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Adaptive Potential, Stress, and Natural Killer Cell Activity in Older Adults

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The authors examined the relationship among psychosocial vulnerability (stress) and resilience (adaptive potential) factors and three outcome measures, self-reported physical symptoms, positive and negative affect, and natural killer cell activity in 39 male and female older adults residing in a retirement community (mean age = 73.5). Although life events were directly related to physical health symptoms, both perceived stress and adaptive potential were significantly associated with positive and negative affect. There was a tendency for adaptive potential to buffer the effect of perceived stress on negative affect. However, natural killer cell activity was not significantly related to any psychosocial vulnerability and resilience factors in this small sample. Implications for studying the effects of stress on health in older adults are discussed.

Considerable interest has focused on the susceptibility to ill health among individuals experiencing distressing life events. There is sufficient evidence suggesting that individuals exposed to higher degrees of stressful life experiences have more episodes of mental and physical

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illnesses (Dohrenwend & Dohrenwend, 1974; Rabkin & Struening, 1976). Furthermore, numerous studies have documented alterations in various parameters of the immune system under stressors such as life changes, bereavement, loneliness, and academic pressures (see Ader, 1981; Irwin, Daniels, Bloom, Smith, & Weiner, 1987; Irwin, Daniels, Smith, Bloom, & Weiner, 1987; Kiecolt-Glaser, Garner, Speicher, Penn, Holliday, & Glaser, 1984; Kiecolt-Glaser, Ricker et al., 1984; Locke, 1982; Rogers, Dubey, & Reich, 1979; Stein, Schiavi, & Camerino, 1976). Compromised functioning of this system is believed to have health consequences ranging from increased susceptibility to infections to higher probability for cancers and autoimmune diseases (Penn, 1981; Roitt, Brostoff, & Male, 1985; Walford, 1969). This evidence, coupled with implications of an immunologic basis for health problems such as arteriosclerosis, rheumatoid arthritis, diabetes, and cancers (Lattime & Strausser, 1977; Riley, 1981; Solomon, 1981; Walford, 1969), which are more common among older adults, argue for the need to investigate psycho-neuro-immunologic processes in an elderly population (cf. Biondi & Pancheri, 1987).

However, most quasi-experimental studies focus on only one measure or type of stressor, and few examine multiple indicators of well-being. In addition, studies of immune system functioning often do not include resilience factors that moderate stress, such as hardiness (Kobasa, 1979), sense of coherence (Antonovsky, 1979, 1987), or adaptive potential (Colby, 1987; Colby, Aldwin, Price, Stegemann, & Mishra, 1985). The purpose of this study is to examine the ability of adaptive potential to buffer the effects of stressors, operationalized as life events of relevance to the elderly (Aldwin, 1990) and perceived daily stress (Cohen, Kamarck, & Mermelstein, 1983), on three outcome measures: self-reported physical symptoms (Belloc & Breslow, 1972), positive and negative affect (Bradburn, 1969), and natural killer (NK) cell activity.

Natural Killer Cells

Natural killer cells are thought to be of particular importance for health in later life as these cells exhibit unique morphological and functional characteristics within the immune milieu. These cells are distinguished by their spontaneous, cytolytic activity against a variety of tumor cells, some normal cells, certain infectious diseases (viral and microbial), and bone marrow transplants (Herberman & Holden, 1978; Herberman & Ortaldo, 1981; Lotzova & Savary, 1977; also see Roitt et al., 1985). Additionally, there is growing evidence suggestive of NK cells playing an important role in immuno-surveillance (Bloom, 1982) and immuno-regulation (Lotzova, 1986).

As noted earlier, numerous studies have explored the effects of various types of stressors on NK cell activity. For instance, stressors such as bereavement (Irwin, Daniels, Bloom et al., 1987), frequent and severe daily hassles (Levy et al., 1989), and sense of helplessness (Levy, Herberman, Maluish, Schlien, & Lippman, 1985) have been associated with lower levels of NK cell activity, whereas relaxation protocols have been associated with higher levels (Kiecolt-Glaser et al., 1985). However, very few studies have examined the effects of moderating variables on immune functioning in general and on NK cell activity in particular.

