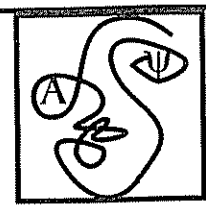

Environmental Stress

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GLOSSARY

adaptation level shifts in environmental perception History of experience with an environmental stressor changes referential criteria for environmental perception of current environmental conditions

behavioral aftereffects Performance deficits following exposure to environmental stressors

cognitive consequences of learned helplessness Lower mastery, reduced self-efficacy, or greater externality in locus of control from chronic environmental stressor exposure.

coping perseveration The use of well-learned coping strategies when an environmental condition is no longer present.

cumulative fatigue The buildup of fatigue from expenditure of energy to cope with an environmental stressor; the three types of cumulative fatigue are behavioral aftereffects, spillover, and diminished coping with multiple stressors.

diminished coping with multiple stressors The reduced ability to cope with a subsequent stressor following exposure to an environmental stressor

effort by environmental stressor interaction Physiological mobilization produced by cognitive or physical effort to maintain task performance during stressor exposure

environmental stressors Physical characteristics of the environment that produce stress (e.g., commuting, crowding, noise, pollution)

learned helplessness The realization, caused by uncontrollable environmental events, that one cannot control one's environment. This may result in diminished motivation to assert control even when feasible to do so, the inability to learn that subsequent challenges that are objectively controllable can be controlled, and feelings of anxiety and depression.

overgeneralization Strategies for coping with chronic environmental stressors may become overlearned so that coping perseveration occurs in the absence of the stressor; adaptation level shifts in environmental perception may also occur

physiological mobilization Elevated physiological stress produced by chronic exposure to environmental stressors; also caused by acute environmental stressor exposure in combination with the effort to maintain optimum task performance.

spillover The negative affect, strained interpersonal relationships, or fatigue produced by exposure to an environmental stressor in one setting that carries over into another setting

Apart from the direct physical insults produced by toxins, mental health, psychophysiology, performance, and human motivation are all affected by environmental quality. In this article, we present a theoretical framework for understanding how environmental quality impacts human behavior. Human beings are not passive recipients of environmental conditions; instead, they work to optimize the balance between environmental conditions and human needs. Human beings thrive in a vast array of ecological niches.

However, we pay a price for our enormous adaptational capacities. The adaptive costs of coping with suboptimal physical conditions provide a theoretical framework for describing how the physical environment influences human behavior. We develop this theoretical framework and illustrate psychological impacts of poor environmental quality.

1. THEORETICAL FRAMEWORK

There are four categories of the adaptive costs of coping with poor environmental quality that have psychological consequences. These categories are cumulative fatigue, learned helplessness, physiological mobilization, and overgeneralization.

1.1. Cumulative Fatigue

It takes energy to cope with suboptimal environmental conditions. Expenditure of energy, particularly when demands are high or prolonged, causes fatigue. Three types of cumulative fatigue are behavioral aftereffects, spillover, and diminished coping with multiple stressors.

1.1.1. Behavioral Aftereffects

Behavioral aftereffects refer to impaired task performance following exposure to an environmental demand. In a typical aftereffects paradigm, an individual works on a task during a physical stressor such as noise. Following cessation of stressor exposure, the individual is asked to perform another task. Compromised performance on the second task, when the stressor is no longer present, is an index of behavioral aftereffects.

In the Glass and Singer behavioral aftereffects paradigm, subjects work on a simple task while exposed to an environmental stressor. Environmental stressors that have been studied include noise, crowding, temperature, and air pollution. During the environmental exposure period, subjects worked on simple tasks (e.g., anagrams). Performance during exposure is generally unaffected. Immediately following task performance under the environmental stressor, the stressor is terminated, and the subject is given a behavioral aftereffects task. Two commonly used aftereffect measures are persistence on a difficult or unsolvable puzzle and ability to detect errors in a proofreading task. Table I depicts a typical set of findings from one of Glass and Singer's studies, in which immediately after uncontrollable noise exposure was terminated, subjects were administered a task that assessed their persistence on unsolvable puzzles.

