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Journal
Journal of Environmental Psychology, 8(1)

ISSN
0272-4944

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Publication Date
1988-03-01

DOI
10.1016/s0272-4944(88)80023-9

Journal of Environmental Psychology (1988) **8**, 57–75

THE EFFECTS OF ENVIRONMENTAL CHANGE ON INDIVIDUALS AND GROUPS: SOME NEGLECTED ISSUES IN STRESS RESEARCH

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Abstract

Homeostatic models of the effects of environmental change often entail certain assumptions that may not be warranted. It is widely assumed that the effects of negative environmental change or stress are necessarily adverse and have relatively short-term effects. It is further assumed that these effects are linear, that is, the greater the stress, the more negative the outcome. In contrast, from an ecological and developmental perspective, environmental change is seen as having possible paradoxical (i.e., positive) outcomes as well, depending upon the type and timing of the outcome assessed, and situational and individual factors. Non-linear models are reviewed for their applicability to a broader conceptualization of environmental change. This approach includes both multiple determinants and outcomes of stress, and is sensitive to ecological and developmental concerns, such as the timing and context of the stressor and possible long-term outcomes.

Introduction

The central concern of this paper is the effects of environmental change on the behavior and well-being of individuals and groups. Our intent is to develop a conceptualization of the relationship between environmental change and stress that encompasses the temporal aspects of people's environmental experiences. That these experiences unfold over time involves two corollary observations: both positive and negative outcomes can result from an initially stressful environmental change, and the consequences of that change should be examined at multiple levels of analysis (e.g., individual, interpersonal, organizational, and community). To this end, we will briefly review literature relevant to multiple levels of analysis and positive outcomes of stress, then examine in detail theoretical models of environmental change and stress. Before discussing the notion of environmental change, it is important to clarify our use of the term environment.

Conceptualization of Environmental Change

Environments are sometimes described in terms of their social and physical components, their objective (actual) or subjective (perceived) qualities, and their immediacy to individuals (i.e., proximal/distal). Moreover, environments can be described as an array of independent attributes (e.g., lighting, temperature, noise, space arrangement, and group size), or in terms of the composite relationships among several features, as exemplified by constructs such as behavior settings, person-environment fit, and social climate (Stokols, 1987).

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0272-4944 88/010057 + 19 $03.00/0

Given these various dimensions for describing environments, the definition of environmental change could be correspondingly diverse. One could speak of changes that emanate solely from the physical environment, e.g., natural disasters or changes in lighting, or those that emanate from the social environment, e.g., changes in group memberships or divorce (Stokols, 1986). Rather than attempting to delineate a broad taxonomy of environmental changes, we will focus on two specific aspects of environmental change.

First, in most naturalistic settings, it is difficult to separate physical from social changes in the environment. For example, natural disasters affect the social environment as well, and many changes in the social environment have implications for the physical environment, as when divorce or widowhood prompts residential relocation. Even developmental or ontogenetic changes in an organism have implications for social relationships and how the physical environment is used. For example, the achievement of developmental milestones in infancy and early childhood, and physical and mental declines among the elderly, directly affect both family interactions and how the environment is arranged and used by family members. Thus, our discussion of environmental change emphasizes, where possible, composite events comprising both the physical and the social environments rather than discrete and isolated changes in either the physical or social environment. However, traditional studies of stress generally emphasize the social rather than physical environment as sources of stress, and we wish to emphasize that the physical environment plays a crucial role in many stress processes. That role must be more thoroughly delimited in future environment and behavior research (Evans, 1982; Stokols and Attman, 1987).

Second, because our primary interest in this paper is on the relationship between environmental change and stress, we will focus on relatively major environmental changes which have long-term implications for development and/or well-being of individuals and groups of individuals. Little attention will be given to imperceptible changes that occur within either the socio-physical environment or within the individual, such as erosion of the physical environment through routine wear and tear, or gradual changes in individual competencies and physical growth. The term environmental change, as used here, refers to major shifts in the relationships between the person and the environment over time which may originate in either the social or the physical environment.

The purpose of this paper is to explore the consequences, both positive and negative, of environmental change. We emphasize the temporal patterning of environmental change and suggest that: (1) initially negative changes can lead to subsequent positive changes and outcomes, and vice versa; and (2) the effects of environmental change should be examined at multiple rather than single levels of analysis.

Environmental Change and Stress

Early biobehavioral research equated environmental change with stress. Any change, whether positive or negative, was considered stressful in that it required psychological and physical mobilization (Cannon, 1929; Selye, 1956; Holmes and Rahe, 1967). Recently, this equation of environmental change with stress has been criticized, and many studies have found that only undesirable change is linked with negative health outcomes (for a review see Thoits, 1983). Thus, the focus of the research has

shifted to *negative* environmental changes, as exemplified by the literature on stressful life events (cf., Dohrenwend and Dohrenwend, 1974, 1981) and learned helplessness (Seligman, 1975; Wortman and Brehm, 1975).

