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Optimism Is Associated With Mood, Coping, and Immune Change in Response to Stress

Suzanne C. Segerstrom, Shelley E. Taylor, Margaret E. Kemeny, and John L. Fahey
University of California, Los Angeles

This study explored prospectively the effects of dispositional and situational optimism on mood (N = 90) and immune changes (N = 50) among law students in their first semester of study. Optimism was associated with better mood, higher numbers of helper T cells, and higher natural killer cell cytotoxicity. Avoidance coping partially accounted for the relationship between optimism and mood. Among the immune parameters, mood partially accounted for the optimism–helper T cell relationship, and perceived stress partially accounted for the optimism–cytotoxicity relationship. Individual differences in expectancies, appraisals, and mood may be important in understanding psychological and immune responses to stress.

Recent years have witnessed substantial progress in understanding the contribution of psychosocial factors to physical health. One such factor, optimism, or the expectation of positive outcomes, has been tied to better physical health (Scheier et al., 1989) and more successful coping with health challenges (Carver et al., 1993; Stanton & Snider, 1993). However, the routes by which optimism might be associated with better health have not received systematic investigation. One plausible route is through effects on the immune system. Optimists cope differently with stressors, experience less negative mood, and may have more adaptive health behaviors, all of which could lead to better immune status. The present investigation examined optimism in the context of a major stressor, namely, the first year of law school, specifically examining relationships among optimism, mood, and immune changes. Coping and health behaviors were also examined as potential routes for these effects.

Suzanne C. Segerstrom and Shelley E. Taylor, Department of Psychology, University of California, Los Angeles; Margaret E. Kemeny, Department of Psychology and Department of Psychiatry and Biobehavioral Sciences, University of California, Los Angeles; John L. Fahey, Department of Microbiology and Immunology, University of California, Los Angeles.

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Correspondence concerning this article should be addressed to Suzanne C. Segerstrom, who is now at the Department of Psychology, University of Kentucky, Lexington, Kentucky, 40506-0044. Electronic mail may be sent to scsege0@pop.uky.edu.

Optimism has been shown to mitigate the effects of stressors on psychological functioning. Dispositional optimists (who hold generalized positive outcome expectancies) have shown less mood disturbance in response to a number of different stressors, including adaptation to college (Aspinwall & Taylor, 1992; Scheier & Carver, 1992), breast cancer biopsy (Stanton & Snider, 1993), and breast cancer surgery (Carver et al., 1993). These findings may be attributed to optimists' belief that discrepancies between their goals and their current attainment will be resolved, minimizing defeat-related moods such as shame, depression, and anger (Carver & Scheier, 1985).

Optimism has also been associated with better physical health. Dispositional optimists reported better physical health (Scheier & Carver, 1992), showed fewer signs of infarct during coronary artery bypass surgery (CABG), and reported better quality of life after surgery (Fitzgerald, Tennen, Affleck, & Pransky, 1993; Scheier et al., 1989). F. Cohen et al. (1989) found that dispositional optimists had more T lymphocyte immune cells than pessimists in response to stressors lasting less than 1 week, though the opposite was true in response to stressors lasting more than 1 week. Situational optimism about health outcomes with respect to HIV has been associated with slower immune decline (Kemeny, Reed, Taylor, Visscher, & Fahey, 1998), later symptom onset (Reed, Kemeny, Taylor, & Visscher, in press), and longer survival time in AIDS (Reed, Kemeny, Taylor, Wang, & Visscher, 1994).

Mediational Paths Between Optimism and Immune Change

Because optimism is reliably associated with less negative mood, mood is a plausible first pathway by which optimism could be associated with immune changes under stress. Clinical states, primarily major depression, but also generalized anxiety and posttraumatic stress, have been associated with fewer circulating lymphocytes and poorer lymphocyte function (Herbert & Cohen, 1993; Ironson et al., 1997; LaVia et al., 1996). In addition, subclinical mood disturbance, changes in daily mood, and experimentally induced mood have correlated with lymphocyte

number, function, or both (Futterman, Kemeny, Shapiro, & Fahey, 1994; Stone, Cox, Valdimarsdottir, Jandorf, & Neale, 1987; Stone et al., 1994; Zorrilla, Redei, & DeRubeis, 1994).

Another means by which optimism could result in immune differences is coping. Dispositional optimists make less use of avoidance strategies such as denial and giving up, which has accounted for mood differences between optimists and pessimists (Aspinwall & Taylor, 1992; Carver et al., 1993; Scheier, Weintraub, & Carver, 1986; Stanton & Snider, 1993; Taylor et al., 1992). Avoidance coping, a passive coping style, and denial have been associated, mainly cross-sectionally, with worse immune status in both healthy and clinical samples (Futterman, Wellisch, Zighelboim, Luna-Raines, & Weiner, 1996; Goodkin, Blaney, et al., 1992; Goodkin, Fuchs, Feaster, Leeka, & Rishel, 1992; Ironson et al., 1994; Kedem, Bartoov, Mikulincer, & Shkolnik, 1992; Kemeny, 1991).