TABLE I
Glass and Singer Aftereffects Data Following Uncontrollable Noise

	Noise	*Quiet*
Number of attempts on two unsolvable puzzles	10.88	41.20

In addition to the large number of replications of the Glass and Singer aftereffects data across a wide array of environmental stressors, another aspect of this paradigm is noteworthy. Several investigators have examined behavioral aftereffects of chronic environmental stressors such as commuting, crowding, and noise. Bullinger *et al.* noted that the longer the duration of noise exposure in the case of the opening of a new airport, the stronger were the impacts of chronic noise exposure on behavioral aftereffects (see Fig. 1).

1.1.2. Spillover

A second type of cumulative fatigue produced by poor environmental conditions is spillover. Spillover occurs when conditions in one setting influence a subject's well being in another location. A common example of spillover is when poor working conditions interfere with

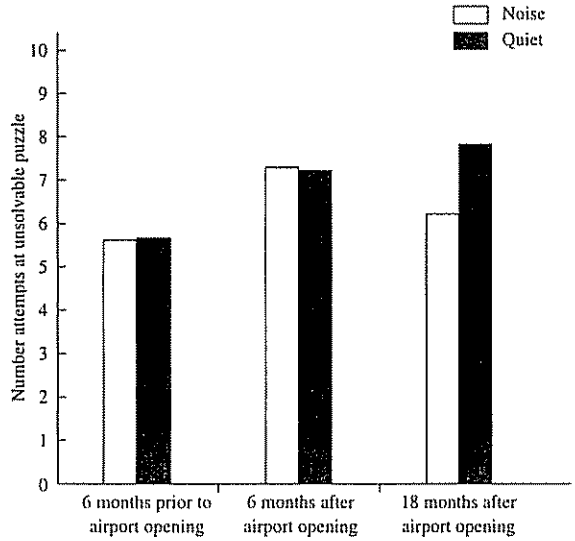

FIGURE 1 Task persistence among elementary aged school children in relation to airport noise exposure before and after the opening of a new airport. Controls matched on SES.

home life. A more congested commute creates interpersonal strains with family members at home. Epstein and Karlin reported that men but not women following a short term crowding experience in the laboratory felt less cohesive and more competitive. Immediately following exposure to crowded shopping conditions or high noise levels in a laboratory, individuals are less likely to behave altruistically when given a chance to provide help in a low stress setting. Table II provides illustrative data. A stranger (experimental confederate) appeared to be looking for a dropped contact lens on the floor of a shopping center in a low-density, inactive area of the center. Immediately prior to the assessment of spillover, subjects had been randomly assigned to perform a series of shopping tasks in noisy and crowded or relatively desolate areas of a mall

1.1.3. Diminished Coping with Multiple Stressors

The effort applied in coping with environmental stressors can result in reduced capacity for coping with subsequent demands. Reduced coping capacity has been found following exposure to noise, crowding, high temperature, and pollutants. For example, the adverse effects of traffic noise on blood pressure in school children are accentuated if they also live in noisy homes. Residents of noisy areas respond more negatively to stressful events than residents with similar backgrounds (SES) who live in quiet areas. Crowding exacerbates the impact of high temperature on negative affect. Maxwell noted that the adverse influence of high-density daycare conditions on children's levels of behavioral disturbances was accentuated by crowding levels in the child's home. Researchers have also investigated crowding interactions with psychosocial rather than physical stressors. For example, elementary school aged children experienced greater physiological stress and psychological distress in relation to greater family turmoil if they lived in more crowded homes and the effects of daily hassles on psychological health in adults were accentuated in high density homes.

Air pollution also accentuates adverse responses to other stressors. The effects of polluted working conditions on respiratory and dermatological symptoms were greater for workers also contending with higher levels of job stress. Evans and colleagues found that ozone was linked to psychological distress, but only among individuals also experiencing stressful life events (see Fig. 2).

TABLE II

Altruistic Behavior Following a Simulated Shopping Task in a Crowded or Uncrowded Shopping Center

	Crowded	*Uncrowded*
Percent of subjects who helped	16.5	56.5
Seconds spent looking for contact lens	15	41

1.2. Learned Helplessness

Attempts to cope with uncontrollable environments can result in learned helplessness. Individuals who try to abate a negative environmental condition and are unable to do so eventually learn that their efforts to control their environment are fruitless. They become unmotivated to assert control (motivational consequences), even when it is feasible to do so, unable to learn that subsequent challenges they confront that are objectively controllable can be controlled (cognitive consequences), and become anxious and depressed (affective consequences).