The usual assumption underlying much stress research is that negative environmental events have negative behavioral and physical consequences. At best, these detrimental outcomes can be mitigated by social support and various coping activities (cf., Thoits, 1982; Lazarus and Folkman, 1984; Cohen and Syme, 1985). An alternative possibility, that environmental changes initally perceived as negative can be associated with longer-term benefits for individuals and groups, has received very little attention in stress research (cf., Taylor, 1983). Generally, the focus of stress research has been on the short-term negative impacts of stressful (negative) events and, to a lesser extent, on the positive psychological and health outcomes resulting from desirable or 'felicitous' environmental changes (cf., Cohen and Hoberman, 1983; Zautra and Reich, 1983).

The emphasis on negative consequences of stressful events experienced by individuals reflects an overly narrow research focus and involves some simplifying assumptions that may be unwarranted. For example, this perspective generally focuses on short-term rather than long-term outcomes. This assumes that stress is episodic, i.e., that it exists within a delimited, and usually short, time-frame, and has readily identifiable and consistent effects on singular response dimensions. Further, the episodic view of stress often assumes that the effects of environmental changes are manifested primarily at psychological or individual (rather than aggregate) levels of analysis. However, many categories of environmental change, whether stressful or beneficial, do not conform to these specifications.

The hypothesized long- and short-term effects of environmental change are outlined in Table 1, which categorizes environmental changes in terms of (1) the positive or negative quality of the event as it is perceived at onset, and (2) the positive or negative consequences that are actually associated with the initial event over time.

Environmental change also has effects at multiple analytic levels within individuals and groups. Table 2 illustrates a variety of analytical levels, ranging from the 'micro' level of psychophysiology to the 'macro' perspectives of sociology and anthropology. The various levels at which stressors and their outcomes occur can be viewed as

TABLE 1
Foci of stress research

Quality of initial environmental change	Quality of outcomes resulting from environmental change	
	Positive	Negative
Positive	1 Psychological and behavioral benefits of positive life events, person-environment fit, and 'restorative' environments	2 Boredom and stagnation resulting from overly predictable and controllable environments
Negative	3 Immunological activation and positive developmental outcomes resulting from coping with environmental challenges	4 Detrimental emotional, behavioral, and health consequences of negative life events and exposure to social and environmental stressors

TABLE 2
Evidence for positive and negative consequences of stressful events at different levels of analysis

Level of analysis	Quality of outcomes precipitated by environmental stressors	
	Negative	Positive
Physiological	Decrements in neuroendocrine functioning and immunocompetence	Increments in neuroendocrine functioning and immunocompetence
Cognitive	Excessive narrowing of attention during and after exposure to environmental stressors	Creativity, heightened awareness, memory enhancement resulting from certain stressors
Affective	Motivational deficits (e.g., learned helplessness) following exposure to stressors	Sense of challenge, competence and positive self-esteem arising from coping efforts
Behavioral	Negative after-effects of stressors on performance	Virtuosity of performance following setbacks from negative life events
Social	Derogation of victims, stigmatization; increased divorce rate in families confronted by chronic ills	Interpersonal co-operation and strengthened social identity and cohesion due to adversity
Cultural	Cultural upheaval and disintegration	Cultural innovation

'nested' or embedded within each other. For instance, a negative life event may have extremely adverse short-term impacts on cognitive performance, emotional well-being and physical health. However, longer-term outcomes at the social (interpersonal) or cultural levels may be positive.

While the findings summarized in Table 2 are not intended to provide a representative cross-section of the evidence concerning environmental change and human well-being, they are useful for highlighting the conflicting findings about stress phenomena that have been observed across several areas of research. These results suggest that the negative effects of environmental change on one level of analysis can be counterbalanced by positive effects on another. For example, parental divorce may be associated with improved mood and developmental benefits in children if the divorce removes the child from an emotionally-troubled parent or a highly stressful, conflict-laden environment (Hetherington *et al.*, 1979; Wallerstein and Kelly, 1980).

Our contextual view of stress suggests that the diverse outcomes precipitated by negative environmental events should be examined as a composite pattern, comprised of the multiple and interrelated changes that are associated with the initial (or 'triggering') events at various levels of analysis. Environmental changes and their outcomes are not self-contained phenomena, but typically become further differentiated into a pattern of subsidiary changes and corresponding impacts on behavior and well-being. These chains of events may be experienced as positive, negative, or a mixture of both (cf., the contextual study of relocation by Stokols *et al.*, 1983).

As noted above, the preponderance of stress research has been on the negative

consequence of stressful events (see No. 4 in Table 1). One of the major purposes of this paper is to provide a brief review of the empirical evidence across a variety of fields documenting the positive effects of negative environmental changes (No. 3 in Table 1). This review suggests that the linear models currently typifying stress research (e.g., negative events lead to negative outcomes) inadequately represent the effects of environmental change. Subsequently, we review the relevance and shortcomings of certain key conceptual models of stress in terms of their ability to address positive and negative effects of environmental change at multiple levels of analysis.

Evidence for the Positive Outcomes of Environmental Stress

Only a brief review of this literature can be presented here. Basically, this literature can be organized by the positive physiological and psychosocial effects of environmental stress.

Physiological effects

Most environmental stress literature focuses on the adverse physiological effects of discrete changes in the physical environment. However, a few studies have suggested that the quality and timing of stressful stimuli can reverse the usual trends and result in more positive effects.