Health behavior constitutes a third pathway by which optimism may be associated with immune changes under stress. Scheier and Carver (1987) suggested that optimists have more positive health habits as a function of their generally more adaptive coping style. Furthermore, as they use less avoidance to cope with stressors, they may use less alcohol as an avoidance strategy; they may sleep better because they have less depression and anxiety. Health behavior such as alcohol use and sleep are known to affect immune parameters (Kiecolt-Glaser & Glaser, 1988).

The Present Study

The first goal of the present study was to examine the degree to which optimism, both dispositional and situational, was associated prospectively with changes in mood disturbance and immune parameters during a stressor. A second goal was to assess whether mood, coping strategies, and health behaviors account for these effects.

The first year of law school has been reported, both anecdotally and in research, to be extremely stressful (Clark & Rieker, 1986; Heins, Fahey, & Leiden, 1984; Turow, 1977). We expected that, because it is stressful, the first two months of law school would be associated with an increase in negative mood and changes in the immune system, specifically, in the number and function of lymphocytes, immune cells found in peripheral blood. Among lymphocyte subsets, natural killer (NK) cells and T cells are particularly sensitive to naturalistic psychological stressors in young, healthy adults. These two lymphocyte subsets have been found to decrease in number in medical school students taking examinations (Glaser et al., 1985; Glaser, Rice, Speicher, Stout, & Kiecolt-Glaser, 1986). Decreases in NK cell cytotoxicity have also been observed in that context (Glaser et al., 1986).

We predicted that situational and dispositional optimism would mitigate these effects. We expected that optimists would have less negative mood than pessimists. In terms of the immune system, we expected that optimists would also have higher numbers of lymphocytes and higher NK cell cytotoxicity than pessimists under stress. These differences might be due to optimists' better mood, more adaptive coping, or healthier behavior.

Method

Participants

In June 1994, the University of California, Los Angeles (UCLA) School of Law mailed recruitment packets for the study to all successful applicants intending to attend, a group of approximately 375 students. Materials included a study description, informed consent form and information about the rights of human participants in medical experiments. Participants were instructed, if interested in participating in the study, to return a signed informed consent form, telephone contact information, and screening questionnaire in the return envelope provided.

One hundred five students (31% of the 337 students who matriculated) returned screening materials in time to participate in the study. Potential participants were excluded from the study if examination of screening materials revealed any of the following: previous psychiatric hospitalization, use of psychiatric medication in the previous 3 months, or severe psychological distress (such that the person could not function in her or his usual work or activities for 2 weeks or more) in the previous 3 months. One student reported psychological distress and was excluded from the study.

Of the 104 eligible participants, 99 returned questionnaires at Time 1, and 94 returned questionnaires at Time 2.[1] Following data collection, four participants' data were excluded from analysis: One participant reported taking antidepressant medication during the study period, and 3 reported serious life stressors during the study period, which might have confounded results (e.g., 1 participant was divorcing).

The final sample for the study, then, was 90 first-year law students. Mean age of the sample was 23.9 years (range = 20–37). The sample was about equally divided between men (51.1%) and women (48.9%). The racial–ethnic makeup of the sample was as follows: 54.4% of the sample was White, 8.9% was Hispanic–Chicano–Latino, 15.5% was Asian American (including Pacific Islander), and 11.1% was African American. Ten percent of the sample either indicated that they were of mixed race–ethnicity or gave responses from which we could not determine their race–ethnicity. The majority of the sample (90%) was single and childless.

Participants had to meet strict eligibility criteria to have immune measures taken. These criteria were intended to ensure that any findings represented changes in a healthy and normally functioning immune system. This necessarily reduced the number of participants for analyses including immune measures. However, power analyses had indicated that stress-immune effects would be detected with a sample size of 50. Exclusion criteria were moderate to severe anxiety about venipuncture, past or current immunologically mediated disease (e.g., rheumatoid arthritis), possible current infection, anemia, habitual alcohol use (e.g., two or more drinks daily), anesthesia in the previous 3 months, major medical illness (e.g., diabetes), or use of medication or drugs that could affect the immune system. Fifty-eight participants completed questionnaires and had blood drawn at Time 1, and 53 completed questionnaires and had blood drawn at Time 2. Following data collection, 3 additional participants' immune data were excluded from analysis because they reported taking prescription medication that might affect the immune system.

The final sample for immune study was 50 participants. The demographic characteristics of these participants did not significantly differ from those of the other participants. Furthermore, the two groups did not significantly differ on other Time 1 measures, including dispositional optimism, situational optimism, and mood.

[1] Participants were lost to follow-up because they left law school or failed to return questionnaires. In addition, anemia and failed venipuncture resulted in some participants not giving blood at Time 2.

Procedure

Data were collected in two waves. Time 1 data were collected during the 2 weeks preceding law school orientation and the first day of classes. Time 2 data were collected during 2 weeks at midsemester (Weeks 8 and 9 of a 16-week semester).

Participants having blood drawn were contacted by telephone and scheduled for venipuncture, which occurred between 7:00 a.m. and 9:00 a.m. at both time points to control for circadian changes. Participants were asked not to drink alcohol or caffeinated beverages, smoke, or exercise in the morning before venipuncture. Participants came to a room at the law school where a phlebotomist drew 50 ml of blood from an antecubital vein into sterile, preservative-free, evacuated tubes (Vacutainer Systems, Becton Dickinson, Rutherford, NJ). Participants were given a questionnaire packet containing psychological measures with instructions to complete the measures the same day. These participants were paid $30 at each time point.