For example, Locke and his colleagues (1984) divided their sample of college students into groups based on stress and psychological symptoms and found that the group termed *good copers* (high stress, low symptoms) had significantly higher NK cell activity than did *poor copers* (high stress, high symptoms). These findings suggest that there is an interaction effect between life events and psychological symptoms of NK cell activity. However, a better test of this hypothesis would require a more complex statistical technique to accurately assess whether or not there is a significant interaction between two independent variables (see Cohen & Cohen, 1983).

Nonetheless, NK cells are clearly an important component of the immune system. The fact that psychosocial factors appear to affect this important component is of great interest, and more research is needed to supplement these preliminary findings. In particular, more

work is needed to (a) document the effects of different types of stressors on NK cell activity, and (b) examine which factors can modify the effects of stressors on NK cell activity.

Adaptive Potential

One potential modifier of particular interest is adaptive potential (Colby, 1987). Adaptive potential refers to three constructs, namely, altruism, adaptivity, and creativity, thought to be important in adaptation on both the individual and cultural levels. These positive values grow out of lifelong experiences and are hypothesized to affect adaptation to stress.

A preliminary examination of stress, adaptive potential, and self-reported health in an older, community-residing population found that adaptive potential significantly buffered the effects of life events on mental and physical health (Colby et al., 1985). Specifically, individuals who were high in adaptive potential reported significantly fewer psychological and physical complaints under high stress levels.

Present Study

The present pilot study explores the efficacy of adaptive potential as a stress buffer in a sample of older men and women. We are particularly interested in the complex interaction that can occur among different levels of psychosocial vulnerability (e.g., negative life events and perceived stress) and resource (adaptive potential) factors, and health and well-being outcomes such as self-reported physical health, mental well-being (positive and negative affect), and NK cell activity.

The two main questions of this research are (a) Do older adults experiencing higher levels of psychosocial stressors suffer from poorer mental well-being and physical health, as well as suppressed NK cell activity, as compared to older adults experiencing lower levels of psychosocial stressors? And (b) Does adaptive potential buffer the impact of psychosocial stressors on the three outcome measures?

Method

SAMPLE

We focused on older adults (64-89 years) residing in a retirement community in Southern California. These respondents were part of a larger sample studied in 1983 (see Colby et al., 1985). Inclusion of subjects in this study was based on two delimiting criteria. First, the subjects had to be scored as either high or low on adaptive potential at the time of their first assessment in 1983 (Colby et al., 1985); and second, they had to consent to be contacted for a medical evaluation. In all there were 40 eligible subjects (based on the first criteria), all of whom consented to be contacted to participate in the exploratory medical phase of the study. The final sample size was 39, with a completion rate of 97.5%. One subject was lost due to scheduling difficulties.

SAMPLE CHARACTERISTICS

The 39 respondents ranged in age from 64 to 89 years, with a mean age of 73.5 years. Nearly two thirds (61.5%) of the respondents were females, 69.2% were married, and 82% were retired. The majority of the respondents (95%) were White, and 43.6% were Jewish. Over a third (38%) had a college education or had completed postgraduate training, and most respondents (84.6%) were professionals or business people before their retirement. In 1983, 55.5% of the respondents had an annual income greater than $25,000 even though the majority of them were retired. This sample was comparable to the original population surveyed in 1983 (Colby et al., 1985).

PROCEDURE

Data were collected in three parts. At first, trained interviewers administered the Health Status Questionnaire (Belloc & Breslow, 1972), obtained written consent for the exploratory medical follow-up,

and left a set of psychometric measures (including the Bradburn Affect Balance Scale) with each respondent. Approximately 2 weeks after these interviews, the respondents were recontacted for the final phase in batches of four to six subjects per day. On this occasion, during the morning sessions, interviewers administered the Perceived Stress Scale (PSS; Cohen et al., 1983) and the Elders Life Stress Inventory (ELSI; Aldwin, 1990).

On the same day, blood samples were drawn by a nurse practitioner from the subjects interviewed in the morning. Due to scheduling constraints of the nurse practitioner and the respondents, the blood samples had to be collected in the evenings. Each blood draw session was conducted at approximately the same time (between 5 p.m. and 7 p.m.), to control for circadian rhythm effects. Prior to the blood draw, as part of a standardized protocol, the nurse practitioner explained the blood draw procedure, conducted a brief physical examination, and generally addressed any concerns on the part of the respondents. Blood was drawn with the respondent in a seated position. Each set of blood samples was stored, at room temperature, for approximately 12 hours before assessing NK cell activity. All interviews, along with the blood draw, were done at the respondents' residences.