Subjecting infant rats in the first 10 days of life to environmental stressors such as handling or mild electric shock has certain beneficial effects on later behavioral and neuroendocrine functioning (Denenberg, 1964; Levine, 1966; Levine *et al.*, 1967). Exposure to environmental stressors in infancy

> . . . cause[s] an earlier appearance of body hair, earlier opening of the eyes, earlier locomotion, and earlier puberty. In addition, there are complex changes in the brain, including an earlier start to the process whereby neurons become covered by a myelin sheath (aiding in conduction of the nerve impulse) (Gray, 1971, p. 109).

Infant-handled rats also show decreased fear and increased exploratory behavior in open field settings, are quicker to learn avoidance tasks, and are more resistant to conflict-induced ulcers. In adulthood, they also exhibit more flexible adrenocortical responses to stress (Gray, 1971). Infant-handled rats also develop more robust immune systems in later life, as assessed by strength of response to immune challenges (Solomon and Amkraut, 1981).

Thus, it is likely that early handling, at least in rats, does accelerate and enhance the maturation of various physiological systems and may lead to a greater resistance to stress in later life. The developmental effects of handling stress in rats show an inverted-U pattern. Too little stimulation or too much has negative effects on development, whereas a moderate amount appears to have positive effects on physical and perhaps cognitive development.

Under certain conditions, exposure to environmental stressors such as noise and spatial disorientation in adulthood can enhance immune system functioning and retard tumor growth rates in adult mice and rats (for reviews see Monjan, 1981; Riley *et al.*, 1981). The critical factors in immunoenhancement (as opposed to immunosuppression) appear to be the duration and timing of the stress. Counterintuitively, chronic stress may enhance immune system functioning, at least if it occurs prior to exposure to chemical carcinogens, viral or bacterial agents (Rashkis, 1952; Solomon, 1969; Joasoo and McKenzie, 1976; Newberry, 1976; Newberry and

Songbush, 1979; Solomon and Amkraut, 1981). Chronic or even short-term stress, if induced simultaneously or *after* exposure, results in immune suppression (Solomon and Amkraut, 1981).

Monjan and Collector (1977) have suggested an explanation for this surprising finding. They subjected mice to an intermittent auditory stress at night for 40 days and assessed B- and T- lymphocyte cell responsiveness (a measure of immune system functioning). Exposure to stress initially decreased immune system competence, but the immune system recovered and was enhanced with continued exposure. In fact, their findings suggest that immune system functioning follows a form of the inverted U-curve, with immunosuppression occurring after short and very long exposure to stress, but immunoenhancement occurring after intermediate-term stress. Thus, temporal factors need to be considered when estimating the positive or negative effects of environmental stress on physiological functioning.

Obviously, similar studies in humans are nearly impossible to conduct, given ethical concerns. Further, there are inherent difficulties in generalizing from animal models to humans. But intrigued by the findings on the effects of infant handling in rats, anthropologist J. Whiting and his colleagues utilized cross-cultural data to determine whether there are parallel effects of exposure to environmental stress in human infants (for a review see Landauer and Whiting, 1981). In a variety of samples, mean adult physical stature was shown to be significantly greater in cultures with stressful procedures in infancy (e.g., circumcision, scarification, sleeping apart from parents) than in those cultures which carefully protect infants from stressful stimulation. This finding holds even controlling for nutrition, climate, and a 'variety of genetic, geographic, and historical differences' (Landauer and Whiting, 1981, p. 358). Further, females in these cultures also show an earlier average age at menarche (Whiting, 1965). Interestingly, early vaccination (before age 2) also appears to enhance physical growth, apart from any effect on morbidity and mortality. Exposure to environmental stressors after age 2, however, does not appear to affect physical growth in children (Whiting *et al.*, 1968).

These findings suggest that enhanced physical maturation may result from exposure in infancy to certain types of environmental stressors in humans as well as rats. To our knowledge, however, studies of immunoenhancement following exposure to stress in adult humans have not been conducted.

Psychosocial effects

The focus in this section is on stress arising from changes in the social environment. As with the physiological studies, exposure to environmental stress in early childhood may have a marked impact on developmental processes. Again, the majority of the studies examining the effects of exposure to stressors in childhood entailing changes in the social environment, such as death of a parent or separation from parent, focus on deleterious consequences (for reviews see Furman, 1974; Rutter, 1981; Berlinsky and Biller, 1982). However, children can be remarkably resilient to stress (Murphy and Moriarty, 1978; Werner and Smith, 1982; Garmezy, 1983), and, in some cases, may demonstrate enhanced psychosocial functioning in later life.

For example, scientific and artistic genius have been found to be associated with bereavement in childhood. Some 20–30 percent of generally-acknowledged geniuses have experienced the death of one or more parents in childhood, as compared to

an expected 5–10 percent in similar populations (Eisenstadt, 1978; Albert, 1983; Simonton, 1984). A possible confound is that extremely gifted individuals tend to have older parents who would possibly be more likely to die while their offspring were still young. As yet, no study of bereavement and genius (to our knowledge) has controlled for this factor.

