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The Interaction of Stressful Life Events and Chronic Strains on Community Mental Health[1]

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One of the possible adaptive costs of coping with stress is diminished capacity to respond to subsequent adaptive demands. This paper examined the complex interplay between major life events and one source of chronic strain. Residents of the greater Los Angeles metropolitan area exposed to higher levels of smog, who had also experienced a recent stressful life event, exhibited poorer mental health than those exposed to pollution who had not experienced a recent stressful life event. There were, however, no direct effects of smog levels on mental health. These patterns of results were replicated in both a cross-sectional and a longitudinal study. The interplay of psychosocial vulnerability and environmental conditions is discussed.

There may be different health implications of relatively discrete, short-lived stressful events that often require mobilization of major resources than the more persistent and demanding sources of annoyance and irritation confronted in daily living (Evans & Cohen, in press; Lazarus & Cohen, 1977; Pearlin, Menaghan, Lieberman, & Mullan, 1981). Although one or more

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discrete life events may prove deleterious for many persons, strain probably arises from a constellation of chronic and repetitive stresses.

One of the more important yet largely unresearched predictions of the original physiologically based model of stress was that an individual's capacity to cope with a stressor would be influenced, among several factors, by the demands placed upon that person by other sources of environmental stress (Selye, 1956). To put it in alternative terms, if the effects of various social and physical stressors in the environment share some common mechanism of impact, one cost of coping with environmental demands is reduced capacity to respond to ensuing adaptive challenges (Catalano, 1984; Dubos, 1965; Fleming, Baum, & Singer, 1984).

Although there has been a plethora of recent research on mediating variables in the stress-strain process including social support (Brownell & Shumaker, 1984; Cohen & Syme, 1985), coping resources (Folkman & Lazarus, 1980; Pearlin & Schooler, 1978), psychological defenses (Haan, 1977; Kobasa, 1979), and social and economic resources (B. P. Dohrenwend & Dohrenwend, 1969; Dooley & Catalano, 1980), there is markedly little empirical work on the interaction of social or physical stressors in the stress and strain process (Evans, 1982). This paper examines the hypothesis that exposure to one or more recent stressful life events can alter one's psychological vulnerability to a chronic source of stress, ambient air pollution.

The adaptive cost hypothesis states that individual attempts to adapt to stress may have negative consequences in and of themselves in addition to negative outcomes associated with strain. These adaptive costs may include cumulative fatigue, overgeneralization of coping strategies, helplessness, and reduced ability to cope with other environmental demands. Cumulative fatigue has been found, for example, in poststressor deficits in task performance or decreased social sensitivity (altruism) toward others (Cohen, 1980; Glass & Singer, 1972). Overgeneralization of coping strategies has been indicated, for example, in studies of children chronically exposed to noise (Cohen, Evans, Krantz, & Stokols, 1986). One way children appear to adapt to noise is by tuning out auditory stimuli. Unfortunately, this coping strategy overgeneralizes and children chronically exposed to noise who have normal auditory thresholds have deficits in auditory discrimination (the ability to distinguish similar sounding stimuli). This process has been linked as well to reading disorders (Cohen, Evans, Krantz, & Stokols, 1980). Learned helplessness may follow efforts to cope with stressors that have proven difficult or impossible to modify. Research with both social and physical sources of uncontrollable stress has demonstrated motivational deficits in initiating instrumental responses (Cohen, 1980; Seligman, 1975).

One study has examined cognitive and physiological consequences of the interactions of sequential noise exposures. Individual responses during moderate noise levels (72.5 dBA) changed as a function of immediately prior noise exposure to one of three levels of intensity: 56, 72.5, or 85 dBA. Frankenhaeuserand Lundberg (1977) found that performance in the second, moderate noise, session deteriorated with increasing noise intensity in the initial session. Adrenaline levels and heart rate, however, increased similarly irrespective of prior noise levels. Pearlin et al. (1981) investigated some of the adaptive costs of diminished coping resources stemming from recent stressful life experiences. They found that the occurrence of disruptive job events created new and/or intensified preexisting economic strains which in turn had significant psychological impacts. We know of no research on the interplay among stressful life events and the ambient physical environment.

