Positive Emotional Style Predicts Resistance to Illness After Experimental Exposure to Rhinovirus or Influenza A Virus

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Objective: In an earlier study, positive emotional style (PES) was associated with resistance to the common cold and a bias to underreport (relative to objective disease markers) symptom severity. This work did not control for social and cognitive factors closely associated with PES. We replicate the original study using a different virus and controls for these alternative explanations. **Methods:** One hundred ninety-three healthy volunteers ages 21 to 55 years were assessed for a PES characterized by being happy, lively, and calm; a negative emotional style (NES) characterized by being anxious, hostile, and depressed; other cognitive and social dispositions; and self-reported health. Subsequently, they were exposed by nasal drops to a rhinovirus or influenza virus and monitored in quarantine for objective signs of illness and self-reported symptoms. **Results:** For both viruses, increased PES was associated with lower risk of developing an upper respiratory illness as defined by objective criteria (adjusted odds ratio comparing lowest with highest tertile = 2.9) and with reporting fewer symptoms than expected from concurrent objective markers of illness. These associations were independent of prechallenge virus-specific antibody, virus type, age, sex, education, race, body mass, season, and NES. They were also independent of optimism, extraversion, mastery, self-esteem, purpose, and self-reported health. **Conclusions:** We replicated the prospective association of PES and colds and PES and biased symptom reporting, extended those results to infection with an influenza virus, and "ruled out" alternative hypotheses. These results indicate that PES may play a more important role in health than previously thought. **Key words:** emotions, influenza, disease susceptibility, common cold, rhinovirus, affect.

BMI = body mass index; **CI** = confidence interval; **NES** = negative emotional style; **PES** = positive emotional style; **RV** = rhinovirus; **TCID** = Tissue Culture Infectious Dose.

INTRODUCTION

Typically when we refer to the roles of emotions and affect in health, we mean *negative* emotions such as anger, depression, and anxiety. However, recent evidence indicates that positive emotions may be associated with lower rates of morbidity and mortality and with reports of less severe symptoms and pain (reviewed in (1)).

The strongest links between positive emotions and health are found in studies that examine "trait" affective style, which reflects a person's typical emotional experience, rather than "state" affect, which reflects momentary responses to events. For example, positive emotional style (PES) was found to be associated with lower rates of stroke among noninstitutionalized elderly (2), lower rates of rehospitalization for coronary problems (3), fewer injuries (4), and improved pregnancy outcomes among women undergoing assisted fertilization (5). PES also predicts better self-reported health and fewer symptoms in the elderly (6) and less pain in patients with rheumatoid arthritis (e.g., (7)) or fibromyalgia (e.g., (8)). However, there is some question as to whether the PES association with better self-reported outcomes reflects its effect on underlying pathology, on how physical sensations are interpreted, or both (1,9).

Although the evidence linking PES to health is provocative, it has been criticized on several fronts. One potential problem is the difficulty in distinguishing between the effects of positive and negative emotions. That is, are associations between PES and health merely attributable to persons with low PES being high in negative affect? Interestingly, people's experiences of positive and negative emotions are partly independent in some circumstances (e.g., (10)). For instance, in looking back over a month or a lifetime (like in typical measures of emotional style), one can reasonably report having been both happy and sad. A definitive answer to whether positive or negative emotions are making independent contributions to a health outcome can only come from studies that measure both types of emotions separately and examine their independent contributions to health. Because past studies on negative emotions and health usually failed to measure and control for the effects of positive emotions, it is difficult to conclude from the existing literature whether negative emotions such as sadness result in a less healthy or shorter life or if positive ones like happiness lead to a healthier or longer life, or if both make contributions.