Participants not eligible for blood draw were contacted by phone and informed of the procedures of the study. Each of these students received, in his or her law school mailbox, questionnaires that contained the psychological measures with instructions to complete the questionnaire during the data collection period (e.g., the 2 weeks before classes started) and return it to the experimenter. These participants were paid $10 at each time point for their participation. All materials were coded to protect participants' confidentiality.

Questionnaire Measures

Dispositional optimism: Life Orientation Test (LOT). The LOT (Scheier & Carver, 1985) measures dispositional optimism, which is defined as generalized positive outcome expectancies. Four items are positively phrased ("In uncertain times, I usually expect the best"), and four are negatively phrased ("If something can go wrong for me, it will"). An additional four items are fillers. Respondents indicate their agreement with each item on a 5-point scale ranging from *strongly agree* (1) to *strongly disagree* (5). The LOT has acceptable psychometric properties and discriminant validity with respect to related concepts such as locus of control and helplessness. The LOT was administered at Time 1.

Situational optimism. A 10-item scale was designed for use in this study. This scale measures three aspects of specific optimism based on previous research in optimism about HIV (Reed et al., in press) and adapted for the first semester of law school. These aspects were perceived risk of failure ("It's unlikely that I will fail"), optimistic bias ("I will be less successful than most of my classmates"), and confident emotions ("I feel confident when I think about it"). Five items were phrased positively and five, negatively. Respondents indicated their agreement with each statement on a 5-point scale ranging from *strongly agree* (1) to *strongly disagree* (5).

The situational optimism scale was administered at Time 1 and Time 2. The internal reliability of the scale was .86 at Time 1 (as measured by coefficient alpha) and .91 at Time 2. The test–retest correlation was .66.[2] The correlation between dispositional and situational optimism at Time 1 was .30, suggesting that these two constructs were discriminable.

Coping. The Coping Operations Preference Enquiry (COPE; Carver, Scheier, & Weintraub, 1989) is a coping inventory that participants completed at Time 2 for each of two stressors identified in pretesting.[3] The COPE has meta-factors, including Problem Solving, Mental Accommodation, and Avoidance. These factors were found in two separate validation samples (Carver et al., 1989). Problem Solving includes active coping, planning, and suppression of competing activities; Mental Accommodation includes acceptance and positive reinterpretation and growth; and Avoidance includes denial, mental disengagement, and behavioral disengagement. A ninth first-order factor, focus on and venting of emotions, was included, as emotional approach has been conceptualized as a mental accommodation strategy (Stanton, Danoff-Burg, Cameron, & Ellis, 1994).

Mood: Profile of Mood States (POMS). The POMS (McNair, Lorr, & Droppleman, 1971) is a measure of mood state over the previous week. Respondents rate how much they have been feeling each of 65 different moods on a 5-point scale ranging from *not at all* (0) to *extremely* (4). The scale yields Total Mood Disturbance, which comprises subscales measuring tension–anxiety, depression–dejection, anger–hostility, fatigue–inertia, vigor–activity, and confusion–bewilderment. The POMS has high internal consistency (.74 to .91 for the subscales) and good validity. The POMS was administered at Time 1 and Time 2.

Health behavior. Participants were asked about their health behaviors over the 7 days preceding questionnaire administration. Use of caffeine, nicotine, alcohol, and drugs was assessed, as well as days of aerobic and anaerobic exercise and average hours of sleep nightly.

A number of these health behaviors were not normally distributed, had outliers (values lying more than three standard deviations from the mean), or both. Values for outliers were set equal to the next highest value in the distribution. This change was necessary for 2 participants' caffeine use reports at Time 1 and for 1 participant's alcohol use reports at Time 1 and Time 2. Positively skewed distributions—caffeine use, number of drinks over a week, and days of aerobic exercise over a week—were $\log_{10}$-transformed, improving normality. Finally, cigarette smoking was dichotomized into a smoker–nonsmoker variable, because only 9 participants reported smoking at either time point.

Demographic and personal characteristics. Participants reported their age, sex, race–ethnicity, marital status, and how many children they had living with them (if any). They were also asked to report their law school aptitude test (LSAT) results in terms of a raw score and percentile.[4]

Stressors. Participants were asked to describe in a free-response format "other extremely stressful experiences in your life lately" and to rate such stressors on a 7-point Likert-type scale that ranged from 1 (*not at all stressful*) to 7 (*the most stressful thing I have ever experienced*).

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[2] Although .66 is low by conventional standards of reliability, the measure in question would be expected to change over time as participants gained experience with the situation. The test–retest reliability suggests moderate stability, all that would be expected of a situational measure. As the main objective of the study was to predict mood and immune change prospectively, reported analyses were limited to use of the Time 1 measure. Analyses using the Time 2 measure revealed slightly higher correlations with other Time 2 questionnaire measures (mood, coping), a result that might be attributed to shared measurement variance. Time 2 situational optimism was not related to any immune measures.

