies described earlier also used poststress measures of social behavior. Thus Rotton et al. (1978) found that both loud speech and the combination of conglomerate noise and a taxing task reduced one’s ability to differentiate among people occupying different roles. Epstein and Karlin (1975) reported that groups of men who were crowded were less cohesive and more competitive following the stress experience. Women, however, were more cohesive and less competitive following the crowded versus noncrowded experience. Finally, Dooley (1978) failed to find any relationship among social density, volunteering for a future experiment, or rating of attractiveness of same-sex persons.

Overall, it appears that exposure to unpredictable and uncontrollable stress is followed by a decreased sensitivity to others. This includes a decrease in helping, a decrease in the recognition of individual differences, and an increase in aggression.

Naturalistic-Correlational Studies of Aftereffects

A number of recent studies have investigated the impact of living and/or working in a stressful environment on task performance and social behavior outside of the stressing environment. For example, several investigators have examined the effects of prolonged exposure to community noise on the performance of elementary school children. In one study, Cohen, Glass, and Singer (1973) tested children living in apartment buildings built on bridges spanning a busy expressway. When tested in a quiet setting, children who lived in noisier apartments showed greater impairment of auditory discrimination and reading ability than did those who lived in quieter apartments. The length of residence increased the magnitude of the correlation between noise and auditory discrimination. Additional analyses ruled out social class variables and hearing losses as possible explanations. A study of children attending school in the air corridor of a busy metropolitan airport (Cohen, Evans, Krantz, & Stokols, 1980) indicated that children living and attending school in the air corridor were poorer on both a simple and a difficult puzzle-solving task and were more likely to give up on the task than their quiet neighborhood counterparts. Again, there were controls for social class and for hearing damage. Unlike the apartment noise study, this study did not find that children from noisy environments (schools) had poorer verbal abilities.

A study of 4½- to 6½-year-old children from homes described by their parents as either noisy or quiet similarly suggests poorer poststimulation task performance on the part of children from noisier homes (Heft, 1979). The children performed a simple matching (visual search) task and then were administered a recall test for some of the incidental stimuli in that task. Children from noisy homes performed more poorly on both the matching and incidental memory tasks than those from quieter homes. Performance on a second matching task indicated similar deficits for children from noisy as opposed to quiet homes. Analyses controlled for age, preschool experience, and income level of parents. It should be noted, however, that self-reports of noise level do not usually correlate highly with objective noise measures (cf. Kryter, 1970) and thus limit the generality of these findings.

Two naturalistic investigations of crowding also suggest effects that occur outside of the stressing environment. Baum and Valins (1977) reported a number of studies of the behavior of dormitory residents who, because of dormitory design, were exposed to prolonged and repeated personal encounters with large numbers of other residents (long-corridor residents) versus those whose forced encounters included a comparatively small number of others (short-corridor and suite residents). Under controlled conditions outside of the dormitory, those who had a large
number of personal encounters showed less group consensus after a discussion, sat further away from, spent less time looking at, and initiated fewer conversations with a stranger (confederate), used a withdrawal strategy more often in a prisoner’s dilemma game, and were less likely to assert themselves by asking questions in an ambiguous situation.

Two studies reported by Rodin (1976) similarly suggest aftereffects of residential density. In the first study 6-9-year-old children from high-density apartments of a low-income housing project were less likely than children from less dense homes from the same project to control (choose) their own outcomes. In a second study, eighth-grade children from high-density apartments were more adversely affected by a learned helplessness pretreatment—insoluble puzzles—than were their low-density counterparts. These effects persisted even after statistical control for social class and race were used.

The studies discussed previously suggest that prolonged exposure to a stressor is associated with a number of poststimulation effects on performance and social behavior. Although it is likely that some of these effects are specific to the stressor (e.g., the tendency of those who are forced into constant contact with others to avoid strangers in the Baum and Valins work), a number of the studies indicate a more general helplessnesslike effect (Baum & Valins, 1977; Cohen et al., 1980; Rodin, 1976). It is important to emphasize that these studies are all correlational and thus do not allow causal inference.