At the start of each blood draw session, a sample of blood was drawn from a healthy individual free of any immuno-modulatory conditions (i.e., infections and/or medications). The majority of the 10 control subjects were women (60%), ranging in age from 28 to 56 years ($M = 41.9$, $SD = 10.4$). Blood samples from the healthy control subjects were used to check for changes in NK cell activity due to the 12-hour time lag between blood draw and blood assays. Analyses of paired data for neutrophil and NK cell activity of the respondents and control subjects at 12, 24, and 36 hours indicated no degradation in NK cell activity due to the overnight storage (R. Oseas, personal communication, August 12, 1990). An extensive search of the literature revealed no evidence of degradation in NK cell activity within the first 12 hours. Additionally, there is some evidence suggestive of no significant effect of the anticoagulant heparin used for storage of blood on NK cell activity (see Gorelik, Bere, & Herberman, 1984).

MEASURES

Six measures were used in this study, assessing adaptive potential, two different kinds of stressors, and three different kinds of health and well-being outcomes such as positive and negative affect, self-reported physical health, and NK cell activity. Means and standard deviations for all measures are presented in Table 1.

The Life Experience and Values Questionnaire. This questionnaire is a shortened, 21-item version of a previously tested inventory (Colby et al., 1985). Each item is scaled on a 5-point Likert-type scale with values ranging from *strongly disagree* (1) to *strongly agree* (5). Mean substitution was used on missing items. Despite selecting only individuals high or low on adaptive potential, as scored in the study by Colby et al. (1985), the majority (61.5%) of the respondents were categorized as being in the medium adaptive potential group, whereas 25.6% were in the low adaptive potential group and the remaining 12.8% in the high adaptive potential group. The changes seen in the respondents' adaptive potential scores between the first and second assessments may be due to a statistical regression to the mean.

The Elders Life Stress Inventory (ELSI). This is a 31-item scale developed to assess incidence and severity of stressful life events of particular relevance to populations (Aldwin, 1990). Items were rated on a 5-point scale — *not at all stressful* (1) to *extremely stressful* (5). Overall event scores are based on a sum of the item stressfulness rating. Two health-related items (deterioration of memory, and illness and injury to self) were deleted from the analyses because they could be potential confounds with the health outcomes. Average number of items reported was 2.12, ranging from 0 to 8, with 94.9% of the respondents reporting at least one negative life event.

The Perceived Stress Scale (PSS). This is a 14-item, self-report measure developed to quantify perceptions of stress as appraised by individuals over the past 2 weeks (Cohen et al., 1983). Items on this scale are designed to assess the unpredictability, uncontrollability, and

Table 1
Means, Standard Deviations, and Zero-Order
Correlations of the Main Study Variables (N = 39)

	1	2	3	4	5	6	7	8
1. Negative life events	—	.34*	.04	.22	−.12	.34*	−.16	−.19
2. Perceived stress		—	−.35*	.37*	−.47*	.22	−.07	−.11
3. Adaptive potential			—	−.27	.30	−.17	−.18	.10
4. Negative affect				—	−.58**	.50**	−.17	.03
5. Positive affect					—	−.22	.06	.05
6. Physical health						—	−.04	.06
7. Lytic units (4 hours)							—	−.10
8. Age								—
M	6.39	32.94	1.87	9.59	7.33	7.05	20.67	73.46
SD	5.12	7.47	0.62	3.06	1.95	3.22	24.44	6.37

$*p < .05; **p < .001.$

overloading dimensions of experiences occurring in daily life. A simple sum was used to score the PSS.

The Bradburn Affect Balance Scale. This is a commonly used measure of mental well-being assessing positive and negative affect (Bradburn, 1969). A nine-item variant of the original scale was used, with six items assessing negative affect and three items assessing positive affect over the past month. Items were summed to obtain scores on the negative and positive affect subscales.

Health Status Questionnaire. This widely used self-report inventory of physical health consists of common chronic illnesses, symptoms, disabilities, and energy ratings (Belloc & Breslow, 1972; Belloc, Breslow, & Hochstim, 1971). The questionnaire has been found to be highly reliable, and in situations where it is possible to make comparisons, health status items corresponded favorably with physicians' medical records (Meltzer & Hochstim, 1970). To further cross-validate self-reported health complaints, respondents in this study were given a brief medical examination. Respondents were requested to include and rate only those conditions persisting over the past 9 months from

the date of the study. We computed simple additive scores of the number of illnesses, symptoms, and disabilities reported following Jette (1980).