[3] In the year prior to the study, questionnaires listing stressors associated with law school (generated from Clark & Rieker, 1986; Heins et al., 1984) were distributed to the first-year law students 8 weeks into their first semester. Response rate was approximately 18%. Two stressors, understanding legal material and lack of positive feedback, were rated by students as uniformly stressful (M = 4.28 on a 7-point scale) and were selected for the purposes of the present study. Pretesting also indicated that stressors impacted male and female law students equally (Segerstrom, 1996). Analyses using separate stressfulness ratings and coping scores from the two stressors did not result in different results. Therefore, results collapsing across the two stressors are reported. Stressfulness ratings correlated .38; problem solving, .47; mental accommodation, .61; and avoidance, .83.

[4] Controlling for LSAT scores did not affect the results of the study; therefore, this variable is not discussed further.

Immune Measures

Immune measures included number of cells in four lymphocyte subsets: $CD4^+$ cells (helper T), $CD3^+CD8^+$ cells (cytotoxic T), $CD19^+$ cells (B), and $CD3^-CD16+56^+$ cells (NK). Natural killer cell cytotoxicity (NKCC) was also measured. Following collection, samples were kept at room temperature for no more than 2.5 hr and were then taken to the Clinical Immunology Research Laboratory in the Center for Interdisciplinary Research in Immunology and Disease at UCLA for immunologic analysis. Laboratory personnel were unaware of the hypotheses of the study.

All immune measures were examined for outliers (i.e., values more than three standard deviations from the group mean). One value for absolute number of $CD3^+CD8^+$ cells and two values for absolute number of $CD19^+$ cells were dropped from analysis because they were outliers. Examination of immune parameters for the 3 participants with outlying values suggested that the outliers were anomalous, because all other immune values were well within normal limits.

Lymphocyte subset analysis. Fifty microliters of whole blood that had been collected in EDTA anticoagulant was incubated with 0.01 ml of fluorescein isothiocyanate (FITC-), phycoerythrin (PE-), and peridinin chlorophyll protein (PerCP-) conjugated murine antihuman monoclonal antibodies (MAb) for 15 min at 4° C. After incubation, the cells were washed once and tested immediately. The samples were analyzed with a FACScan flow cytometer (Becton Dickinson, San Jose, CA) equipped with a 15-W argon laser. List mode data were stored and analyzed with FACScan research software (Becton Dickinson, San Jose, CA). Lymphocytes were identified by gating on forward (low-angle) and 90° (wide-angle) light scatter parameters and verified using a combination of anti-CD45/CD4 monoclonal antibodies. Isotype controls were used to evaluate nonspecific binding and to position cursors. MAb were purchased from Becton Dickinson Immunocytometry System Inc. (San Jose, CA). Three-color analysis was conducted with the following combinations of FITC, PE, and PerCP-labeled MAb: CD19/CD62L/CD4 and CD3/CD56+16/CD8.

White blood cell and differential counts on whole blood were performed on a Coulter MD16 instrument (Hialeah, FL) to obtain total lymphocyte counts, which were used to calculate absolute numbers of the cells within the lymphocyte subsets. The total number of lymphocytes was multiplied by each subset percentage obtained by flow cytometry to obtain the absolute numbers of lymphocytes with specific phenotypic antigens.

Natural killer cell cytotoxicity (NKCC). Heparinized whole peripheral blood was layered on Ficoll-Hypaque gradient (Histopaque; specific gravity, 1.077; Sigma, St. Louis, MO). Gradients were centrifuged at 800 × gravity for 10 min. The cell interface, which contained the mononuclear cell fraction, was harvested by aspiration, and the cells were washed twice with Hank's balanced saline solution (GIBCO, Life Technologies, Inc., Gaithersburg, MD). A viable cell count was done by trypan blue dye exclusion. The effector cell preparation was resuspended in RPMI-1640 with 5% newborn calf serum at a concentration of 5×10^6 lymphocytes/ml.

Cytotoxicity was measured in a standard 3-hr chromium release assay with K562 cells as the target cells. The target cells were labeled with ^{51}Cr as sodium chromate. Triplicate aliquots (0.1 ml) of the target cell suspension were added to the effector cell suspensions at three effector–target ratios (50:1, 25:1, 12.5:1) in 96-well microliter plates. Use of several effector–target ratios is customary to provide a comprehensive evaluation of the functioning of this cell system. Spontaneous release was determined in wells that contained only target cells; maximal release was determined in wells with target cells in media that contained detergent (Triton-100). The plates were incubated for 3 hr in a 5% CO_2 incubator at 37° C. They were centrifuged, and 100-μl aliquots were removed to count with a gamma counter (Gamma-Tm 1193, Tm Analytic, Brandon, FL) the amount of sodium chromate (^{51}Cr) released. Percent lysis was calculated by using the following formula: (cpm sample − cpm spontaneous)/(cpm maximum release − cpm spontaneous), where cpm equals counts per min. Lytic units were not calculated because percent lysis was too low in many cases.

Percent lysis (NKCC) was divided by percent NK cells to yield adjusted NKCC (aNKCC). Effector–target cell ratios were calculated using lymphocytes, not only NK cells, as effector cells. However, target cells are susceptible to killing only from NK cells. When the proportion of NK cells in the effector mix drops, the effective ratio of cytotoxic cells to target cells also drops, potentially yielding misleading results (Kiecolt-Glaser & Glaser, 1991). Expressing NKCC as a ratio between percent lysis and percent NK cells in the effector mix corrects for this problem (cf. Naliboff et al., 1995).