The Meaning of the Stressor and the Meaning of the Control Manipulation

Although the data on the effects of uncontrollable stressors on poststimulation performance and social behavior is reasonably consistent, there have been a number of published and unpublished failures to replicate these effects. These inconsistencies are probably inevitable given the complexity of the situation being presented to a subject. First, it is likely that our responses to loud noise and to other potentially stressing stimuli are mediated by cognitions other than control, and we may often unintentionally invoke such cognitions in our laboratories. For example, Cohen (in press) has outlined a number of situational characteristics of laboratory settings that may affect the meaning of the potential stressor for the subject and consequently, whether it will produce stress-related responses. Among others, these factors include (a) whether the participants in the study are aware that the exposure to the aversive stimulus will last for only a short period (cf. Altman, 1975), (b) the salience of the implied contract between the experimenter and the subject that suggests no harm will come to the subject during the experimental procedure, (c) whether the subject chose to participate in the study and whether an informed consent slip was signed.

Averill (1973) has pointed out that the stress-reducing properties of a personal control intervention similarly depend on the meaning of the control response for the individual. Thus telling a subject that pressing a button will terminate a loud noise may or may not suggest that he or she has control over the termination of the stressor. One alternative interpretation of this intervention might be that the stressor must be pretty dangerous if the experimenter needs to provide an escape mechanism.

Theory Review

Adaptive-Cost Hypothesis

Glass and Singer’s (1972) working hypothesis was that the process of adaptation requires cognitive work. This work included searching for appropriate coping responses and/or attempting to redefine the stimulus. Moreover, they assumed that the work required to adapt to unpredictable and uncontrollable stressors was substantially greater than that required to adapt to predictable and controllable stimulation. According to Glass and Singer, the adaptive-cost hypothesis predicts that poorer performance on aftereffects tasks should vary directly with degree

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2 Unpublished research conducted in my own laboratory (See, also, Baddeley, Note 3; Evans, Note 4; Tokoš, Note 5)
of adaptation, since a greater degree of adaptation implies a greater amount of adaptive effort. Presumably, increased adaptive effort would deplete one’s available psychic energies and would thus result in deficits on subsequent demanding tasks.

Glass and Singer (1972) presented two arguments that led them to discard this hypothesis. First, they assumed that decrements in galvanic skin response (GSR) to noise and shock are valid indices of the cognitive effort involved in adaptation. This follows from their assumption that the greater the adaptation, the greater the amount of adaptive effort. There were no significant correlations between aftereffects scores and indices of GSR adaptation for subjects in various conditions. Thus there was no evidence for differential cognitive work. Second, they assumed that a situation in which one was exposed to unpredictable stress but in which adaptation was inhibited would not result in poststimulation effects. This should be true, since a lack of adaptation implies a lesser degree of adaptive effort. They were successful in inhibiting physiological adaptation in two studies (pp. 141–153) but found poststimulation effects even in the conditions in which subjects did not physiologically adapt. They thus concluded that “it is not the adaptive process that causes adverse aftereffects” (p. 153).

Although the authors describe the effort of adaptation as a cognitive process of searching for appropriate coping strategies and of redefining the stimulus, they take physiological evidence based on one index of autonomic response as the measure of adaptation. Existing knowledge concerning the relationship between cognition under stress and corresponding physiological fluctuations is equivocal at best (cf. Kahneman, 1973). Moreover, it is likely that those subjects who were prevented from physiologically adapting worked just as hard (if not harder) to cope with and redefine the stressor. In other words, it is possible that a significant amount of effort may be expended even if adaptation does not occur. Thus, aftereffects may occur because of the adaptive process even when adaptation fails. In sum, although the Glass and Singer (1972) data do not provide support for the adaptive-cost hypothesis, neither do they provide convincing evidence to justify its rejection. Unfortunately, none of the more recent studies have attempted direct tests of this explanation.

**Information Overload**

An alternative form of a psychic cost hypothesis was recently proposed by Cohen (1978). He argued that unpredictable, uncontrollable stressors, because they are potentially threatening, substantially increase demands on attentional capacity. This increased demand might occur because individuals are required to continually monitor potentially threatening stimuli to evaluate their adaptive significance and to decide on appropriate coping responses (cf. Lazarus, 1966). Increased demand may also occur because of effort required in tuning out or inhibiting response to the distracting stimulus. Cohen further suggested that an individual’s attentional capacity is not fixed but shrinks when there are prolonged demands. This shrinkage or cognitive fatigue presumably increases with both the attentional load of an activity and the duration of an activity. Thus prolonged exposure to an environmental stressor and/or to a high information rate task should result in cognitive fatigue—an insufficient reserve of attention to perform demanding tasks.