Although there has been an enormous amount of toxicological and epidemiological research on air pollution and physical health, there is a paucity of research on behavioral responses to air pollution. Community surveys indicate considerable levels of awareness of and annoyance with ambient air pollution. Significant variations in citizen responses are associated with social class, level of knowledge, preexisting respiratory disorder, and amount and length of ambient exposure to physical pollutants (Barker, 1976; Evans & Jacobs, 1981). Laboratory studies show that secondary cigarette smoke (Jones, 1978; Stone, Breindenbach, & Heimstra, 1979) as well as malodorous pollutants (Rotton, 1983) cause annoyance, irritation, fatigue, and negative affect plus lead to dislike and avoidance of others (Bleda & Bleda, 1978; Rotton, Barry, Frey, & Soler, 1978). Furthermore, under some circumstances, air pollution has been shown to increase aggression (Jones & Bogat, 1978; Rotton, Frey, Barry, Milligan, & Fitzpatrick, 1979) as well as reduce altruism (Cunningham, 1978).

A few studies have examined possible links between air pollution and mental health. Clinical case studies suggest associations of indoor air pollutants (e.g., lead, solvents, formaldehyde) with various behavioral abnormalities including somolence, irritability, psychomotor dysfunctioning, and depression (Randolph, 1970; Weiss, 1983). Two recent studies found simple aggregate level correlations between ambient pollutants and psychiatric admissions. Strahilevitz, Strahilevitz, and Miller (1979) noted a positive correlation between carbon monoxide and nitrogen dioxide levels with psychiatric admission in St. Louis. Similarly, Briere, Downes, and Spensley (1983) reported that an overall index of air pollution correlated with psychiatric admissions in Sacramento, California. Rotton and Frey (1984) employing a time series analysis with careful controls for meteorological factors, and other pollutants, established a relationship between ozone levels and psychiatric-related 911 emergency phone calls over a 2-year period in Dayton, Ohio.

The present study makes two important contributions to the study of stress and health. First, we test the hypothesis that one or more recent stressful life events will increase individual risk for negative, mental health reactions to ambient air pollution. As noted above, very little research has examined the complex interplay of social and physical sources of life events and chronic strains in the everyday environment. Second, the present study makes some methodological contributions of note. Unlike the three prior epidemiological studies of air pollution and psychological health, this study utilizes individual level data, thus allowing for both important control parameters (e.g., prior psychological symptoms) and analysis of individual differences, i.e., recent stressful events, that may modify the influence of air pollution on psychological health. Studies that have found little or no relationship between environmental quality and changes in health may have misestimated the strength of association by relying exclusively on aggregate level analyses (Evans, 1982).

Furthermore, analysis of the direct links between life events, ambient air pollution, and mental health is strengthened by the design employed. For example, only undesirable, non-health-related life event items are used in a prospective design, controlling for Time one psychological symptoms. As noted by several reviews of the life events literature (Rabkin & Struening, 1976; Thoits, 1983), retrospective designs, absence of prior psychological symptom controls, and use of health-related items in life event inventories, are among the more serious methodological problems that have plagued many earlier studies. Finally, the present study also incorporates a cross-sectional replication of the prospective panel study.