Results

Mood and Immune Changes Over Time

Mood and immune parameters were expected to change from Time 1 to Time 2, reflecting the stressful nature of the first semester of law school. From Time 1 to Time 2, mood disturbance increased from a mean of 1.24 (SD = 0.51) to a mean of 1.55 (SD = 0.58), $t(88) = 6.42$, $p < .0001$.[5] Repeated measures multivariate analysis of variance (MANOVA) on the four enumerative immune measures showed a trend toward a Cell Type × Time interaction, $F(3, 43) = 2.52$, $p < .07$). In individual comparisons, there was a significant change only in the number of NK cells, which decreased from a mean of 336 cells at Time 1 (SD = 178) to a mean of 281 cells (SD = 147), $t(49) = -2.55$, $p < .01$. Repeated measures MANOVA on the three aNKCC ratios indicated a significant increase in aNKCC, $F(1, 48) = 5.02$, $p < .03$, which varied somewhat across ratios, $F(2, 47) = 3.31$, $p < .05$. Post hoc analyses showed that change at the 12.5:1 and 25:1 ratios was significant, $t(49) = 2.35$ and 2.39, respectively, ps $< .03$, whereas change at the 50:1 ratio only approached significance, $t(49) = 1.93$, $p < .06$.[6]

Effects of Optimism on Mood and Immune Change

Optimism was predicted to be associated with better mood and higher lymphocyte subset numbers and function at Time 2. As predicted, both dispositional and situational optimism were associated with less mood disturbance at Time 2, both before and after controlling for Time 1 mood (see Table 1). Situational optimism had a slightly stronger relationship to negative mood.

Table 2 shows the correlations between dispositional and situational optimism and the immune measures at Time 2, partialing the corresponding Time 1 immune measure. Optimism, and in particular situational optimism, was related to higher lymphocyte subset numbers and function. Dispositional optimism was positively associated, though not significantly, with higher numbers of cytotoxic T ($CD3^+CD8^+$) cells. Situational optimism was similarly related to number of cytotoxic T cells. In addition, situational optimism was significantly positively correlated with number of helper T ($CD4^+$) cells and with aNKCC at the 12.5:1

[5] Two participants were missing Time 1 mood data.

[6] For purposes of comparison with other research, we conducted an exploratory analysis using unadjusted NKCC. There was no change in unadjusted NKCC from Time 1 to Time 2, $F(1, 48) = 0.07$, $p > .05$.

Table 1
Correlations Between Optimism and Mood

Variable	1	2	3	4
	Bivariate			
1. Dispositional optimism	—			
2. Situational optimism	.30**	—		
3. Time 2 mood	−.33**	−.39**	—	
4. Time 1 mood	−.25*	−.28**	.70**	—
	Partialing Time 1 mood			
1. Dispositional optimism	—			
2. Situational optimism	.23*	—		
3. Time 2 mood	−.23*	−.28**	—	

* $p < .05$. ** $p < .01$.

and 25:1 effector–target ratios; the correlation with aNKCC at the 50:1 ratio just failed to reach significance ($p < .06$).

Correlates of Optimism

The relationships among optimism, mood, and immune changes might be due to differences in stress appraisals, to differences in coping, or to variations in health behaviors. As a first step, we examined correlations between optimism and these variables.

Coping strategies and stress appraisal were examined first. To confirm the factor structure of the COPE scales, we submitted coping scores to confirmatory factor analysis (CFA) using EQS software (Bentler & Wu, 1995) As has been true in prior research (Carver et al., 1989), the model had a Problem-Solving, a Mental Accommodation, and an Avoidance factor, which were allowed to covary. Focus on and venting of emotions loaded on the Avoidance factor, rather than on Mental Accommodation. This may be due to the fact that this strategy is confounded with distress (Stanton et al., 1994), and therefore might also be expected to load with other coping strategies associated with distress during chronic stressors (i.e., avoidance; Roth & Cohen, 1986).

The three-factor model was an acceptable fit,[7] $\chi^2(24, N = 90) = 25.02$, $p > .05$ (Bentler–Bonett nonnormed fit index [BBNNFI] = 1.00). There was a significant correlation between Problem Solving and Mental Accommodation ($r = .82$, $p < .0001$). There were smaller correlations between Mental Accommodation and Avoidance ($r = .21$, $p > .05$) and between Problem Solving and Avoidance ($r = -.14$, $p > .05$).

Some data have suggested a two-factor, second-order structure of the COPE (e.g., Carver et al., 1993) that separates avoidant and nonavoidant coping scores. In this case, the two-factor structure was not as good a fit to the data, $\chi^2(26, N = 90) = 39.58$, $p < .05$; BBNNFI = .93. Comparison of the models verified that the three-factor solution was a significantly better fit, $\chi^2(2, N = 90) = 14.56$, $p < .05$.