What are the implications of the cognitive fatigue hypothesis for the performance of ongoing and subsequent tasks? Task duration under experimental conditions is usually limited to between 20 minutes and an hour. Although this may be sufficient to cause a significant decay in available capacity, it may not affect performance on an ongoing task that by that point is well practiced and requires little effort. Subsequent tasks, however, that demand considerable attention on the part of the subject would be sensitive to fluctuations in available processing capacity. Thus we would expect depletions in attentional capacity resulting from prolonged task and environmental demand to be manifest in deficits on difficult tasks administered immediately after termination of the principal task.
Three recent studies (mentioned earlier) have provided direct support for the cognitive fatigue hypothesis. All three suggested that those experiencing a high task load perform more poorly on subsequent tasks than those experiencing lower task loads. For example, Hartley (1973) reported that both increased task load and increased noise result in poorer performance on a subsequent serial reaction time task performed in quiet. Moreover, there is an additive effect of task load and noise on poststimulation performance. Rotton et al. (1978) similarly reported that deficits on the Feather tolerance for frustration task increase with both task load of a previous task and the addition of noise to that task. Again, there is an additive effect when these conditions are combined. In a final study, Cohen and Spacapan (1978, Experiment 1) reported that deficits on the tolerance for frustration task (but not on the proofreading task) increased as task demand and task duration of a previously performed task increased. Moreover, self-reports of mental fatigue similarly increased with both task load and task duration. Thus subjects' self-perceptions were consistent with both the predictions of the cognitive fatigue hypothesis and the data from the tolerance for frustration task.

A study reported by Wohlwill et al. (1976) is not, however, consistent with the cognitive fatigue hypothesis. They reported that subjects who listened to noise but did not perform a concurrent task showed the same aftereffects as those who worked on a task while listening to noise. Since performing a task under noise should demand greater attentional capacity than merely being exposed to the noise, the cognitive fatigue hypothesis would suggest that the noise plus task condition would show a greater magnitude of aftereffects. Interpretation of this study is difficult, however, since the no-task subjects were given instructions that may have led them to assume that they were expected to process (possibly remember) task stimuli. Unfortunately, the investigators did not administer any self-report measures of cognitive fatigue or ask subjects how they perceived the experimental situation.

Cohen also suggested that posttask (or poststress) attentional deficits can have detrimental effects on interpersonal behavior. He argued that lacking adequate attention reserves, an individual sets priorities for use of his or her attention. The most common strategy is to focus available attention on inputs most relevant to one's own goals, neglecting other cues, social and nonsocial alike (cf. Milgram, 1970). Important social cues that are often neglected when attention is restricted include those that carry information concerning the moods and subtly expressed needs of others. The neglect of such cues results in a lowered probability of helping another, expressing sympathy for another, or reacting appropriately to another's needs. Other proposed social consequences of attentional focusing following high attentional demand include oversimplification and distortion in the perception and evaluation of communications and persons.

Evidence for the contention that conditions leading to cognitive fatigue will result in less sensitivity to others comes from a number of recent studies. In a study conducted in a field setting (Cohen & Spacapan, 1978, Experiment 2), after performing a high-load shopping task, subjects were less likely to help a woman search for a contact lens than their counterparts who performed a low-load task. Similarly, subjects who had been crowded were less likely to help than those who had not been crowded. Again, there is an additive effect in the high task load, high-density condition. Rotton et al. (1978) reported increased difficulty in differentiating between people who occupy different roles following both increased task load and noise exposure. Thus it appears that poststimulation task deficits and insensitivity to social cues can be induced by manipulation of task load as well as by unpredictable stress. Previously cited studies on poststress aggression (Donnerstein & Wilson, 1976) and poststress helping (Sherrod & Downs, 1974) can be similarly viewed from this perspective.

**Learned Helplessness Theory**

Glass and Singer (1972; see, also, Seligman, 1975) suggested that aftereffect deficits
are attributable to learned helplessness. They argued that subjects who are unable to predict and control a stressor learn that their reinforcements are independent of their responses, which results in motivational decrements that are manifested in poorer performance on poststimulation tasks. Such an interpretation requires at least two assumptions: (a) Learned helplessness can be induced when performance on the experimental task (task performed during stressor exposure) is not instrumental in escaping or avoiding the aversive stimulus; and (b) helplessness will generalize to a wide range of cognitive tasks, including tasks that do not require a direct problem-solving strategy. (Test tasks used in learned helplessness studies usually require subjects to initiate responses in a trial-and-error fashion; cf. Wortman & Brehm, 1975.)