Elder's (1974) study of the effects of economic deprivation on middle- and working-class children during the Depression nicely demonstrates the importance of examining the effects of environmental change over time and on multiple levels. The deprived children were more emotionally sensitive and generally more psychologically distressed than those not experiencing economic deprivation. Over time, however, the middle-class children appeared to profit from their experience: they matured more quickly, were more likely to be responsible, industrious and achievement-motivated, and set clearer goals for themselves than their non-deprived peers. In adulthood, they were more likely to pursue higher education, were financially more secure, advanced in their careers more quickly, and in general demonstrated greater upward mobility than their non-deprived peers. The economically-deprived working-class children, however, did not fare so well and, in general, were more poorly adapted on most measures than their non-economically deprived peers.

Rutter (1981) suggested that children can readily adapt to a single major negative experience (e.g., death of parent), but can be overwhelmed by multiple experiences (e.g., parental death plus poverty or mental illness in the remaining parent). Perhaps economic environmental change for middle-class children, while initially negative, triggered a chain of events that eventuated in enhanced psychosocial functioning. Similar changes in working-class children, given their poorer socio-economic standing, appeared to lead to a chain of negative events that had long-lasting deleterious consequences.

There are many other studies, too numerous to mention, which demonstrate positive effects of initial negative environmental change. For example, suicide rates and admissions to mental hospitals often decrease during times of war (Antonovsky, 1979; Keegan, 1984); forced relocation, while initially deleterious to individual survival, can eventually result in more diverse economies and creative solutions to cultural problems (Scudder and Colson, 1982). Clearly, more sophisticated models of stress and environmental change are needed to accommodate differing outcomes over time and at different levels.

Theoretical Models of Stress and Environmental Change

As mentioned earlier, most current models of stress assume implicitly or explicitly that the relationship between stress and negative outcomes is linear; that is, the greater the stress, the more likely the negative outcome (see Figure 1a). Accordingly, stressful life events (SLE) rating scales are additive; respondents are asked to rate the stressfulness of negative events on scales of increasing magnitude. The regression models generally used to test the effects of stress also assume linearity. However, these linear models cannot readily account for the multiplicative effects of stress, for positive outcomes of initially negative environmental changes, or for outcomes at different levels of analysis.

Based on the findings in the physiological literature showing impaired immune functioning following short-term stress, but enhanced functioning following long-

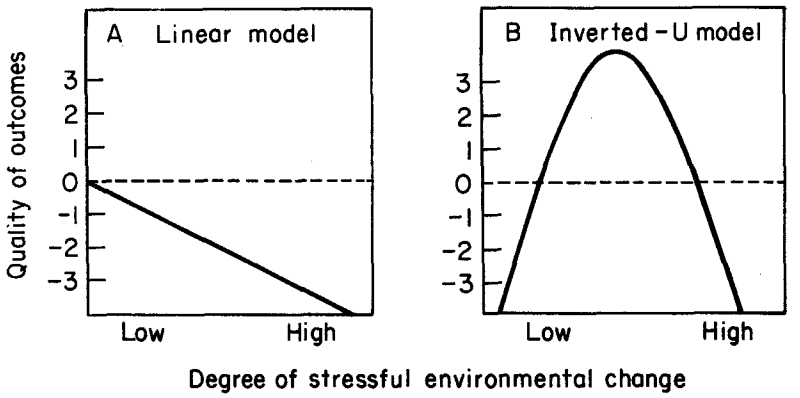

FIGURE 1. Non-temporally oriented models of stress.

term stress, Eysenck (1983) suggested that episodic stress has negative effects, but that chronic stress may have positive effects. However, this model is markedly at odds with the psychosocial literature, in which chronic stress is seen as far more destructive than short-term, episodic stress. For example, Aldwin and Revenson (1986) demonstrated that temporary economic distress had almost no impact on psychological functioning a year later; however, ongoing economic problems markedly impaired psychological functioning (see also Brown and Harris, 1978; Pearlin and Schooler, 1978). It is also well established that exposure to long-term stress can kill experimental animals (e.g., Riley *et al.*, 1981). Thus, it would appear that additional factors other than simple chronicity must be involved in determining positive or negative outcomes of stress.

A non-linear model may best accommodate these somewhat anomalous findings concerning the dual nature of stress outcomes. The three most salient models are the Yerkes-Dodson inverted-U model of performance and arousal (Sanders, 1983), the opponent-process theory of motivation (Solomon, 1980), and a modified systems theory model of deviation amplification (Maruyama, 1963). The remainder of this section examines how well each of these models accounts for patterns of environmental change and stress.