Correlations between optimism, perceived stress, and coping were calculated. Time 1 mood disturbance was partialed out, as concurrent distress might be related to optimism (Smith, Pope, Rhodewalt, & Poulton, 1989). Dispositional optimism and situational optimism were significantly associated with less avoidance coping (dispositional optimism, $r = -.21$, $p < .05$; situational optimism, $r = -.27$, $p < .05$). Situational optimism was also significantly associated with less perceived stress ($r = -.28$, $p < .05$).

Finally, health behaviors were examined. However, only one health behavior correlated with optimism: Hours of sleep at Time 2 (partialing Time 1 sleep) correlated with situational optimism, an effect that was marginally significant ($r = .20$, $p < .10$).

Roles of Coping, Stress, and Health Behavior in Optimism Effects

Both types of optimism were associated with more avoidance coping, and situational optimism was also associated with higher perceived stress and fewer hours of sleep. These relationships, therefore, could account for mood and immune changes associated with optimism. Furthermore, mood differences between optimists and pessimists could account for correlations between situational optimism and lymphocyte subset numbers and function.

The first analyses examined effects of coping and perceived stress on the association between optimism and negative mood. As optimism was significantly correlated with both avoidance coping and mood, and avoidance coping was itself significantly correlated with mood (after partialing baseline mood, $r = .43$, $p < .0001$), coping could mediate the relationship between optimism and mood (Baron & Kenny, 1986; Holmbeck, 1997). To test this possibility, correlations between optimism and mood were repeated, partialing baseline mood and avoidance coping.[8] For dispositional optimism, the partial correlation between optimism and mood dropped from −.23 ($p < .05$) to −.15 ($p < .16$) after controlling for coping, suggesting partial mediation of the effect. However, the difference between the two coefficients was not significant ($z_{diff} = 0.77$, $p > .05$). The magnitude of this z score indicates that the decrease after controlling for coping was modest and should be interpreted with caution. Coping appeared to account for no more than part of the effect of dispositional optimism on mood. Turning to situational optimism, the correlation between optimism and mood was reduced from −.28 ($p < .05$) to −.19 ($p < .08$) after partialing avoidance coping. Again, this difference was modest ($z_{diff} = 0.89$, $p > .05$). Overall, the results indicate that a portion of the effect of optimism, both dispositional and situational, on mood was due to less avoidance coping by optimists; however, this portion was modest and did not account for the entire effect.

Situational optimism was also associated with perceived stress, which itself significantly correlated with negative mood

[7] Fit was measured by chi square and fit index. When a model fits the obtained data, the chi-square probability exceeds alpha (in this case, .05). The BBNNFI Index is a measure of fit that takes into account the degrees of freedom of the model. Values above .90 are desirable (Bentler, 1995).

[8] Structural equation models of Time 1 and Time 2 mood, optimism, and coping were attempted; however, the stability of the mood measure led to overdetermined models. A simpler method of analysis was therefore chosen.

Table 2
Correlations Between Optimism and Immune Parameters

					aNKCC ratio		
Optimism	$CD4^+$	$CD8^+$	$CD19^+$	$CD16 + 56^+$	12.5:1	25:1	50:1
Dispositional	.01	.25†	.15	−.01	.00	.06	.12
Situational	.35*	.24†	.08	.01	.28*	.31*	.27†

Note. Correlations are with Time 2 immune measures, partialing out the corresponding Time 1 measure. $CD4^+$ = helper T cells; $CD8^+$ = cytotoxic T cells (also $CD3^+$); $CD19^+$ = B cells; $CD16 + 56^+$ = natural killer cells (also $CD3^-$); aNKCC = adjusted natural killer cell cytotoxicity.
† Marginally significant at $p < .10$ * $p < .05$.

($r = .21$, $p < .05$). Perceived stress therefore could mediate the relationship between situational optimism and mood. The correlation between situational optimism and mood was therefore repeated, partialing Time 1 mood and perceived stress. The correlation was reduced from −.28 ($p < .05$) to −.19 ($p < .08$). The magnitude of this difference ($z_{diff} = 0.89$, $p > .05$) was similar to that obtained with coping, suggesting that perceived stress could account for part of the relationship between situational optimism and mood.

The second set of analyses examined mediators of the significant relationships between situational optimism and number of helper T cells and NKCC. We recalculated the correlations between situational optimism and these immune parameters, partialing out the corresponding Time 1 immune measure and each potential mediator: mood, perceived stress, avoidance coping, and hours of sleep (see Table 3).

The relationship between optimism and number of helper T cells changed very little after controlling for perceived stress, avoidance coping, and sleep. However, a modest reduction resulted from controlling for mood disturbance, which itself correlated with number of helper T cells ($r = -.47$, $p < .001$). The correlation between situational optimism and helper T cells dropped from .35 to .21 ($z_{diff} = 0.95$, $p > .05$). These findings suggest that the relationship between situational optimism and number of helper T cells was explained, in part, by changes in mood disturbance.