Evidence relevant to this last assumption has been reported by Cohen et al. (1976). These authors found that task impairment on the Glass and Singer aftereffects tasks can be replicated when a more standard learned helplessness pretreatment is used. Employing a pretreatment used by Roth and her colleagues (e.g., Roth & Bootzin, 1974) in previous studies, Cohen et al. found that subjects who received noncontingent reinforcement showed deficits on the tolerance for frustration and the Stroop color word task similar to the deficits found by Glass and Singer for subjects exposed to uncontrollable noise. Further support for the helplessness explanation is provided by a study by Glass and Singer (1972) in which subjects who were told that solving experimental puzzles would terminate the noise, but who actually received insoluble puzzles, took more time to solve a final puzzle that was solvable than those subjects who had been working on soluble puzzles and perceived that they were shortening noise exposure (p. 89). Both of these studies confounded controllability and success–failure. (Cohen et al. did attempt to minimize this effect by yoking the contingent and noncontingent groups on number of reinforcements and number of trials.) As mentioned earlier, a number of learned helplessness studies involved the administration of escapable or unescapable noise. However, since controllability and success–failure are also confounded in these studies, it is unclear whether they are appropriate analogs of the aftereffects paradigm.

The strongest source of support for the learned helplessness interpretation comes from the naturalistic studies of stress aftereffects. Work in crowded college dormitories (Baum & Valins, 1977), in high-density low-income housing (Rodin, 1976), and in schools located in the air corridor of a busy urban airport (Cohen et al., 1980) all suggested that those living under environmental stress show behavioral manifestations of helplessness.

Although the above data lend support to the helplessness hypothesis, there are recent data that call the helplessness interpretation into question. Seligman (1975) argued that a major consequence of experience with uncontrollable events is motivational—undermining the motivation to initiate voluntary responses that control other events. One manifestation of the motivational deficit is that “helplessness retards the initiation of aggressive as well as defensive responses” (Seligman, 1975, p. 33). A study by Donnerstein and Wilson (1976), however, indicated that after stimulation is terminated subjects who lack control over noise are more (not less) likely than subjects with perceived control over the noise to shock a person who angers them.

The helplessness interpretation is especially compelling because it provides an obvious explanation for poststimulation effects on the extremely reliable Feather task. That is, less persistence on a difficult task is characteristic of helplessness. It is, however, difficult to explain why increased task load would lead to helplessness, especially when success feedback is held constant across conditions (Cohen & Spacapan, 1978, Experiment 1). Moreover, helplessness is accompanied by a relatively negative affective state (Gatchel et al., 1975; Miller & Seligman, 1975; Pittman & Pittman, 1979; Seligman, 1975). Yet aftereffect studies generally reported no differences between conditions in reported affect following stressor exposure (e.g., Cohen & Spacapan, 1978;
Glass & Singer, 1972; Mills & Krantz, 1979, Experiment 2; Pennebaker, Burnam, Schaeffer, & Harper, 1977; Wohlwill et al., 1976). In addition, the overall mood tone of subjects in all conditions is sometimes positive (e.g., Cohen & Spacapan, 1978; Wohlwill et al., 1976).

Arousal Theory

A number of investigators have mentioned the possible role of arousal in producing aftereffects (e.g., Evans, 1978; Glass & Singer, 1972; Poulton, 1978). The most popular form of this theory assumes that those exposed to uncontrollable and unpredictable stressors show higher levels of arousal immediately following exposure than those exposed to predictable and/or controllable stressors. How would increased arousal affect poststimulation task performance and social behavior? It is generally believed that there is an optimal level of arousal for performance of a particular task (cf. Poulton, 1970). Performance increases with increments in arousal up to that optimal point and decreases as the arousal level increases above that point (the classic inverted U curve). This proposed relationship between arousal and task performance is often attributed to a narrowing of attention that occurs under conditions designed to induce arousal (Easterbrook, 1959). The first inputs to be reduced (dropped out) are those that are irrelevant or only partially relevant to task performance. As arousal increases, attention is further restricted and task relevant cues are also neglected. In some tasks, proficiency demands the use of a wide range of cues (e.g., dual-task performance or single tasks that require the integration of information from many sources). Any narrowing of attention is likely to adversely affect performance of such tasks because remaining attention would likely be less than that required to process task-relevant cues. In other tasks, proficiency demands the use of only a restricted range of cues. Such tasks improve with moderate reductions in attentional span (improvement in performance occurs only to the extent that reducing competing cues facilitates a particular task) but are detrimentally affected when available attention falls below that required to process task-relevant cues. Thus, continued reduction in attentional span will improve and then impair performance.