1.2.1. Cognitive Consequences

Experiencing uncontrollable environments can lead to the inability to learn that controllable environments

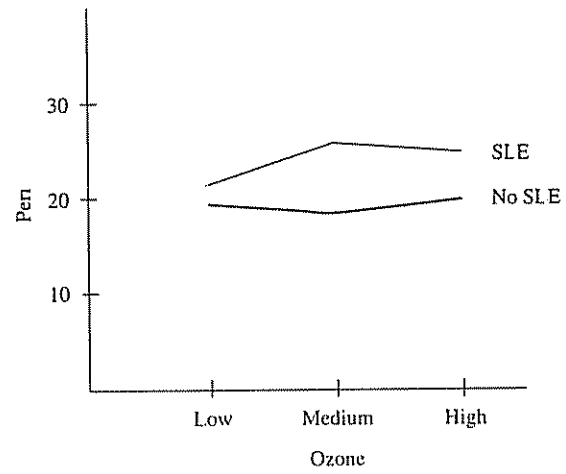

FIGURE 2 Psychological distress as a function of the interaction of exposure to pollution and recent stressful life events among a representative sample in Los Angeles

can be managed or affected by personal effort. For example, individuals living under crowded conditions report less perceived control or feelings of mastery over their immediate surroundings compared to others living under less crowded conditions. Traffic congestion levels negatively impact feelings of control over commuting itself and in general among car drivers. Bus drivers facing more traffic congestion report significantly less control over their job.

Community airport noise exposure has also been linked to diminished feelings of personal control. For example, the typical maturational trajectory of increased internal locus of control was altered among elementary school children living for longer periods of time in airport noise impact zones (see Table III). SES controls were incorporated.

1.2.2. Motivational Consequences

As discussed previously, exposure to uncontrollable noise, crowding, or air pollution leads to deficits in behavioral aftereffects tasks. In the original aftereffects studies, Glass and Singer included an independent variable that points toward learned helplessness as a possible mechanism for behavioral aftereffects. When subjects were led to believe they could terminate the noise if it became too aversive by pushing a button, there were no behavioral aftereffects of noise. This occurred even though no one in this "perceived control" condition actually pushed the button. In short, aftereffects occurred only among those exposed to "uncontrollable" stressors. Table IV adds the noise with perceived control condition to our original behavioral aftereffects example shown before in Table I. Subjects were randomly assigned to conditions.

This salutory effect of perceived control over noise on behavioral aftereffects has been widely replicated. Parallel results have been uncovered in studies of crowding and pollution.

TABLE III
Chronic Noise Exposure and Control Beliefs among Elementary School Children[a]

	Years in residence	
	<3	>3
Low noise	5.56	6.00
High noise	6.00	5.43

[a]Higher numbers reflect greater internality.

TABLE IV
Aftereffects of Noise, Quiet, and Noise with Perceived Control

	Noise	*Quiet*	*Noise with perceived control*
Number of attempts on two unsolvable puzzles	10.88	41.20	41.67

More direct evidence that suboptimal environmental quality can produce helplessness comes from two paradigms. In one paradigm, participants performed a task in order to avoid a noxious stimulus. For some subjects, exposure to the noxious stimulus was contingent upon their performance—by performing well, they could minimize exposure to the noxious stimulus. Other subjects were "yoked" to the first group in that they were exposed to the same noxious stimulus for the same duration of time. For these subjects, however, exposure to the noxious stimulus was independent of their performance. These conditions (contingent vs noncontingent performance and punishment) were then followed by a second phase in which a performance contingent task was administered. For this task, avoidance of the noxious stimulus was possible for all subjects. Prior exposure to the inescapable stimulus condition induced learned helplessness in the second phase. Even when an instrumental response was available, subjects who had been in the initial inescapable condition took much longer to learn the escape response. Of particular interest is the fact that exposure to inescapable noise versus escapable noise reliably produces learned helplessness in adults.