Table 3
Partial Correlations Between Situational Optimism and Immune Parameters

		aNKCC ratio		
Correlation	$CD4^+$	12.5:1	25:1	50:1
Initial	.35*	.28*	.31*	.27†
Partialing				
Mood[a]	.21	.26†	.29*	.25†
Stress	.33*	.18	.25†	.25†
Avoidance	.31*	.27†	.31*	.30*
Sleep[a]	.36*	.27†	.30*	.26†

Note. Correlations are with Time 2 immune measures, partialing out the corresponding Time 1 immune measure. $CD4^+$ = helper T cells; aNKCC = adjusted natural killer cell cytotoxicity.
[a] Mood and sleep at Time 1 and Time 2 were partialed.
† Marginally significant at $p < .10$. * $p < .05$.

A different result occurred with aNKCC. The magnitude of correlations changed very slightly, if at all, after controlling for mood, avoidance coping, and sleep. The only substantial decrease in the correlation between situational optimism and aNKCC occurred after controlling for perceived stress. This decrease was most noticeable at the 12.5:1 ratio, at which the correlation between optimism and aNKCC dropped from .28 to .18, though even at this ratio the magnitude of the change was rather small ($z_{diff} = 0.68$, $p > .05$). The decrease was even less marked at the 25 : 1 ratio and was very slight at the 50:1 ratio. This can be attributed to the magnitude of correlation between perceived stress and aNKCC, which was highest at the 12.5:1 ratio ($r = -.23$, $p < .11$) and lower at the 25:1 ($r = -.18$, $p < .23$) and 50:1 ($r = -.08$, $p < .57$) ratios.

Discussion

Optimism has been associated with better psychological and physical adjustment to stressful events. Results of the present study suggest that optimism may also be associated with immune change during stressful circumstances. Specifically, students in their first semester of law school who scored high on situational optimism by endorsing an optimistic bias (Taylor & Brown, 1988; Weinstein, 1980), expectations for success, and confident emotions in regard to their first semester of law school tended to have higher lymphocyte subset number and function. These results add to an emerging body of literature to suggest that appraisal of stressful events relates to concomitant immune changes (Ironson et al., 1997; Kiecolt-Glaser et al., 1987).

The immune changes that varied with optimism are generally thought to be beneficial ones. Optimists had more helper T cells, an essential immunoregulatory cell that mediates immune reactions to infection. Similarly, among HIV-seropositive gay men, situational optimism about future health was associated with higher numbers of helper T cells (Kemeny et al., 1998); this immune parameter has been found to be prognostic of health changes in HIV. Optimists in the present study also had higher NKCC. NKCC is thought to be important in mediating immunity against viral infection and some types of cancers. The changes observed here in healthy participants, although substantial, were within normal limits, and such changes may not be clinically relevant. Whether this magnitude of immune change would affect reactions to a health challenge remains a question for future study.

The increase in NKCC seen in this study from before starting

law school to midsemester contrasts with a stress-related NKCC decrease that has been found, for example, in medical students during examination periods (Glaser et al., 1986). There are two possible explanations for this contrast. First, NKCC decrease in other studies might have been an effect of decreased percentage of NK cells in the assay (Kiecolt-Glaser & Glaser, 1988). Although this study adjusted for this effect, most previous research has not done so. Second, optimism and appraisals may offer a clue. The present participants were studied two months before their first examination period. Within this time, optimists showed an increase in NKCC and number of helper T cells, whereas pessimists stayed roughly the same or decreased in these immune parameters (see Table 4). Optimists may have seen this period as a challenging, positive experience rather than as threatening, and thus showed increases in immune parameters rather than the decreases that are often associated with taxing or threatening stressors.

Situational optimism was a stronger predictor of mood than dispositional optimism and predicted immune changes where dispositional optimism did not. Several theories of behavior and affect predict that situation-specific cognitions predict in that situation better than trait constructs (e.g., Ajzen & Fishbein, 1977; Bandura, 1977; Lazarus, 1991; Weiner, 1986). In research on psychosocial concomitants of HIV infection, HIV-specific optimism predicted behavior, mood, immune status, and health changes better than dispositional optimism (Kemeny et al., 1998; Reed et al., in press, 1994; Taylor et al., 1992). The present study adds additional evidence to the observation that situation-specific appraisals may predict reactions to specific situations better than more general measures and provides converging evidence that these effects extend to immune changes as well. Moreover, the present results add credence to the more general methodological and measurement concern regarding the need to match the level at which cognitions are assessed to the context in which they occur, whether general or specific.

Mediators of Optimism–Immune Relationships

Three variables were evaluated for their potential role as mediators of the relationship between optimism and immune change: mood, coping strategies, and health habits. Mood has predicted neuroendocrine and immune changes in a number of studies (Futterman et al., 1994; Herbert & Cohen, 1993; Ironson et al., 1990; Ironson et al., 1997; Linn, Linn, & Jensen, 1981; Stone et al., 1987; Stone et al., 1994; Zorrilla et al., 1994), and it accounted for part of the relationship between situational optimism and number of helper T cells in this study. However, the relationship between situational optimism and NKCC was not accounted for by mood. It may be that the current mood measurement was too blunt to reveal a relationship between optimism, mood, and NKCC. Future research might explore alternative means of measuring mood, perhaps including measures specific to the stressor, more sensitive to daily mood changes (Stone et al., 1987; Stone et al., 1994), or less sensitive to self-report biases (e.g., Stroop tasks).