It follows that the optimal level of arousal (and thus attentional focus) varies with the complexity (number of cues required) of the task. Optimal levels of arousal for complex tasks are lower than those for simple tasks. Thus high levels of arousal, like those that are presumably elicited by laboratory stress manipulations, are usually assumed to have detrimental effects on complex tasks but not on simple tasks. Assuming that the standard aftereffects measures are complex tasks and that subjects are experiencing a high level of arousal following stressor termination, arousal theory would account for poststimulation deficits in task performance. However, it is unclear whether the standard aftereffects tasks can be considered complex and/or whether they generally show performance deterioration under heightened levels of arousal. For example, existing data show that Stroop performance often improves under arousal-inducing conditions. (See the review in Broadbent, 1971.) This improvement is attributed to an arousal-elicited focusing of attention on appropriate task cues (colors) and to a consequent dropping out of competing cues (words). As an aftereffects task, Stroop performance suffered following exposure to unpredictable and uncontrollable stress. Moreover, the proofreading task could be classified as a simple rather than a complex task, since it involves processing of only a restricted range of cues (cf. Easterbrook, 1959). Thus we might also expect improved performance on proofreading under heightened arousal.

To further complicate the situation, Poulton (1978) has argued that postnoise effects on task performance are due to the level of arousal falling below normal following exposure. If we assume that the standard aftereffects tasks are simple, this approach would similarly provide an explanation for poststimulation effects, since optimal levels of arousal for simple tasks are presumed to be high and any decrease in arousal would cause a decrease in performance.

Insensitivity . social cues can also be ex-
plained by the arousal model if we assume that levels of arousal are increased following exposure to unpredictable, uncontrollable stress. Increases in arousal level are said to be associated with a focusing of attention on cues most relevant to task performance (Easterbrook, 1959; Kahaneman, 1973). As suggested in our earlier discussion of Cohen's (1978) attentional model, attentional focusing could lead to an insensitivity to others' needs.

The omnipresent problem in making arousal theory interpretations is the elusiveness of the arousal concept. Although a detailed description of this problem is beyond the scope of this article, it is important to point out that it is unclear how an investigator is to determine a subject's level of arousal. Some argue for behavioral (subjects behave "as they should" when aroused) and self-report measures (cf. Poulton, 1970), and many investigators use physiological measures—usually measures of autonomic response. Unfortunately, behavioral, physiological and self-report measures of arousal do not consistently correlate with one another (cf. Poulton, 1970). Moreover, it is generally accepted that there is no unitary form of physiological arousal (cf. Lacey, 1967) and that individual physiological measures do not correlate with one another. (See the review by Sternbach, 1966.) Nevertheless, many investigations of arousal under stress in laboratory situations use only one or two measures and assume that they reflect a general level of arousal. Thus the first point to be made is that the existing data on the relationship between poststress arousal level and performance are suspect, since we are not sure what arousal is or how it is to be measured and since we are sure that the way it has been measured in the past is inadequate.

Do those exposed to unpredictable and uncontrollable stressors show different levels of physiological arousal than those exposed to predictable and/or controllable stressors after the stressor is removed? There are little existing data on physiological response after exposure is terminated, but there are considerable data on relative levels of arousal at or near the end of the stress session.3 Glass and Singer (1972) used three phasic measures of arousal in their research: Palmar skin resistance, vasoconstriction of blood vessels in the fingertip, and an electromyographic (muscle tension) measure. They reported that subjects habituate on all three autonomic channels, irrespective of the unpredictability and perceived controllability of the noise. That is, by the end of the exposure period, there is no difference among experimental groups in the levels of reaction to stressor stimuli obtained. A similar lack of differences between conditions in phasic response was reported in two studies of perceived control over the termination of noise by Pennebaker et al. (1977). This lack of differences, however, is inconsistent with some earlier research which suggested that there are significant reductions in electrodermal response, in conditions in which the subject can control or predict the onset and/or offset of stressor stimuli (e.g., Champion, 1950; Corah & Boffa, 1970; Geer, Davison, & Gatchel, 1970).

It is, however, more generally acceptable to use tonic rather than phasic response as a measure of a general level of arousal (cf. Glass & Singer, 1972). The only study that compared tonic response after exposure to predictable or unpredictable noise (Weidner & Matthews, 1978) found that subjects exposed to noise as compared with quiet had