Yerkes-Dodson inverted-U model

The Yerkes-Dodson inverted-U model was originally formulated to describe the relationship between performance and arousal. Simply put, both low and high levels of arousal were thought to result in decreased performance; medium levels of arousal were thought to enhance performance (see Figure 1b). Translating this into a stress model, both low and high levels of stress would be associated with negative outcomes; the positive outcomes would be associated with moderate levels of stress. At first glance, such a model appears to be a powerful tool for organizing the environmental change and stress literature. For example, it is congruent with the findings of Ruch *et al.* (1980), which showed increased symptoms with both low and high exposure to stressful life change, but decreased symptoms with moderate levels. Further, it appears that Selye's three-stage General Adaptation Syndrome follows an inverted-U curve: marked deterioration in physiological functioning in stages

one and three, but improved functioning in the intermediate stage, the stage of resistance.*

Further consideration, however, reveals a number of flaws in the simple inverted-U model. First, the analogy with Selye's General Adaptation Syndrome is not exact: Selye's model refers to the *chronicity* rather than *intensity* of stress, and clearly does not posit that a low level of stress is associated with impaired physiological functioning, as the U-shaped model would suggest. Further, with the exception of the Ruch *et al.* (1980) study, there is little evidence in the stress literature that low levels of stress in an individual's life lead to impaired physiological or psychological functioning. Indeed, Ruch *et al.* suggest that low reported levels of life stress may be more a reflection of neurotic security needs and avoidance of change rather than an accurate reflection of actual levels of psychological stress in a person's life.

Additionally, it is not clear that an inverted-U model accurately describes the relationship between arousal and performance (see Broadbent, 1971), much less environmental stress and health outcomes. Sanders (1983) also has cautioned against simply equating stress with arousal, suggesting little or no correlation between the two. Rather, an understanding of various situational contingencies is needed to describe these relationships. This argument is especially applicable to studies of environmental change. Finally, the Yerkes-Dodson model is a purely descriptive one, and does not afford an *explanation* of why a particular level of stress may have a positive or negative outcome (Lazarus *et al.*, 1974).

Still, from the standpoint of ego psychology, it is tempting to argue for a U-shaped model of environmental change, stress and well-being. If there are positive outcomes of stress, it seems eminently reasonable that these would most likely coincide with moderate levels of environmental change, which could be appraised as challenging. To the extent that individuals learn to master moderately stressful situations, they can add to their coping repertoire and increase a sense of effectance (Murphy, 1974; White, 1974). High levels of change may threaten to overwhelm the ego, resulting in health problems; low levels of change may prove boring, restrict opportunities for growth and insufficiently prepare an individual for inevitable life changes. Given the historical connection between ego psychology and the field of stress and coping (e.g., Menninger, 1963), it is surprising that there have been relatively few attempts to test this hypothesized curvilinear relationship between stress and well-being.

While attractive and no doubt partially correct, especially in a developmental context, an inverted-U model still neglects certain key issues pertaining to the positive effects of stress and environmental change. For example, situational contingencies such as the timing and type of stressor, and the availability of social and environmental resources are, for the most part, neglected. Further, there are the nagging and somewhat unsettling clinical reports of psychological enhancement and social cohesion under conditions of extreme stress (Antonovsky, 1979; Keegan, 1984).

Opponent-process theory

The opponent-process theory was originally formulated as an alternative explanation to the classical conditioning or 'associative-process' theory of acquired motives. Specifically, Solomon (1980) posited that the phenomenon of addiction is not readily

* Eysenck's (1983) observations of enhanced immunocompetence with chronic stress, discussed earlier, may actually be a reflection of a resistance stage.

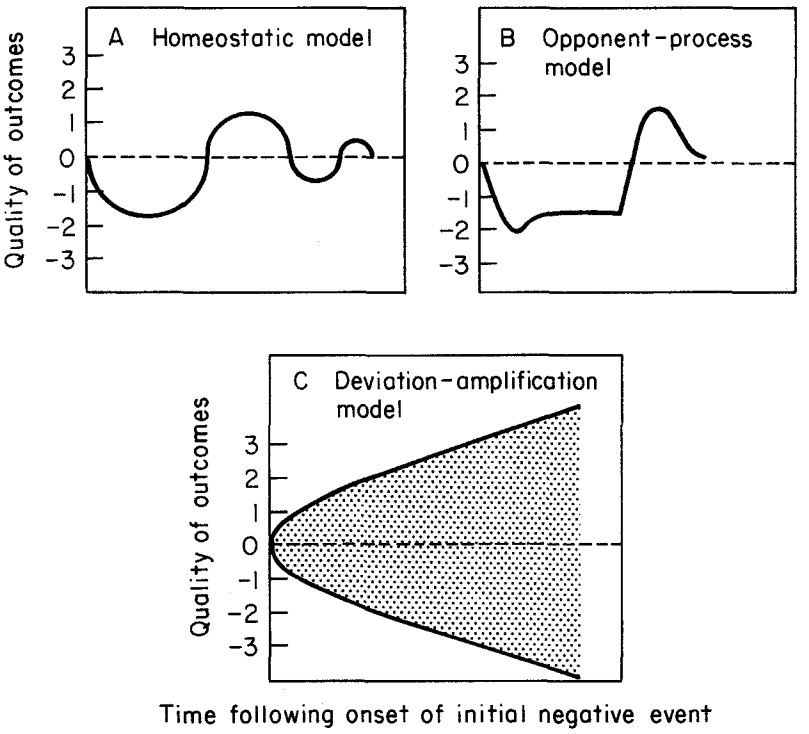

FIGURE 2. Temporally-oriented models of stress.

explained by a simple associative model as it is characterized by the dual phenomena of drug craving and abstinence agony. The opponent-process model focused on affective contrast: a strong affective state, whether positive or negative, is thought to be followed by its opposite or opposing affective state. Individuals facing an extremely stressful experience (e.g., parachutists) may find that their initial terror is followed with euphoria once the episode has passed (cf., Epstein, 1982). Of course, the opposite pattern also holds: initial positive affect may be followed by negative affect, as is often the case with drug addiction.