In a second paradigm, vulnerability to the induction of helplessness is related to chronic environmental conditions. Cohen *et al.* gave elementary school children in either airport noise-impacted or quiet schools a jigsaw puzzle to work on. More children from high-noise areas failed to solve the puzzle. Of those children who failed, a larger percent of children from noise-exposed areas failed the puzzle because they simply gave up trying prior to the end of the testing period (see Table V). SES controls were included.

Crowded living conditions similarly affect learned helplessness in children. For example, the longer college students lived in a crowded dormitory, the greater their helplessness behaviors compared to students in

TABLE V
Percentage of Children Who Gave up on a Solvable Jigsaw Puzzle prior to the Total Time Available[a]

	Noisy school	Quiet school
Percent giving up	31	7

[a]Total time available was 4 minutes.

uncrowded dormitories. Moreover, these helplessness behaviors closely mirrored the extent to which they felt powerless to regulate social interaction in their dormitory.

1.3. Physiological Mobilization

The marshalling of coping resources requires energy. This expenditure of energy requires mobilization of physiological resources, as reflected by elevated physiological stress. This occurs primarily in cardiovascular and neuroendocrine systems. Mobilization of energy in response to acute environmental demands is adaptive. The problem occurs with chronic physiological mobilization in order to meet repeated environmental demands. These elevations produce wear and tear on the body, alter the body's ability to turn off these systems when external demands cease, and can eventually lead to physical and psychological morbidity.

Effort and physiological mobilization are interrelated. When performing a task under a stressor, if effort is high, task performance is maintained but physiological mobilization escalates. If effort is low under a stressor, performance suffers, but physiological mobilization is minimal. Thus, there is an effort by stressor tradeoff.

1.3.1. Physiological Stress

A large number of studies have been conducted on occupational noise exposure and blood pressure. The data are mixed and methodological flaws plague many of these studies. Community noise studies have used better designs and revealed consistent elevations in blood pressure in children exposed to airport noise. Fig. 3 shows data comparing school children's physiological stress levels before and after the opening of an airport. Children were tested 1 year before the airport opened, 1 year after, and then again 6 months later.

Crowding has similar effects on the physiological stress response. Crowding has been associated with elevated blood pressure in the laboratory and among institutional populations and in some but not all studies of crowded housing and neighborhoods. Traffic congestion has been associated with elevated blood pressure and stress hormones; more crowded or more difficult train commuting elevates stress hormones as well.

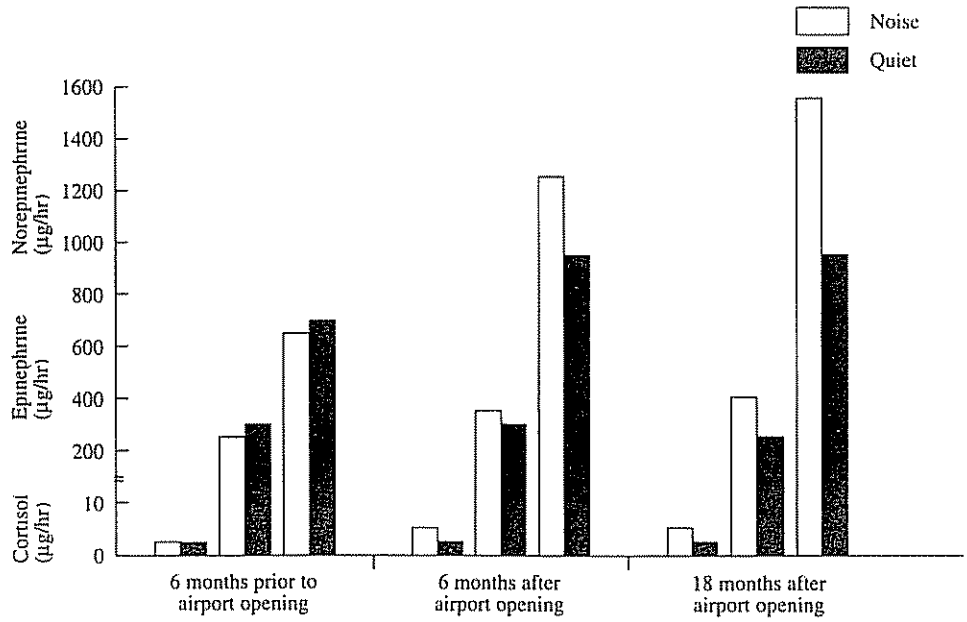

FIGURE 3 Physiological stress responses in children in a prospective study of airport noise. The samples were well matches on SES