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3 The exception to this is evidence that during the initial stage of a word puzzle, administered after noise exposure, students exposed to inescapable noise (learned helplessness condition) had a lower skin conductance level (SCL) than did those exposed to escapable noise (Gatchel & Proctor, 1976; Gatchel et al., 1977). An experimental control group in which subjects merely listened to loud tones (equivalent to the Glass and Singer no-control condition) showed the lowest SCL. There were, however, no differences between conditions in skin conductance response in either study. Moreover, the earlier study (Gatchel & Proctor, 1976) found no differences among escape, experimental control, and no-escape (helplessness) conditions following noise for either spontaneous skin conductance fluctuations or heart rate. As suggested earlier, these studies did not find postnoise behavioral aftereffects in the experimental control condition that was similar to the no-perceived-control condition in the Glass and Singer study.
elevated hand temperature and blood pressure but that subjects exposed to predictable versus unpredictable noise showed no difference. Glass and Singer also reported that there were no differences between various experimental conditions in their studies in the level of skin conductance during stressor exposure, and a later study of control over electric shock (Glass et al., 1973) similarly indicated no difference between conditions in tonic conductance. Some earlier studies, however, suggested that those with control over termination of a stressor do show lower tonic levels during stressor exposure (e.g., Geer et al., 1970), although the evidence is mixed (e.g., Glass et al., 1973; see also, review by Averill, 1973).

Comparisons of tonic arousal levels under stress and no-stress conditions (no manipulations of control or predictability) have, however, suggested differences at or near the end of the stress session (e.g., Aiello, Epstein, & Karlin, 1975; Evans, 1979), but only mixed support for differences comes from the studies that assessed arousal after the stressor was removed (Frankenhaeuser & Lundberg, 1974; Rotton et al., 1978; Weidner & Matthews, 1978). Thus it appears that there is little evidence for differential levels of physiological response following stressor termination. However, as we have suggested, "the fact that one autonomic measure fails to reveal expected differences does not necessarily rule out the existence of arousal differences" (Glass & Singer, 1972, p. 146).

Self-report measures of stress also provide only meager evidence for differential levels of arousal among the various experimental conditions. Although Glass and Singer (1972) reported a study in which one self-report measure suggested greater stress for those in the unpredictable, uncontrollable stress conditions, as opposed to those exposed to predictable and/or controllable stress (p. 66), for the most part these measures vary with the presence or absence of the stressor but not with the presence or absence of control or predictability. Several later studies (Mills & Krantz, 1979, Experiment 2; Pennebaker et al., 1977) similarly reported no differences between those with and those without control on self-reports of frustration, tension, and alertness. The previously described study by Sherrod and his colleagues (1977) also found that neither initiation nor termination control affected self-reports of stressfulness.

In sum, there is little evidence for differential levels of arousal following an unpredictable, uncontrollable stressor, as opposed to predictable and/or controllable stressor. Moreover, it is also unclear whether such differences in arousal level would have consistently negative effects on the standard aftereffects tasks.

Frustration-Mood Hypothesis

A simple explanation for the aftereffects of stress is that exposure to unpredictable, uncontrollable stressors causes frustration, annoyance, and irritation, which results in a less motivated performance on poststress tasks and in a lower likelihood of being sensitive to the needs of others. There is evidence that those who experience a negative mood state are less likely to help another (cf. Isen, 1970; Moore, Underwood, & Rosenhan, 1973) and that frustration often results in aggression and other negative interpersonal behaviors (e.g., Berkowitz, 1969). Evidence that those exposed to unpredictable, uncontrollable stressors experience negative mood states following stress termination is, however, equivocal.

The study that comes closest to testing the frustration-mood hypothesis is Donnerstein and Wilson's (1976) investigation of poststress aggression. Consistent with the frustration-mood hypothesis, those subjects who were exposed to noise without perceived control (and thus who were presumably frustrated) and who were also angered (additional frustration) administered more shock to a confederate than either subjects with perceived control over the termination of the noise or those who were not angered. A number of other studies, however, do not indicate any differences in poststress annoyance and irritation between those with and those without perceived control (Glass & Singer, 1972; Pennebaker et al., 1977; Sherrod et al., 1977). Moreover, even studies that compared unpredictable, uncontrollable stressors to no-
AFTEREFFECTS OF STRESS

stress experimental control conditions often indicated that there were no reliable differences in reported mood between conditions (e.g., Cohen & Spacapan, 1978; Frankenhaeuser & Lundberg, 1974; Wohlwill et al., 1976) and that the overall mood of subjects in all conditions was positive following the experimental session (e.g., Cohen & Spacapan, 1978; Wohlwill et al., 1976). These studies, however, typically include only one or two global items about the “stressfulness” or “enjoyableness” of the experiment and thus may not provide a sensitive measure of mood. As summarized earlier (in the section on Arousal Theory), there is also little evidence for the differential levels of arousal that one might expect to be correlated with increased frustration and mood shifts. In sum, although a frustration-mood hypothesis is compelling because of its simplicity, there are few data which suggest that significant differences in mood or arousal actually exist following the various experimental conditions.