There is also concern that some measures of positive emotions may be markers of cognitive and social dispositions such as extraversion, self-esteem, personal control, purpose, and optimism, which are also thought to be important predictors of health outcomes (1). In general, these factors have moderate associations with PES, but few existing studies control for the possibility that they and not PES are responsible for reported associations of PES and health. Also complicating PES measurement is that some positive affects may themselves be direct indicators of physical health. For example, endorsing adjectives such as energetic, full of pep, and vigorous reflect a positive mood, but may also describe how healthy one feels.

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This is especially important because self-rated health has been found to predict illness and longevity above and beyond objective health measures such as physician ratings (reviewed in (11)).

A final issue is the potential importance of differentiating activated (e.g., enthusiastic, joyful) and nonactivated (e.g., calm, content) affect (e.g., (12,13)). Health researchers consider physiological arousal a primary pathway through which emotions may influence health (e.g., (14,15)). It is thus possible that the arousing nature of an emotion, not only its valence, contributes to its potential influence on health outcomes. This is especially relevant in that most measures of PES use primarily activated emotions.

In an earlier study of 334 healthy adult volunteers experimentally exposed to one of two rhinoviruses (16), we reported that higher levels of undifferentiated PES were prospectively associated with a lower susceptibility to developing a common cold (diagnosed through objective markers of illness). In an additional analysis, we also found that those high in PES reported fewer symptoms of illness than one would expect from objective markers of their disease. The association between PES and colds was *independent* of negative emotional style (NES). However, these results are subject to the alternative explanations discussed previously: the measures of positive emotions may themselves be markers of associated cognitive and social dispositions such as extraversion, self-esteem, purpose, personal control, and optimism or may have been merely tapping self-reported health.

This article describes a replication of the earlier study with the intent of establishing the reliability and generalizability of reported associations. We do this by exposing subjects to either a rhinovirus (like in the earlier study) or an influenza virus that causes a common cold-like illness. We address the issue of possible (third) spurious factors that may influence both affect and health by including controls for the potential influence of NES, optimism, mastery, purpose, self-esteem, and extraversion. The possibility that measures of positive affect may actually be markers of self-reported (perceived) health is addressed by controlling for self-reported health using a measure that was previously associated with morbidity and mortality. Finally, we also assess whether the effects of PES are attributable to activated affect, nonactivated affect, or both with the hope of providing insight into how positive affect might influence health outcomes.

METHODS

Design

After we assessed emotional styles, demographics, personality characteristics, self-reported health, and virus-specific antibody levels, volunteers were quarantined in separate rooms, exposed to either a rhinoviruses (RV) or influenza virus and followed for 5 (for RV) or 6 (for influenza virus) days to assess infection and signs and symptoms of illness.

Subjects

Data were collected between 2000 and 2004. The subjects were 95 men and 98 women aged 21 to 55 years (mean = 37.3, standard deviation [SD] ± 8.8) who responded to advertisements and were judged to be in good health. They were studied in 11 groups and were paid $800 for their participation. The study received Institutional Review Board approval and informed consent was obtained from each subject.

Experimental Plan

Volunteers underwent medical screenings and were excluded if they had a history of nasal surgery, asthma, or cardiovascular disorders; had abnormal urinalysis, complete blood cell count, or blood enzymes; were pregnant or currently lactating; seropositive for HIV; or on regular medication. They were also excluded if they had been hospitalized for psychiatric problems during the previous 5 years or were currently taking medications for psychiatric problems. Those in influenza virus trials also had baseline electrocardiograms and were excluded if there were any abnormal findings.

Specific serum antibody titer to the challenge virus, demographics, weight, and height were assessed at screening. To maximize the rate of infection, only subjects with viral-specific antibody titers ≤ 4 were included in the study. Baseline emotional styles and psychosocial measures were assessed during the 6 weeks between screening and virus exposure.

During the first 24 hours of quarantine (before viral exposure), volunteers had a nasal examination and a nasal lavage. Baseline symptoms, nasal mucociliary clearance, and nasal mucus production were assessed. Volunteers were excluded at this point if they had signs or symptoms of a cold and data for subjects were excluded from the analyses if a viral pathogen was isolated from the nasal lavage obtained at that time.