The opponent process theory posits that a change in affective patterns (state *a*) stimulates the opposite, or opponent process (state *b*). Whether or not an organism is in state *a* or state *b* is determined by an (unspecified) summation process, or $/ a - b /$. At the onset of the excitatory stimulus, the *a* process is more intense than the opposing *b* process, which diminishes the intensity of the state *a* affect. Once the excitatory stimulus is absent or habituation has set in, the *b* process becomes dominant (see Figure 2b). Further, there appear to be temporal changes in this opponent process. During the initial presentations of a stimulus, the *a* process is stronger than the *b* process; however, after many presentations, the organism no longer reacts as strongly during the *a* phase, but there is a concomitant increase in the *b* phase.

Solomon argues that the opponent-process model applies to several phenomena, such as drug addiction and parachute jumping. For example, the first few times opiates are used, the experience is generally pleasurable with only mild ensuing discomfort. But when opiate use becomes more frequent, the initial doses are no

longer adequate to produce the same level of euphoria (state *a*), and the negative after-effects increase in strength (state *b*). Increasing the dosage in an attempt to recapture the initial euphoria results in an even stronger opponent process, until the unfortunate addict needs the drug simply to escape from state *b*. Similarly, the initial terror of the first few parachute jumps is followed by a state of euphoria. Eventually, the terror wears off, and most experienced parachutists can approach the jump with relative equanimity; however, they still experience euphoria following the jump.

The opponent process theory of motivation is highly relevant to stress research. In many ways it is more sophisticated than and extends a simply inverted-U curve with a function that more closely resembles a sine curve. The proposed rebound effect may account for some of the positive outcomes of stress such as euphoria or relief at the conclusion of a stressful episode, and enhanced immune functioning following initial depression. It also may account for clinical reports of positive affect following extremely traumatic episodes in a way that the inverted-U model does not. However, there are a number of problems in applying this model to research on environmental change.

First, the opponent-process theory is based mainly on laboratory or field studies that examine a single, episodic stressor (e.g., parachute jumping). It may not apply very well to changes in the environment that include chronic or multiple stressors. One would predict from an opponent-process standpoint that environmental change resulting in depression should always be followed by euphoria or mania. While this may occur with bi-polar depressions, it clearly cannot account for chronic or uni-polar depression (e.g., Ranieri and Weiss, 1984) or for the multiplicative effects of stressors. It may be that multiple stressors overwhelm the usual mutually-inhibitory processes to create chronic, negative conditions. Horowitz's (1976) studies of cyclic, long-term negative reactions to trauma provide evidence against a simple application of opponent-process theory to stressful environmental change.

Second, many environmental changes provoke both positive and negative experiences. For example, a new job may yield several benefits (increased responsibility, status, income), but also have certain drawbacks in terms of increased demands. It is not immediately clear how the opponent-process theory would handle such a mixed event. While it might be argued on the basis of the summation process that the two types of affect (i.e., multiple state *a*'s and *b*'s) would simply cancel each other out, it is more likely that some sort of sequencing or amplification of affect would occur.

A mechanism for the affective summation process has yet to be proposed. While the conception of opponent processes in affective states is a logical extension of the well known mutually-inhibitory characteristic of central nervous system pathways (see Hurvich and Jameson, 1974), a more explicit statement of the summation mechanism, perhaps cast in terms of limbic system processes, might offer a more adequate conceptualization of stressful events and outcomes.

Finally, the opponent-process theory neglects major contextual factors such as the timing and sequencing of change, parameters such as chronicity and severity, and also differences in how individuals react to environmental change. Nonetheless, if opponent-process theory can be translated into a form that is appropriate to field (as opposed to laboratory) conditions, it may prove to be a powerfully predictive model (cf., Craig and Siegel, 1980).

Thus, both the inverted-U and the opponent-process model of stress and environmental change are limited. The first model is descriptive rather than predictive, and does not encompass various factors that are relevant for influencing the outcomes of change, such as its timing, chronicity and rapidity of occurrence. Opponent-process theory, while promising, is also limited by its inability to include multiple environmental events and chronic negative affect. What is needed is a theoretical framework that accounts for environmental complexity, contradictory outcomes, and the potential multiplicative effects of negative environmental change.

Systems theory: deviation countering and deviation amplification

At first glance, systems theory offers a broad theoretical framework for untangling the complicated effects of environmental change. As we have seen, multiple factors at biological, psychological, social and environmental levels can singly or interactively moderate the effects of stressful events. Systems theory offers a framework for representing the multiple relationships in such complex interactions. However, traditional systems theory, such as that proposed by von Bertalanffy (1950), posits an essentially homeostatic model, in which multiple feedback loops return the organism to a homeostatic state (see Figure 2a). As traditionally formulated, systems theory would be hard-pressed to handle change in the organism, whether positive or negative, as an outcome of environmental change.