Persistent Coping Strategies

It is possible that those exposed to unpredictable, uncontrollable stressors use coping strategies during stressor exposure and maintain these strategies even after the stressor is terminated. Although a particular strategy may be adaptive during exposure, it may or may not prove to be adaptive after exposure termination. This persistence may be due to overlearning of a coping response (cf. Rodin & Baum, 1978). This approach suggests that the coping response is under stimulus control but is not voluntary. For example, one may cope with crowding by withdrawing and persist in withdrawing from strangers even when not crowded.

The laboratory study of spatial density by Epstein and Karlin (1975) provided evidence for the persistence of a coping strategy that is used during stress exposure. They reported that single-sex groups of women and men differed in their reaction to crowding stress. Consistent with cultural norms, women tended to share their distress with each other, whereas men tended to hide their distress. These norms of sharing and hiding persisted into the poststress session in which men who had been crowded were less cohesive and more competitive than uncrowded men and in which women who had been crowded were more cohesive and less competitive than uncrowded women. Baum and Valins (1977) studies of dormitory design similarly suggested the persistence of a coping response. Those subjects from dormitories with a high level of forced interaction made more active attempts to avoid the possibility of contact with a stranger outside of the dormitory than those from dormitories with lower levels of interaction. Thus, an avoidance response that presumably developed as an attempt to cope with dormitory life seemed to persist even outside of the dormitory setting.

A persistent coping strategy as a response to prolonged exposure to noise was proposed by Deutsch (1964). She suggested that children reared in a noisy environment eventually become attentive to acoustic cues; that is, they learn to “tune out” sound. In tuning out his or her noisy environment, a child is not likely to distinguish between speech-relevant and speech-irrelevant sounds. Thus he or she will lack experience with appropriate speech cues and will generally show an inability to recognize relevant sounds and their referents. The inability to discriminate sound is presumed to account, in part, for subsequent problems in learning to read. A child who cannot readily discriminate basic speech sounds faces a difficult task in learning to associate these sounds with their appropriate signs.

A study described earlier by Cohen et al. (1973) found some evidence for this hypothesis by establishing that children who spent their earlier years living in an intensely noisy environment were unable to develop adequate auditory discrimination ability and unable to acquire basic reading skills. There was, however, no direct measure in this study of the tuning out strategy. One strong alternative hypothesis is that the traffic noise made it difficult for the children to hear their parents (speech was masked) and consequently to learn auditory discriminations. A later study by Heft (1979), however, does provide evidence for the use of a tuning out strategy on the part of children living in
noisy environments. If children exposed to noise tune out their acoustich environment, they should be less affected by an auditory distractor than are children from quieter environments. Heft found that the performance of children from homes described by parents as noisy was less strongly affected by the presence of an auditory distractor than was the performance of those from homes described as quiet. Unfortunately, children from noisy homes performed more poorly under quiet conditions than those from quiet homes, which suggests that the lack of a distraction effect might be attributable to a base performance level that could not get much worse under any condition (floor effect).

In sum, evidence from laboratory and naturalistic research suggests that persistent coping strategies are responsible for at least some poststimulation effects. Although the data previously described are limited to situations in which the coping strategy is one that develops as a response to a particular stressor (e.g., withdrawal as a response to crowding), it is possible that general strategies that are used to cope with a wide range of stressors persist after stressor termination (cf. Milgram, 1970). For example, the strategy of focusing one's attention on the essential aspects of a task during exposure (e.g., Hockey, 1970; Wachtel, 1968) may persist even after exposure is terminated. This could account for the decrements in performance on complex tasks reported in the aftereffects literature.

Dissonance and Self-Perception

In their early effort to explain aftereffects, Glass and Singer (1972) alluded to cognitive dissonance (Festinger, 1957) and self-perception analyses (Bem, 1967). Briefly, these analyses suggest that since subjects with perceived control choose to be exposed to the noise for little incentive, they judge it less stressing and therefore do not show aftereffects. However, when Glass and Singer (1972, p. 106) turned to a classical dissonance manipulation—allowing or not allowing subjects to choose whether they would be exposed to noise—they were unable to produce aftereffects on the proofreading or Stroop tasks. Sherrod et al. (1977), however, reported that allowing subjects to choose whether they would be exposed to noise did partially ameliorate poststimulation deficits in performance. On the other hand, although the choice manipulation in the Glass and Singer study affected a subject's willingness to participate in a future experiment, Sherrod et al. reported that willingness to participate in a future study was unaffected by manipulations of initiation and termination control. Thus the evidence relevant to this hypothesis is at best mixed.