Subjects were then given nasal drops containing 125 Tissue Culture Infectious $Dose_{50}$ ($TCID_{50}$) of RV39 ($N = 152$) or 10^5 $TCID_{50}$ of influenza A/Texas/36/91 ($N = 38$). Disease expression in both viruses is a common cold-like upper respiratory illness. We used two virus types to establish the generalizability of any observed associations. On each day of quarantine, volunteers recorded their respiratory symptoms, were assessed for nasal mucociliary clearance and nasal mucus production, and nasal lavage samples were collected for virus culture. Approximately 28 days after virus exposure, blood was collected for serological testing. The investigators were blind to all psychological and biological measures.

Emotional Styles

We used a trait affect measure based on the average of daily state affect reports given over a 2-week period. This differs from the more common measure of trait affect in which people are asked at one point in time if they "usually" feel a particular way. We chose the multiple measurement technique because of evidence that single global retrospective emotional assessments are more representative of recent emotional experiences and of peak experience than they are of the average over the specified time period (17). In our earlier work (16), both types of measures predicted disease susceptibility, but the association was substantially stronger when we used the average of the daily affect.

Volunteers were interviewed by phone on seven evenings per week for 2 consecutive weeks during the month before quarantine. They were asked how accurately (0 = not at all accurate to 4 = extremely accurate) each of six positive and six negative adjectives described how they felt during the last day. The positive adjectives represented three subcategories of positive emotion: vigor (lively, full of pep), well-being (happy, cheerful), and calm (at ease, calm) (18,19). The six negative adjectives represented three subcategories of negative emotion: depression (sad, unhappy), anxiety (on edge, tense), and hostility (hostile, angry) (18,19). Anxiety, hostility, vigor, and well-being are all considered "activated" emotions, whereas depression and calm are considered "nonactivated" (13). Daily positive and negative mood scores were calculated by summing the ratings of the six respective adjectives. The internal reliabilities (Cronbach α) for the 14 assessments ranged from 0.82 to 0.90 for positive and 0.83 to 0.90 for negative scores. To form summary measures of emotional style, daily mood scores were averaged (separately for positive and negative) across the 14 days.

Standard Control Variables

In the analyses, we control for the effects of prechallenge antibody titer (within virus), age, years of formal education, body mass index (BMI: weight

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[kilograms]/height [meters^2]), race (white, black, other), sex, virus type (influenza or RV39), and season of exposure (Spring, Summer, Autumn, Winter).

Other Control Variables

The seven-item Mastery Scale (20) was used to assess the extent to which one feels as though they manifest personal mastery over important life outcomes. The 10-item Life Orientation Test-R (21) was used to assess dispositional optimism; the four-item version of the Rosenberg Self-esteem Scale (22) to assess self-esteem; and the six-item Life Engagement Test (23) was used to assess the extent to which a person is purposefully engaged in the current activities of life. On all four scales, respondents indicated how much they agreed or disagreed with self-descriptive sentences. No timeframe or referent periods were used. For all the scales, the appropriate items were reversed and the scale scores were summed. The internal reliabilities were 0.72 for mastery, 0.78 for optimism, 0.84 for self-esteem, and 0.73 for purpose.

Extraversion was assessed with the five-item version of the extraversion subscale from the Goldberg Big Five Questionnaire (24,25). Each item is a trait (bashful [−], shy [−], talkative, extraverted, quiet [−]), and respondents indicated how accurately the trait described how they "generally or typically are" as compared with another person they know of the same sex and age on a scale ranging from 0 (not at all accurate) to 4 (extremely accurate). The extraversion scale was administered twice, approximately 4 weeks apart, and the scores from the two assessments were averaged. The internal reliabilities for the two administrations were 0.71 to 0.78 and the test–retest reliability $r = 0.81$, $p < .001$. Self-reported health was assessed by asking, "In general, would you say your health is: excellent, very good, good, fair or poor?" This item is from the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36 (26)) and has been used widely as a marker of self-reported (perceived) health.