1.3.2. Effort by Stressor Tradeoff

Some of the physiological stress accompanying environmental stressors is caused by increased expenditure of effort to maintain task performance. Cardiovascular and neuroendocrine responses to acute noise rapidly habituate, returning to baseline levels. This habituation does not occur, however, when subjects simultaneously work on cognitively demanding tasks during noisy conditions. More direct evidence for the role of effort emanates from studies showing a performance–physiological stress tradeoff. For example, Tafalla and Evans manipulated cognitive effort and noise in a laboratory experiment, finding that noise adversely affected performance but had little impact on cortisol when effort was low. When participants worked under high effort on a task during noise, the opposite profile emerged: no performance effects of noise but elevated physiological stress. See Table VI for an illustration of some of their findings.

Field studies have uncovered analogous job demand by occupational noise interactions on physiological stress. In one study, the impact of noise on blood pressure more than doubled under high- vs low-demands jobs. A similar effort by stressor interaction on performance and physiology was found in a laboratory investigation of crowding.

1.4. Overgeneralization

Humans respond to environmental insults with strategies to optimize the balance between demands and resources. If the demands are chronic, however, coping strategies can become habitual, persevering even when they are not appropriate. Adaptation level shifts in environmental perception may also occur. This is when the reference criterion one uses to judge a current stimulus is influenced by prior history with that same stimulus. These shifts in referential criteria reflect habituation or reduce sensitivity to the stimulus.

1.4.1. Coping Perseveration

Children chronically exposed to noise appear to adopt a cognitive strategy of tuning or filtering out the noise. This strategy, while adaptive when noise is present, may be harmful if it becomes a characteristic strategy for processing auditory information, including meaningful stimuli such as speech. Cohen *et al.* showed that the louder the exposure to traffic noise at home, the more trouble children had in a task that assessed their abilities to discriminate between phonemes (e.g., the sound for b and d, or p and b). The children were prescreened for normal hearing thresholds. As shown in Table VII, noise exposure impairs phoneme perception, which in turn damages reading acquisition. SES controls were incorporated. Other noise studies have found similar relationships.

Perseveration of coping strategies has also been uncovered in studies of crowding. A common strategy for coping with crowding is social withdrawal. If people cope with overcrowded living conditions by socially withdrawing, an unintended consequence might be the breakdown of socially supportive relationships. Evans *et al.*, Lakey, and Lepore *et al.* found evidence for lower levels of perceived support in more crowded residences. The higher the ratio of people per room, independent of SES, the lower the levels of social support. These studies also showed that the link between residential crowding and poor psychological health was mediated by social support.

The adverse effects of residential crowding on social support appear to be caused by social withdrawal. In one study, college students who lived in high- or low-density apartments were brought into the laboratory. The lab was not crowded. The subject and a

TABLE VI
Stressor by Effort Interaction on Physiological Stress and Task Performance

	Low effort	*High effort*
Quiet		
Reaction time	5138	4250
Cortisol	022	013
Noise		
Reaction time	8110	5987
Cortisol	024	026

TABLE VII
Chronic Noise Exposure, Auditory Discrimination, and Reading Acquisition

Variable	*Variance accounted for (%)*
Noise	Phoneme perception = 19
Noise	Reading = 4
Noise, after statistically partialling out phoneme perception	Reading = 0

confederate were placed into situations in which they each needed social support at different times. As shown in Fig. 4, subjects who lived in crowded homes were significantly more unresponsive to the confederate's offers of support. The obverse occurred as well.

1.4.2. Adaptation Level Shifts

People may become so accustomed to suboptimal environmental conditions that they become desensitized to poor environmental quality. For example, an auditory stimulus will be perceived as softer if loud sounds have recently been experienced. Berglund *et al.* found that a given level of noise is less annoying if one has a history of living in a noisy area. Parallel results have been found for chronic residential crowding history and judgments of perceived crowding.