Although these theories provide an explanation for the ameliorative effects of control, they do not explain why poststimulation effects occur in the unpredictable, uncontrollable stressor conditions. Moreover, it is difficult to apply this interpretation to studies in which subjects have control over an aspect of the situation but not directly over the stressor (e.g., choice of hand to be immersed in cold water, Mills & Krantz, 1979) and studies in which the subject actively copes or implements control (e.g., Glass et al., 1973).

Artifacts of the Experimental Situation

Most of the laboratory aftereffects research has been done with both the exposure task and aftereffects tasks conducted in the same laboratory setting and with the same experimenter. One likely explanation for these effects is that subjects exposed to the more aversive stress—that which is unpredictable and uncontrollable—develop a negative attitude about both the experimenter and the experimental setting. Once deciding that he or she does not like either the experimenter or experiments in general, a subject does not work as hard on subsequent tasks. Glass and Singer (1972) attempted to determine the subjects' attitudes about the experimenter by having them fill out an evaluation form following the experimental session. The form was presented in a way that guaranteed the subjects anonymity and suggested that negative evaluations would not be held against the experimenter. Although there were large mean differences (subjects with perceived control liked the experimenter more than
AFTEREFFECTS OF STRESS

those without control), these differences did not reach statistical significance. Sherrod et al. (1977) also reported no differences between those with and those without control in either liking the experimenter or enjoying the experiment. Later studies that both separated the aftereffects task from the stress situation (e.g., Cohen & Spacapan, 1978; Sherrod & Downs, 1974) and assessed the effects of a naturalistically occurring stressor (e.g., Baum & Valins, 1977; Cohen et al., 1980; Rodin, 1976) are not subject to the artifactual explanation.

Discussion

*What Do We Know?*

The following is a list of the most striking contributions from the studies reviewed in this article:

1. The poststimulation effects of unpredictable, uncontrollable stress on performance have been replicated in a myriad of different laboratories and with a variety of subject populations. They occur as a consequence of a wide range of stressors including noise, electric shock, density, and cold pressor. Moreover, interventions that increase control and/or predictability are effective in reducing these effects. The bulk of the laboratory work, however, has used a limited number of aftereffects tasks whose common characteristics are not clear.

2. The aftereffects of stress can also be induced by high attentional demands. Thus these effects are not limited to a restricted range of stressful situations that involve a lack of predictability and control over a distracting and/or intense stimulus.

3. There are poststimulation effects on social behavior as well as on performance. These effects generally involve an insensitivity toward others following stress exposure.

4. Poststimulation effects of environmental stressors occur following prolonged exposure in naturalistic settings. These studies generally suggest that these effects are mediated by helplessness. It is, however, unclear whether the mechanisms involved in producing these effects are the same as those responsible for deficits in task performance and in interpersonal response following short-term exposure.

5. There is increasing evidence that various forms of control have ameliorative effects similar to those of perceived control over the termination of the stressor. These include termination control in which one actually performs a coping response (implemented control) as well as initiation, choice, and information control. Moreover, some evidence suggests that combining more than one mode of control will further improve poststimulation performance. This improvement, however, seems to reach asymptote at the performance level reached by the no-stress control condition.

We have documented a wide range of stress aftereffects. Although it would be parsimonious to suggest that after further investigation of the problem, the mechanism responsible for these effects will be isolated, the assumption of a unitary explanation for such a wide range of behaviors may be unreasonable. It is likely that the reliability and generality of poststimulation effects occurs in part because of a multiplicity of causes. Thus the eventual goal of research in this area should be to determine the specific conditions that elicit each of a number of cognitive or motivational mechanisms and to determine specific kinds of tasks and behaviors affected by each.

The research reviewed in this article does not provide evidence from which to accept or reject the adaptive-cost hypothesis from which this literature was spawned. However, many of the proposed explanations for stressor aftereffects are, in fact, forms of that hypothesis. They suggest that poststimulation effects are either directly or indirectly caused by the process of coping with stress. The mechanisms proposed included cognitive fatigue that results from the coping effort, feelings of helplessness that result from a failure to cope, and the overlearning of a coping response. Thus 10 years of intensive research has led to the recognition of the costs of adapting to stress, and although this work has answered few specific theoretical questions, it has provided us with an appreciation of the impact of the adaptive process.
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107

AFTER EFFECTS OF STRESS


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