Viral Cultures and Antibody Response

Virus-specific neutralizing antibody titer was measured in serum collected before and approximately 28 days after virus exposure (27) and results were expressed as reciprocals of the final dilution of serum. Nasal lavage samples from each day were frozen at −80°C and later cultured for rhinovirus or influenza virus using standard techniques (27,28).

Signs and Symptoms

On each day of quarantine, subjects rated the severity (during the previous 24 hours) of each of 16 illness symptoms (nasal congestion, sneezing, runny nose, earache, sinus pain, sore throat, cough, chest congestion, headache, chills, muscle ache, joint ache, sweats, fever, poor appetite, or malaise) on a scale of 0 (none) to 4 (very severe) (29).

Daily mucus production was assessed by collecting used tissues in sealed plastic bags (30). The bags were weighed and the weight of the tissues and bags subtracted. Nasal mucociliary clearance function was assessed as the time required for dye administered into the anterior nose to reach the nasopharynx (30).

Baseline-adjusted daily scores for each measure were calculated by subtracting the appropriate baseline score from each of the postexposure daily scores. Negative adjusted scores were reassigned a value of 0. Total scores for symptoms, mucus weight, and nasal clearance were calculated by summing the respective adjusted daily scores over the quarantine days after viral exposure.

Volunteers were considered to have a clinical cold if they were *both* infected and met illness criteria. Infection was defined as recovery of the challenge virus on any of the postchallenge days or a fourfold or more rise in virus-specific serum neutralizing antibody titer (preexposure to 28 days postexposure) (25,31). We used an objective criterion for illness that required a total adjusted mucus weight of at least 10 g *or* a total adjusted mucociliary nasal clearance time of at least 35 minutes (25). For those with clinical colds by this criterion, the mean total adjusted respiratory symptom score was 46.33 (SD ± 35.61) versus 13.24 (SD ± 18.23) for those without colds ($t(188) = -8.48$, $p < .001$).

Statistical Analyses

Scores for BMI, total symptoms, mucus weight, mucociliary clearance, and NES were logged (base 10) to better approximate a normal distribution. Logistic regression was used to predict colds (yes or no) and multiple linear regression was used to predict self-reported symptoms. PES and NES were treated as continuous variables and we report regression coefficients, their standard errors, and probability levels. To illustrate effect sizes, we also report the odds ratios and confidence intervals when PES is split into tertiles for the logistic models. Tertiles are also used to illustrate associations in the tables.

RESULTS

Of 193 subjects, 157 (81.3%) were infected and 62 (32.1%) developed clinical colds. We ran separate equations predicting clinical colds from each of the standard control variables and from NES. Those with greater levels of antibody were protected from developing illness ($b = -0.78 \pm 0.31$, $p < .02$), and those exposed to RV39 were more likely to develop a clinical illness than those exposed to the flu virus ($b = 0.89 \pm 0.45$, $p < .05$). Neither any of the remaining standard controls ($p > .14$) nor NES ($p > .38$) predicted colds.

Preliminary analyses predicted colds and the continuous outcome variables from PES alone (without controls). PES was associated with fewer colds ($b = -0.07 \pm 0.04$, $p < .06$, $N = 193$, adjusted odds ratio [OR] = 2.3, confidence interval [CI] = 1.06–4.89, 1.6, CI = 0.75–3.54; and 1), lower mucus weights ($b = -0.02 \pm 0.01$, $p < .05$, $N = 192$), mucociliary clearance ($b = -0.01 \pm 0.01$, $p < .08$, $N = 193$), and total symptoms ($b = -0.04 \pm 0.01$, $p < .001$, $N = 193$).