Maruyama (1963) proposed a modification of systems theory that can accommodate non-homeostatic relationships between environmental stressors and their effects on individuals and groups. The proposed two-stage model of mutually-causal processes is quite relevant for research on environmental change. In this model, there are two types of systems involving mutual feedback: deviation-countering and deviation-amplifying systems. Deviation-countering systems are the ones most commonly studied, and involve self-regulation and equilibrating mechanisms with a single feedback loop. Examples include thermostatic temperature regulation, normal weight maintenance, and personal-space regulation in group situations.

Deviation-countering processes can result in stabilization or oscillation. Most stress models implicitly or explicitly assume some sort of stabilization or return to a steady state (e.g., Cannon, 1929; Selye, 1956; Holmes and Rahe, 1967). Horowitz's (1976) description of the stress response syndrome, in which a traumatized individual alternates between heightened and flattened affect, is a good example of an oscillation mechanism.

In contrast, a deviation-amplification approach does not assume a return to equilibrium, but rather postulates change, either increasingly positive or negative, as the outcome of an ongoing process. Examples of deviation-amplification mechanisms include Myrdal's (1962) 'vicious circle' model of economics and poverty, and Smith's (1968) 'spiral' model of development and adaptation, and extreme weight loss or gain. In a study of financial strains and stress, Aldwin and Revenson (1986) found that individuals in poorer mental health are more likely to report negative economic events during times of economic downturns. Economic stress, in turn, further increases the severity of emotional distress and can precipitate a downward adaptational spiral. Similarly, emotionally-troubled individuals are likely to engage in maladaptive coping strategies that may actually intensify their troubles (Coyne, Aldwin and Lazarus, 1981; Felton and Revenson, 1984; Aldwin and Revenson, 1987).

The deviation-amplification model also applies to the positive outcome of negative environmental change. According to Maruyama, deviation-amplifying processes can account for dissimilar products of similar conditions: 'a small initial deviation, which is within the range of high probability, may develop into a deviation of low probability . . .' (p. 167). For instance, relatively minor differences in coping resources and strategies, if they trigger deviation-amplification processes, can result in outcomes that are disproportionate to the size of the initial differences. Elder's (1974) research on children of the Depression cited previously exemplifies this process. While both lower- and middle-class economically-deprived children often sustained comparable financial hardships and manifested considerable emotional distress, the middle-class children managed to rebound and demonstrate more positive adaptational practices in later life than non-economically-deprived middle class children. In deviation-amplification terms, the experience of successfully coping with adversity may have encouraged more adaptive orientations among these individuals, thereby allowing them to become more successful than their non-deprived counterparts. Economically-deprived lower class children, however, continued to fare poorly throughout their lives in contrast with non-economically-deprived lower class children. These children and their families may have had insufficient material and psychosocial resources to successfully rebound from these experiences, and a negative deviation-amplification process may have been set in motion. Thus, a deviation-amplification model can incorporate developmental processes and contextual factors in stress research.

An added benefit of a systems model of environmental change is that deviation-countering and deviation-amplification processes are not seen as conflicting models but rather are construed as alternate possibilities, depending on the nature and number of negative feedback loops. It is not clear, however, how one can determine whether a particular change will result in a homeostatic or spiral process. Maruyama suggests that a simple tally of the number of feedback loops may suffice, with odd numbers of feedback loops resulting in deviation-countering processes and even numbers resulting in deviation-amplification processes. This specification is unlikely to prove useful in studies of environmental change, however, because the number of variables (and, hence, feedback loops) included in field research is often arbitrary and potentially innumerable. In living open systems, it would be impossible to adequately specify all factors that can affect a stress outcome. Thus, whether or not one had an even or odd number of negative feedback loops in any model would be, for all intents and purposes, impossible to determine.

Given our present level of knowledge, we cannot specify precisely the processes whereby an environmental change results in either deviation countering or amplification. We can, however, hypothesize that some environmental changes are by definition self-limiting (e.g., relatively minor), while others have the potential to function as 'triggers', setting off a spiral of subsidiary changes and outcomes (see Figure 2c). We also can suggest a number of factors that may play a determining role in whether a particular environmental change is self-limiting, or, instead, results in either an adaptive or maladaptive spiral of change. These factors include the timing, speed, and scope of the change, as well as its meaning to the individual. Environmental changes which occur at a particularly inopportune time, with great rapidity, disrupt several different life domains (Rutter's multiplicative effects), and which hold symbolic meaning for the individual, are expected to result in amplifi-

cation processes, either positive or negative. However, it is also possible that relatively fortuitous or chance occurrences, while initially minor, may set off a chain of events that spreads across domain levels. Thus, it may be impossible to predict with any certainty whether or not a particular environmental change will be self-contained or self-differentiating.

For example, a car breaking down on the freeway is an episodic stressor with immediate and relatively narrow impacts, primarily psychological and financial. Thus, one would expect to find deviation-countering mechanisms of the stabilizing type—the person returns to his or her everyday routine after having the car fixed. A traumatic episodic stressor, such as rape, on the other hand, may promote a broader range of outcomes (psychological, physical, and social) and may be more likely to result in a sustained syndrome of stress. Stressful situations that are extremely traumatic, affect multiple life domains, or those of long duration may be more likely to result in stress amplification processes. This disruptive potential of certain environmental changes is attributable to their *momentum*: relatively small changes may be easily stopped or reversed but large changes occurring with great rapidity and involving a large number of life domains ('mass') may have increasing momentum and be much more difficult to control.