METHOD

Subjects

Twelve quarterly surveys of 500 households (new households drawn each survey wave) in Los Angeles County were conducted from 1978 through 1980. Telephone numbers were generated randomly and up to 12 calls were made to reach the designated respondent. The Trodahl–Carter (1964) sampling method was used to determine the designated adult respondent in each household. None of the respondents were known by the investigators. Participants were informed that researchers from the University of California at Irvine were conducting a survey on health status and quality of life in Los Angeles. Interviews were conducted in English or Spanish. The Spanish interview schedule was constructed by a professional translator employed by Field Survey Research Corporation, a professional survey research firm who administered the interviews. An independent translator from the University translated the interview from English to Spanish as well. The few discrepancies that did occur between the two independent translators were resolved by consensus between the two translators. Compared to the 1980 census the sample was biased toward females (57% in sample vs. 52% in census) and Anglos (67% in sample vs. 58% in census). Sex, age, ethnicity, and socioeconomic status (SES; Hollingshead & Redlich, 1958) were obtained and used for subsequent statistical controls. The average completion rate was 76% with little variation across the 12 survey waves.

Design

Two sampling designs were employed in the present analysis. All participants were initially selected according to the random telephone procedure described above. Following the intital interview respondents were asked if they would consent to a second interview. The reinterview occurred 3 months later. A panel of 406 respondents was selected randomly from the population of respondents who had consented to a reinterview. A second set of respondents was drawn from the overall Time 1 cross-sectional data set. This set consisted of the 300 respondents from the entire 12 quarterly waves with the highest residential exposure to ozone and the 300 citizens with the lowest ozone exposure. These extreme groups were drawn exclusive of the panel set.

Procedure

Air Quality. On the basis of residential zip code, each respondent's exposure to pollution was calculated from the nearest air pollution monitoring station in Los Angeles County. There are 14 monitoring stations in the Los Angeles area (see South Coast Air Quality Mangement District, 1981, for greater technical details on monitoring). The daily 1-hour maximum values for ozone, nitrogen dioxide, sulfur dioxide, and particulates were monitored. In addition measures of temperature, relative humidity, and visibility were recorded.[3] All of the analyses reported here employed the previous 7-day average of daily maximum values. This measure was used because it is a stable measure of recent air quality.

Stressful Life Events. The life event inventory consisted of items drawn from the PERI Life Event Scale (B. S. Dohrenwend, Krasnoff, Askenasy, & Dohrenwend, 1978), the Holmes and Rahe Scale (1967), and the Theorell

[3]Daily maximum values were used instead of daily averages for several reasons. First, the two measures are typically, highly correlated (range in this study from .40–.92 for different pollutants). Second, most epidemiological studies of air pollution use daily maximums (Goldsmith & Friberg, 1977). Third, health standards are set in terms of thresholds.

Workload Scale (Theorell & Floderus-Myrhed, 1977). A simple count of 30 undesirable life events for the prior 3 months was used. Furthermore, only nonhealth life events were used. Sample life events included change to a worse residence, financial loss, legal problems, loss of spouse, loss of other close family member.

Mental Health. Psychological symptoms were measured by a modified version for telephone use of the Demoralization Scales of the Dohrenwend Psychiatric Epidemiology Research Interview (PERI) (B. P. Dohrenwend, Oskenberg, Shrout, Dohrenwend, & Cook, 1981; B. S. Dohrenwend, 1978). These scales which measure nonspecific psychological distress ask the respondent whether he or she has experienced a particular symptom often (2), sometimes (1), or never (0) in the past 3 months. The average score (0–2) based on 25 items was calculated for each respondent. Sample items included: In the past 3 months have you been bothered with: Nervousness, that is being irritable, fidgeting, or tense? Being so blue or depressed that it interfered with your daily activities? Feeling anxious about something or someone? As a partial validity check, the modified scale was trichotomized ($n = 571$) and associated with help-seeking reports, $\chi^2(4) = 53.10, p < .0001$. The modified scale is closely related ($r = .76$) to the Langner-22 measure with which it shares some common items. The Langner scale has been shown in previous research to predict eventual psychiatric case openings (Langner, 1962). Measures of internal consistency ($\alpha = 0.90$) and test–retest over a 3-month period ($r = .70$) suggest adequate reliability for the modified PERI.

More details on sampling, instrument construction, and general survey procedures are available in Catalano and Dooley (1983) and Dooley and Catalano (1984).