Assay for natural killer cell activity. Cytotoxicity tests for NK cell activity were performed by standard ^{51}Cr release assays at various effector-to-target cell ratios such as 100:1, 50:1, 25:1, and 12:1 after 4-hour and 16-hour incubation periods. Target cells used here were K562, a human cell line derived from a patient with chronic myelogenous leukemia. Cytotoxicity was estimated from the release activity according to the following formula:

$$\frac{\text{(test release)} - \text{(spontaneous release)}}{\text{(80\% of total label)} - \text{(spontaneous release} \times 100)}$$

Cytolytic activity per fraction was calculated using lytic units per 10^7 cells where one lytic unit is the number of effector cells required to lyse 30% of the target cells. Mean lytic unit value for the respondents (after 4-hour incubation) was 20.7 and that for the control subjects was 23.9 (SD = 22.3; data not shown). No significant gender differences were seen in the mean lytic unit of the respondents (data not shown). Means for male and female respondents were 21.0 and 20.5, respectively. However, male respondents showed greater variability (SD = 29.9) in their lytic unit values as compared to the female respondents (SD = 21.0). Among the control subjects, higher mean lytic unit value was seen for the male controls (M = 33.1, SD = 30.1) as compared to the female controls (M = 14.4, SD = 22.3).

Results

Table 1 presents the zero-order correlations among age, stressors, adaptive potential, and health outcomes. Given the small sample size and the exploratory nature of the study, we will discuss trends that approached but did not achieve the .05 significance level.

Age was not significantly related to any measure in the study. Adaptive potential was related to both perceived stress (r = −.35, p < .05) and positive affect (r = .30, p < .1), but was unrelated to either life

events or negative affect. Thus older adults scoring high on the positive values of adaptive potential such as adaptivity, altruism, and creativity were more likely to perceive their daily life experiences as manageable and predictable and were more likely to report positive feelings.

The psychosocial vulnerability factors were better correlates of self-reported physical health and mental well-being measures than they were of NK cell activity. Negative life events were positively associated with the number of self-reported physical health complaints ($r = .34$, $p < .05$), and perceived stress was associated with higher negative affect ($r = .37$, $p < .05$) and lower positive affect ($r = -.47$, $p < .05$). The two stress measures were moderately correlated ($r = .34$, $p < .05$). However, based on their association with adaptive potential and the three outcome measures, the two vulnerability variables appear to tap somewhat different psychosocial domains. For instance, older adults who experienced a greater number of negative events were more likely to report more chronic health problems and symptoms, as well as experience a greater number of impairments to their daily functioning. In contrast, and not unexpectedly, older adults who found themselves in uncontrollable daily life situations that were overwhelming and unpredictable were more likely to experience poorer psychological well-being.

Eight hierarchical regression equations, using deviation scores and cross-product interaction terms, were used to test whether adaptive potential buffered the effect of stress on physical health, negative and positive affect, and NK cell activity. Negative life events or perceived stress was entered into the first step of each equation, then adaptive potential, and then the appropriate cross-product interaction term. Deviation terms were used to protect against possible multicollinearity due to correlated independent variables (see Finney, Mitchell, Cronkite, & Moos, 1984).

Table 2 presents summaries of the regression equation examining the interaction effect of negative life events and adaptive potential on health outcome measures. Negative life events had significant direct effects only on self-reported physical health symptoms, accounting for 12% of the variance. Adaptive potential tended to have direct effects only on negative (8%, $p < .1$) and positive affect (9%, $p < .1$). None of the interaction terms reached significance. Neither direct nor

Table 2
*Summary of Regression Equations Examining Stress-Buffering
Effects of Adaptive Potential – Life Event Stress*

Health outcomes	Change in R^2		
	Life events	Adaptive potential	Interaction
Negative affect	.05	.08*	.03
Positive affect	.02	.09*	.01
Physical health	.12**	.03	.03
NK cell activity	.03	.03	.02

*$p < .1$; **$p < .05$.

interactive effects of negative life events and adaptive potential on NK cell activity were found.