Fortuitous events, however, may complicate an initially simple environmental change. In the earlier example of a car breaking down on the freeway, chance events may turn an initially minor problem into a major one. If another car hit the stalled vehicle, a negative spiral could occur, entailing severe personal injury, loss of employment and savings, and a prolonged syndrome of stress. On the other hand, a contrasting chain of (albeit unlikely) events could occur in which the individual whose car broke down meets new people and initiates lasting friendships as a result of the experience, resulting in unexpected social and employment opportunities and a sustained spiral of positive personal experiences.

Given Maruyama's assertion that relatively minor initial differences may spiral into major differences, the term 'catalyst' may best characterize these fortuitous factors. Catalytic circumstances surrounding the occurrence of a stressor may combine in various ways to enhance the probability of a positive or negative outcome by triggering Markovian chains of events. As a case in point, a longitudinal study of stress among marine drill sergeants was conducted to ascertain which factors best predicted court martial for the drill sergeants during an initial two-year period (Cook *et al.*, 1982). The study included a number of social and psychological factors, including locus of control. It turned out, however, that the best predictor of being court-martialled was a measure of physical fitness, namely, resting heart rate. Drill sergeants with lower initial resting heart rates had a lower probability of being court-martialled.

This somewhat improbable finding can be explained within a deviation-amplification framework if a reasonable chain of events can be reconstructed. Drill sergeants function within an extremely stressful environment. They work long hours, engage in strenuous physical activity, have little time for wives and family, and must cope with the social and emotional demands of training young recruits. A sergeant in good physical condition may be better able to cope with the physical demands of the job and become less tired, thereby enabling him to deal with multiple psychosocial demands and more effectively regulate his emotions in stressful situations. Court martials generally result from a sergeant losing control and physi-

cally or verbally abusing recruits. Thus, poor physical conditioning may contribute to a chain of events that eventually can lead to abuse of recruits and a court martial. Other contextual factors may also influence the likelihood of a court martial, including more or less supportive wives and superior officers, the personal characteristics of the recruits, and the beliefs of drill sergeants about the best way to train recruits. A deviation-amplification model suggests the importance of considering alternate sequences of events and fortuitous factors in attempting to explain the consequences of environmental change.

An analysis of the interrelationships between different life domains also may be crucial for predicting the occurrence of deviation-countering or amplification processes. Assume, for example, that individuals' lives can be divided into more or less discrete domains: work or school, marriage, parenting, friendships, religious and leisure activities. If there are strong interconnections between these domains and a relative balance of personal commitment across domains, environmental change may evoke deviation-countering processes because the events occurring within each domain may be related to each other in a compensatory fashion. For example, being laid off from work may not result in a negative adaptive chain if the individual can still take satisfaction in his or her marriage and children, and if friends can help find new employment (e.g., Cobb and Kasl, 1977). If, on the other hand, the individual has imbalanced commitments across life domains (e.g., most of his or her energy revolves around work, with insufficient attention paid to other domains), the individual may not have enough resources among family and friends to counteract the deviation resulting from job loss, and a maladaptive chain of outcomes may ensue. Note that imbalances can result in positive spirals as well: many highly creative and successful individuals, such as artists, may commit the majority of their time and energy to their work, setting the stage for extraordinary career success. If, at the prinnacle of their success, they strengthen their commitments in other life domains, a positive adaptive spiral can occur. Thus, the temporal and social context of imbalanced commitments to various life domains can influence the occurrence of either deviation countering or amplification processes across those domains.

In sum, a deviation-amplification model may be most appropriate for examining the effects of environmental change on individuals and groups. Whether or not an environmental change is self-limiting or serves as a catalyst for adaptive or maladaptive spirals depends upon a large number of factors, including characteristics of the environmental change itself, the context in which environmental change occurs, and fortuitous events.

Summary

Linear models of the impacts of stress offer an insufficient basis for understanding the developmental, social, and health outcomes of environmental change. This paper sought to illustrate the possibility that initial negative environmental changes, both in the physical and the social environment, may promote positive outcomes under certain circumstances. A systems perspective suggests that models of the impact of environmental change and stress should account for contextual factors such as the timing, sequencing, and scope of change, as well as crucial personal factors such as coping skills and resources. Moreover, a comprehensive model of environmental change should encompass multiple outcomes of stress, including those that are homeostatic as well as non-homeostatic; those that involve positive as well as

negative organismic change; and those in which the positive and negative outcomes of stressful events occur simultaneously as well as sequentially. We contend that a modified version of systems theory, encompassing multiple environmental, temporal, personal, and fortuitous factors may be required to adequately model these alternative patterns of stressful environmental change.

Acknowledgements

This article was supported by a National Institute of Mental Health Postdoctoral Traineeship 5–J32–MA16868, the Medical Research Service of the Veterans Administration, and the Focused Research Program on Work Environments at the University of California, Irvine. The authors share equal responsibility for the preparation of this paper.

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Manuscript received: 17 *October* 1987
Revised manuscript received: 17 *December* 1987