RESULTS

All analyses used hierarchical multiple regression, controlling for other pollutants, meteorological factors, socioeconomic status, and, for the panel analysis, initial mental health measures taken at Time 1. Table I specifies the order of entry for the predictor variables from the panel set and includes the zero-order intercorrelations among the predictors and means for all the variables. Statistical tests reported below were for increments in R^2, controlling for variables entered previously in the multiple regression equation. The intercorrelations and means for the extreme groups (cross-sectional sample) were similar. The order of entry for the extreme groups analysis was identical except for the exclusion of Time 1 mental health symptoms that were only available for the panel analysis. The main effects of ozone and negative life events were entered one at a time prior to the test for the interaction term (product of ozone and negative life events). This procedure was followed for both the panel set and the extreme groups analysis.

Table I. Means and Intercorrelations for Predictor Variables in Hierarchical Multiple Regression Panel Set

		Intercorrelations							
	PERI Time 1	SES	Temperature	Relative humidity	Visibility	NO_2	Life events	Ozone	Interaction term (Ozone × Life events)
PERI Time 1	0.25	−.14	.02	.04	−.02	.02	.16	−.06	.11
SES	2.73		−.08	−.02	−.01	.03	−.01	−.05	−.04
Temperature	73.13			−.06	−.29	.16	.04	.55	.24
Relative humidity	75.32				−.61	−.41	.02	.39	.15
Visibility	23.79					.39	−.09	−.50	−.23
NO_2	0.10						−.01	−.30	−.12
Life events	0.74							.05	.81
Ozone	0.05								.39
Interaction term	3.92								

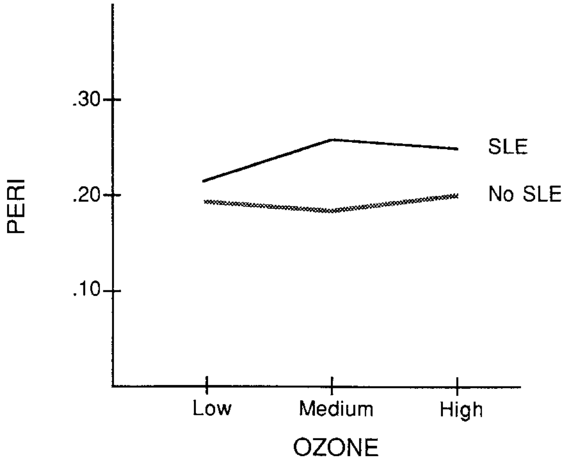

Fig. 1. Prospective panel analysis of PERI data controlling for Time 1 symptom levels. Low ozone = 0.08 ppm; medium ozone, 0.13 ppm; high ozone = 0.18 ppm.

Thus, the panel and extreme groups analyses, respectively, differed in only two respects. The panel analysis included a control for Time 1 mental health symptoms. The extreme groups analysis was drawn from the random cross-sectional sample with the restriction of high or low residential ozone exposure. The panel was drawn randomly from the pool of participants in the cross-sectional sample who agreed to be reinterviewed.

As can be seen in Figure 1, there was a slight interaction of ozone exposure and stressful life events on psychological symptoms (PERI) at Time 2 for the panel sample, $F(9, 280) = 5.30, p < .001$.[4] There was also a strong main effect for stressful life events, $F(8, 278) = 30.50, p < .0001$, but no main effect for ozone exposure, $F(8, 277) < 1.0$. Individual mental health appears to be affected adversely by exposure to photochemical smog only if one has recently experienced one or more stressful life events.

Similar effects were found for the extreme groups analysis on the PERI. Inspection of Table II reveals that persons with more stressful life events are at risk for adverse psychological reactions to smog, $F(8, 438) = 5.18$, $p < .02$. The same pattern of main effects for ozone, $F(7, 436) < 1.0$, and

[4]Degrees of freedom are low and vary slightly because of missing data. Subjects were dropped from the analysis if any control information were missing or if major factors were missing. Most of the missing data were pollutants and meteorological data. Lapses in environmental monitoring due to technical difficulties are a common problem in epidemiological studies of air pollution.