Table 3 presents summaries of regression equations examining the interaction effect of perceived stress and adaptive potential on health outcome measures. Perceived stress had significant direct effects on negative ($13\%, p < .05$) and positive affect ($22\%, p < .01$) but no effect on physical health. Controlling for the influence of perceived stress, adaptive potential accounted for 5% of the variance in NK cell activity, but this did not reach significance ($p = .174$). The interaction effect of perceived stress and adaptive potential on all four outcomes accounted for 5% to 6% of the variance. Although this did not achieve significance in a sample of this size, it is nonetheless interesting.

The interaction effect of perceived stress and adaptive potential on negative affect most closely approached significance; thus we graphed the interaction term according to Cohen and Cohen (1983) to examine the direction of the trend. That is, we solved the following regression equation:

$$Y = 0.15X_1 + (-.73)X_2 + (-.19)X_1X_2 + (-.31)$$

for conditions of high, medium, and low perceived stress, and high, medium, and low adaptive potential, defined as one standard deviation above or below the mean. Note that we used centered or deviation terms. Accordingly, values for perceived stress (X_1) at the three levels were +7.47 (high stress), 0 (medium stress), and −7.47 (low stress). Values for the three levels of adaptive potential (X_2) were +.62 (high

Table 3
Summary of Regression Equations Examining Stress-Buffering
Effects of Adaptive Potential —Perceived Stress

Health outcomes	Change in R^2		
	Perceived stress	Adaptive potential	Interaction
Negative affect	.13**	.02	.06*
Positive affect	.22***	.02	.05
Physical health	.05	.01	.06
NK cell activity	.01	.05	.05

$*p < .1; **p < .05; ***p < .01.$

adaptive potential), 0 (medium adaptive potential), and $-.62$ (low adaptive potential).

Graphing the interaction term (Figure 1) revealed a classical buffering effect, such that individuals high in adaptive potential reported less negative affect under high levels of perceived stress. Thus adaptive potential tended to buffer the effects of perceived stress on negative affect.

Discussion

This study explored the interrelations among psychosocial vulnerability and resilience factors and these health outcomes: physical symptoms, affect, and NK cell activity. We found specificity in these relations.

First, life events experienced in the past 9 months were more associated with physical symptoms, whereas perceived stress related more to affect. This demonstrated the importance of specifying the correct level and temporal juxtaposition of stress and health outcomes. Although this cross-sectional study cannot determine causal directionality, it makes a certain intuitive sense that major stressors are related to illness, whereas perceived stress in the recent past is reflected in the types of affect experienced.

Contrary to findings of Cohen et al. (1983), perceived stress correlated poorly with self-reported physical health in this study. This discrepancy in findings could be attributed to the use of different modes of assessing physical health. This study relied on a measure
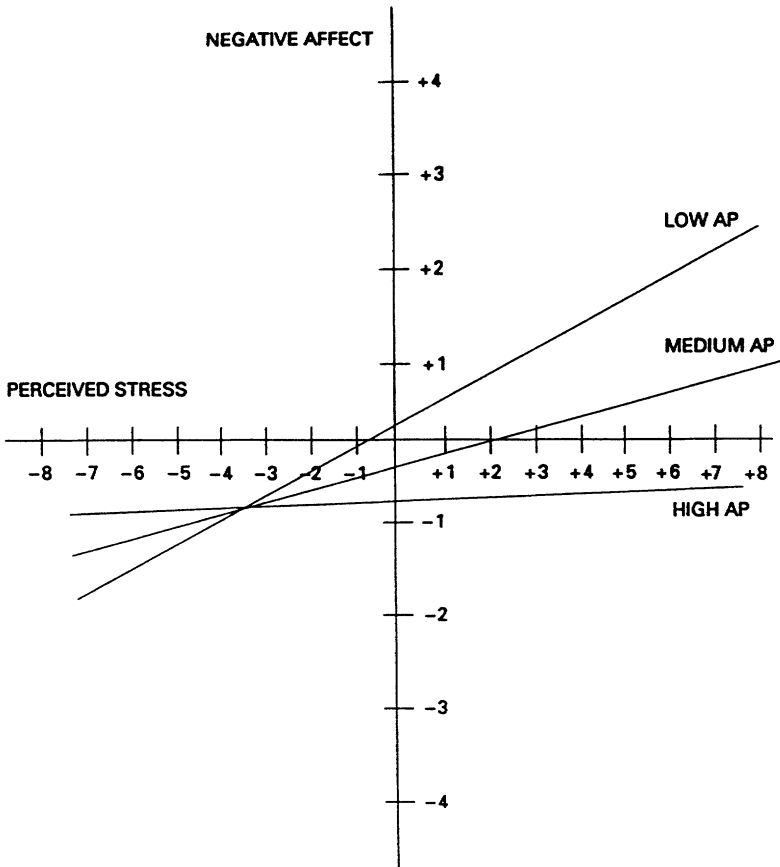
Figure 1. **Relationship between adaptive potential (AP), perceived stress, and negative affect.**