Table 4
Immune Values Associated With Situational Optimism or Pessimism

Immune parameter/group[a]	Time 1 *M*	Time 1 *SD*	Time 2 *M*	Time 2 *SD*	Change
$CD4^+$					
Situational optimists	833	309	943	226	+13%
Situational pessimists	873	380	849	240	−3%
aNKCC (25:1 ratio)					
Situational optimists	3.02	1.57	4.29	2.01	+42%
Situational pessimists	3.15	1.23	3.44	1.90	+9%

Note. $CD4^+$ = helper T cells; aNKCC = adjusted natural killer cell cytotoxicity.
[a] Group was based on a median split.

Alternatively, appraisal may have been associated with NKCC in a manner unrelated to mood. Maier, Watkins, and Fleshner (1994) reasoned that "thoughts ought to be capable of altering immunity" (p. 1009) to the degree that they have come to be associated with aversive events. Negative appraisals or expectancies might lead people to find aversive or threatening meaning in their circumstances. In this case, situational optimism and NKCC were related to some degree through perceived stress, a variable that likely reflects the degree to which students saw law school as aversive. Other research has suggested that cognitive factors may lead to immune changes independent of changes in mood. In three investigations, negative expectations about health and negative self-views predicted the rate of decline of helper T lymphocyte number and lymphocyte function in HIV infection, independent of negative mood (Kemeny et al., 1998; Kemeny & Dean, 1995; Segerstrom, Taylor, Kemeny, Reed, & Visscher, 1996). In addition, experimental priming of anxio- and depressogenic cognitions has been associated with lower NKCC (although negative emotions were also increased by priming; Strauman, Lemieux, & Coe, 1993).

Although avoidance coping has been associated with lower lymphocyte subset numbers and function in other studies, it did not mediate the relationship between optimism and immune change in this study. However, avoidance coping did account for some of the mood effects of optimism, consistent with other research (Aspinwall & Taylor, 1992; Carver et al., 1993; Stanton & Snider, 1993; Taylor et al., 1992). There are several ways in which avoidance coping might have led to more mood disturbance in pessimistic students. First, students who avoided threatening stimuli associated with law school might not have been studying as well or as often. Falling behind in the voluminous reading associated with the first semester of law school could, in turn, have increased distress. Second, the behavioral disengagement component of avoidance may have acted as a measure of helplessness, which has been associated with affective disturbance, particularly depression (Abramson, Seligman, & Teasdale, 1978). Third, efforts to avoid distressing thoughts or situations associated with law school may have had a paradoxical effect: In the long run, rather than helping people minimize distress, avoidance may increase distress, possibly by increasing intrusive thoughts (Wegner, 1989) or preventing full processing of threatening stimuli (Foa & Kozak, 1986; Rodriguez & Craske, 1993).

Some investigators have attributed the positive effects of optimism to its inverse relationship with neuroticism, especially

as concerns self-reported health (Smith et al., 1989; Williams, 1992). In reply, Scheier and Carver (1992) pointed out that neuroticism is a multifaceted construct that may include elements of optimism and pessimism; optimism would therefore be expected to correlate with neuroticism. In the present investigation, optimism predicted coping and negative mood above and beyond initial levels of negative mood, which were measured concurrently with optimism and controlled in all analyses. However, mood measures are only moderately correlated with negative affectivity measures (Watson & Clark, 1984). Therefore, this explanation cannot be definitively ruled out in terms of the relationship between optimism and mood. The relationship between situational optimism and immune changes, however, offers evidence for the discriminant validity of optimism with respect to neuroticism. Although neuroticism is strongly associated with symptom reporting, it is less clear that neuroticism is associated with actual physical changes (S. Cohen et al., 1995; Watson & Pennebaker, 1989).

Limitations

Some limitations of the present study that are due to the sample should be considered. First, this was a relatively small sample that represented approximately one third of the first-year law school class. The sample was further reduced for some analyses because of inclusion criteria necessary to ensure valid interpretation of immune results. Self-selection may have occurred by students who anticipated that participating in the study would not constitute a hardship in time demands (i.e., more optimistic students).

This was also a young sample that was mentally and physically healthy. This restriction of range is less problematic when interpreting significant findings, such as the correlations between situational optimism and immune parameters. However, it may also be responsible for null findings, particularly as regards health behaviors, but possibly also in terms of coping and mood. Self-report may have also affected measurement of health behavior (Kiecolt-Glaser & Glaser, 1988); this group of potential lawyers may have been motivated to present themselves well in this regard, thereby restricting range, obscuring relationships, or both.

Although this study used a longitudinal, prospective design, it should be noted that some predictors (e.g., coping) were measured concurrently with outcome measures at Time 2. In some cases this was unavoidable: Measuring perceived stress or coping at Time 1 would have been fruitless, as students had yet to encounter the stressor. However, future research using a lagged design with more time points could clarify potential relationships found here.

Conclusion

This is the first published study to our knowledge to relate optimism to immune change in a healthy population. It demonstrated that dispositional and situation-specific outcome expectancies were related to mood, coping, and the immune system under stress. This study contributes to a growing body of evidence that elucidates the relation of optimism and other psychosocial factors to biological processes associated with physical health. The investigation thus indicates that beliefs about events, appraisals about events, and associated affective changes are important in examining immunologic change in the context of stressors.

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