Table II. PERI Demoralization Index: Extreme Groups Analysis[a]

Group	Stressful life events	No stressful life events
High ozone	0.35	0.16
Low ozone	0.30	0.18

[a]High ozone $\geq$ 0.20 ppm; low ozone $\leq$ 0.03 ppm.

for stressful life events $F(7, 436) = 27.57$ $p < .001$, was found here as in the panel sample.

DISCUSSION

The results of both the prospective panel study and the extreme groups analysis support the hypothesis that individuals who have recently experienced a stressful life event may be more at risk for adverse psychological consequences from exposure to photochemical smog. This pattern of findings is consistent with one prediction of the adaptive cost hypothesis. The resources used to cope with major environmental challenges may become depleted, rendering individuals less competent to respond to other adaptive demands. A cost of coping with stress may be reduced ability to cope with additional environmental demands. The additional adaptive demands of coping with social stress apparently predisposed some individuals to react more negatively to air pollution. Caution is warranted given the small magnitude of the interaction effects. Nevertheless, the effect replicated and was found after removing a considerable number of control factors for both the longitudinal and cross-sectional data sets.

The present study shows the importance of individual level approaches, utilizing mediating variables when studying community mental health. Most air pollution research has relied on aggregate level analyses which preclude the incorporation of individual variables such as recent stressful life events into models of the environment–health relationship. By focusing exclusively on the direct unmediated effects of pollutants on human health, many complex and subtle indices of human health and well-being have been neglected. It is critical for scientists and policy makers concerned about the health effects of environmental pollutants to more carefully analyze direct and indirect multiple measures of physical and mental health.

One methodological issue not addressed in this study or any previous research on air pollution and mental health is the problem of accurate exposure calculation. Ambient levels from fixed site monitoring stations provide only crude estimates of personal exposure since movement to and from work and attenuation properties of buildings are not taken into account. Future research on air pollution and mental health should take advantage of newly emerging technologies that allow portable personal monitoring of air quality.

Several of the methodological issues we have reviewed may lead to underestimates of the health effects of human exposure to air pollution. Imprecise measurement of personal exposure, aggregate levels of analysis that preclude assessment of individual differences in susceptibility, and catastrophic measures of health may all function to understimate health risks from air pollution. An interesting policy question raised by this is whether pollution standards should be set more conservatively than they currently are to adjust for the imprecision in estimates of health risk. The dangers of underestimating negative health effects overshadow errors in the opposite direction. Recent United States Supreme Court Rulings, moreover, have made it clear that psychosocial effects of changes in the physical environment must be considered in environmental impact assessments for federally regulated projects (Hartsough & Savitsky, 1984).

The data from this survey also show significant main effects of stressful life events on psychological health. These are not new findings and are not discussed here except to note that few previous studies have carefully controlled for contamination in the life events and health relationship by using only non-health-related stressful life event items. Furthermore, even fewer investigations have utilized uncontaminated life event schedules in longitudinal designs with Time 1 baseline, symptomology controls (Rabkin & Struening, 1976; Thoits, 1983).

Los Angeles, California, has the worst levels of photochemical smog in the United States. Yet a large, random sample of the Los Angeles metropolitan area yielded few persons suffering direct psychological consequences from smog exposure. There are, however, subgroups of the population who may be at risk for negative psychological consequences from exposure to high levels of smog. Results of the present study indicate that individuals experiencing a recent stressful life event may be at some psychological risk from exposure to periods of high levels of smog.

The empirical findings of this study are a preliminary attempt to understand a portion of the complex interplay of life events and the more persistent strains of daily life. Considerably more research is needed to examine the dynamic processes of stress and strain in the daily lives of people. Our results call attention to the potential role of the physical environment in causing or exacerbating psychosocial strain.

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