that assessed chronic illnesses, symptoms, and disabilities and not just general symptoms. Also, because most of the health complaints were of a chronic nature, requiring constant medical supervision, the respondents presumably had accepted and/or adjusted to the deleterious effects of their chronic health problems. Thus the health problems may not have been appraised as salient distress-generating conditions.

Adaptive potential had a moderate to strong relationship with perceived stress and mental well-being, and a weaker relationship with

self-reported physical health complaints. The buffering effects of adaptive potential on health outcome measures were evident with respect to the impact of perceived stress on negative affect. In part, the weak effects of adaptive potential could be attributed to the poor variability of the sample on this measure. Nonetheless older adults who have developed relatively greater positive resources may be better situated to cope with daily life stresses.

Surprisingly, immune functioning as indicated by our NK cell activity measure was independent of our psychosocial vulnerability factors. Although Kiecolt-Glaser and her colleagues (1985) found that one type of stress, loneliness, was a predictor of NK cell activity in elderly people, Locke et al. (1984) found that stress was unrelated to NK cell activity, as did our study. There are four possible reasons for this discrepancy. First, the size of the sample was very small, and there may not have been sufficient statistical power to uncover the relationship. Second, a more sophisticated research design may be needed to understand the effects of stressors on NK cell activity. Perhaps one that compared NK cell activity under baseline conditions and then after a challenge may be more suitable to this immune parameter. Third, blood was drawn in the evening. It is possible that there may have been degradation of activity due to overnight storage; or we may have seen a circadian rhythm effect, and different results may have been obtained with blood drawn and analyzed in the morning. Fourth, NK cell activity may be sensitive to very specific psychological factors (e.g., loneliness), and not the more common factors used in psychosomatic research (e.g., stress). Preliminary results from another study also showed no relationship between stress and NK cell activity (cf. Mishra, Colby, Milanesi, Cesario, & Yousefi, 1990). This would suggest that there are specific relationships between different psychosocial factors and health outcomes, and not a generalized vulnerability, as suggested by Friedman and Boothe-Kewles (1987). This is supported by the pattern of findings in this study, wherein life events and more immediate stress have different relationships with health outcomes.

A number of caveats must be mentioned. This sample of older adults can in no way be considered random or representative. These people were selected from politically active groups residing in a

relatively affluent retirement community, and the sample reflects predominantly one racial and religious group. Second, this exploratory study had a small sample size, which could limit the results (Kerlinger, 1973). This could especially be true for NK cell activity, which shows wide gender differences in the variability of their assays. However, a small sample size precludes exploration of gender differences between the psychosocial and resilience factors and NK cell activity. These factors, in turn, could reduce generalizability of the results. Third, this study relied, in part, on self-report health measures, which are potentially confounded by reporting biases, although there is ample evidence suggesting that self-report measures of health are associated strongly with objective measures of health (Meltzer & Hochstim, 1970; Tissue, 1972). Fourth, a retrospective, cross-sectional study design was used to gather data. Thus issues of causal directionality are unclear. A retrospective design in this older sample could confound the results by introducing recall bias in the data (Jenkins, Hurst, & Rose, 1979).

Future research in this area should use prospective, longitudinal study designs thus incorporating a temporal component in the analyses of immune functioning. Furthermore, besides using a sufficiently large sample size, detailed medical and medication histories should be elicited, especially in older populations, and, more objective measures for health and well-being should be employed.

In summary, this pilot study attempted to analyze the complex interaction between environmental stressors, a potential stress moderator, and health using a multidisciplinary, multifactorial perspective. This perspective was necessitated by the fact that no one discipline is capable of effectively dealing with the conceptual complexities of an organism embedded within a dynamic, nonrecursively interactive milieu (Ader, 1981; Eisdorf, 1984). Assessing the influence of biological and environmental factors, either independently or in combination, on immune functioning and physical and mental well-being will enable researchers to identify risk factors in disease etiology and help explain why certain individuals are more than others susceptible to ill health.

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