Wohlwill and Kohn examined residential histories and judgments of environmental quality. Adults who had recently migrated to a medium-sized community (Harrisburg, Pennsylvania) were asked to judge the attributes of their new community. Migrants from urban areas judged Harrisburg as significantly less noisy, less crowded, and less polluted than did their counterparts from small towns. In a second study, photographs of environmental qualities of communities varying in scale were shown. Adults from small towns consistently perceived greater levels of noise and crowding for a given photograph compared to individuals from large metropolitan areas.

People's judgments of perceived air quality habituate with continued experience of pollution. Flachsbart and Phillips showed that smaller changes in smog are required to alter judgments of perceived air quality for those unaccustomed to poor air quality compared to those who have prior familiarity with smog. Evans *et al.* analyzed pollution perception with signal detection theory. Signal detection theory enables one to separate perceptual processes from response criteria when judging stimuli. For example, if one is expecting an important phone call, one's threshold (response criteria) for responding to auditory stimuli shifts. It takes less of an indication that a bell has rung under these circumstances in order for someone to check the phone. Note that actual detection sensitivity to hear a bell is not changed, just response criterion.

College students who had recently migrated to southern California were tested. The students were well matched except with respect to prior histories of experience with air pollution. The students were shown two different, unfamiliar scenes of a distant vista. Each scene was shown multiple times with varying degrees of photochemical smog present. Subjects reported whether they saw smog and rated their confidence in their judgments. Students with prior histories of air pollution were less likely to report that pollution was present in a scene compared to people relatively unfamiliar with pollution (Table VIII). Actual visual thresholds of seeing air pollution (detection sensitivity) were equivalent.

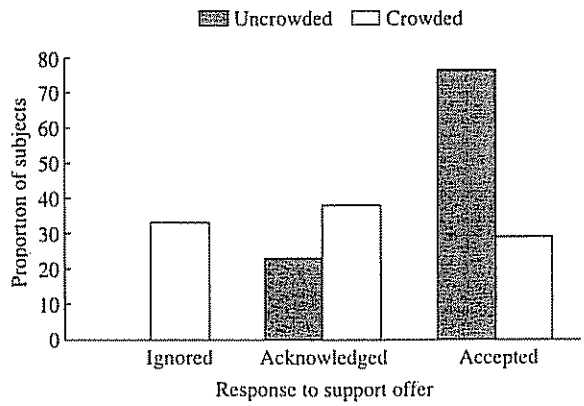

FIGURE 4 Proportion of residents from crowded and uncrowded apartments who ignored, acknowledged, or accepted confederate's social support.

TABLE VIII
Signal Detection Data for Recognition of Smog for People with Long-Term or Little Prior Experience with Air Pollution

History of air pollution	*Response criterion*	*Detection sensitivity*
Long-term experience		
Scene 1	709	2 171
Scene 2	637	2 052
Little prior experience		
Scene 1	211	2 751
Scene 2	276	2 340

2. CONCLUSION

The adaptive capabilities of human beings enables us to cope with a wide range of environmental conditions. Table IX provides a summary of some of the psychological consequences of human attempts to cope with suboptimal environmental quality.

TABLE IX
Adaptive Costs of Coping with Suboptimal Environmental Conditions

Category of adaptive cost	*Types of effects*
Cumulative fatigue	*Behavioral aftereffects*: Performance deficits following exposure to environmental stressors *Spillover*: Negative affect, strained interpersonal relationships, or fatigue produced by exposure to an environmental stressor in a different setting *Diminished coping with multiple stressors*: Reduced ability to cope with a subsequent stressor following exposure to an environmental stressor
Learned helplessness	*Cognitive consequences*: Lower mastery, reduced self-efficacy, greater externality in locus of control from chronic environmental stressor exposure *Motivational consequences*: Diminished motivation in performance or inability to learn new tasks produced by exposure to uncontrollable environmental stressors
Physiological mobilization	*Physiological stress*: Elevated cardiovascular and neuroendocrine activity following stressor exposure *Effort by stressor tradeoff*: Physiological mobilization by cognitive or physical effort to maintain task performance during stressor exposure
Overgeneralization	*Coping perseveration*: Use of well-learned coping strategies when environmental condition no longer present *Adaptation level shifts*: History of experience with an environmental stressor changes referential criteria for environmental perception of current environmental conditions

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See Also the Following Articles

Coping ▪ Privacy ▪ Stress

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