All of the remaining analyses predicting colds and the constituents of the colds (infection and the separate objective markers of illness) included three covariates: virus, antibody level, and NES. We used virus and antibody level because they are associated with risk for developing a cold and NES because of its conceptual importance in this article. Trimming the number of covariates avoids overfitting models. An unacceptable risk for overfitting logistic models in this sample would be more than six predictor variables (see (32)). However, analyses including all of the standard controls and NES produced nearly identical results.

The critical analyses tested the associations of PES with clinical illness in an equation that included virus, antibody levels, and NES as covariates. Increases in PES were associated in a dose–response manner with decreases in the rate of objectively diagnosed colds ($b = -0.10 \pm 0.05$, $p < .03$, $N = 193$; adjusted OR = 2.9, CI = 1.21–7.09; 1.7, CI = 0.72–4.00; and 1). There were no interactions between any of the three control variables and PES in predicting clinical colds. Hence, reported associations were similar across preexposure antibody levels, virus type, and NES. Rates of verified illness by PES and virus are presented in Table 1.

To test whether our results were attributable to individual components of PES (versus the multidimensional representation tested previously), we calculated the average response over the 14 interviews for each of the PES subscales (vigor, well-being, and calm). Cronbach alphas for all three scales were 0.93. We tested each of the PES subscales with standard controls and NES included in the equation.

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TABLE 1. Percent Persons Developing a Cold by Positive Emotional Style (tertiles) and by Virus[a]

Virus	Positive Emotional Style		
	Low	Middle	High
Flu	26.1 ($n = 8$)	17.2 ($n = 15$)	15.5 ($n = 15$)
RV39	40.8 ($n = 56$)	37.7 ($n = 49$)	27.4 ($n = 50$)
Total	39.0 ($n = 64$)	32.9 ($n = 64$)	24.6 ($n = 65$)

[a] Presented data are adjusted for virus, viral-specific antibody level and Negative Emotional Style.

Greater vigor ($b = -0.21 \pm 0.10$, $p < .04$) and well-being ($b = -0.28 \pm 0.13$, $p < .03$) were both significantly associated with fewer colds, whereas calm was not ($b = -0.16 \pm 0.12$, $p < .20$).

Because our definition of clinical colds combines infection with illness, the observed association between PES and clinical colds could have resulted from a decreased risk for infection and/or a decreased expression of illness among infected persons. PES was not associated with infection rates ($p > .21$), but was associated with decreased rates of clinical colds among infected subjects ($b = -0.13 \pm 0.05$, $p < .01$; OR = 3.6, CI = 1.40–9.33; 2.7, CI = 1.07–6.89; and 1). Hence, the relation between PES and colds is attributable to infected people with lower PES expressing more objective signs of illness. Separate analyses of the association of PES with the continuous measures of cold signs and self-reported symptoms in infected subjects were consistent with this association (for mucus weights: $b = -0.03 \pm 0.01$, $p < .04$; for mucociliary clearance function: $b = -0.02 \pm 0.01$, $p < .01$; and for symptoms: $b = -0.04 \pm 0.01$, $p < .01$).

PES was correlated with self-esteem ($r = 0.28$, $p < .001$), optimism ($r = 0.26$, $p < .001$), purpose ($r = 0.33$, $p < .001$), mastery ($r = 0.33$, $p < .001$), and extraversion ($r = 0.13$, $p < .06$). However, only extraversion ($b = -0.06 \pm 0.04$, $p < .15$) was even marginally associated with colds, with extraverts being less susceptible. To determine if extraversion might be able to account for (or contribute to) the association between PES and colds, we fit another equation in which we entered extraversion as a covariate in addition to virus, antibody, and NES and then entered PES. Controlling for extraversion did not substantially influence the relationship between PES and colds ($b = -0.10 \pm 0.05$, $p < .04$, OR = 2.8, CI = 1.15–6.86; 1.6, CI = 0.69–3.82; and 1). We also fit an equation that included all five cognitive and social factors ($b = -0.12 \pm 0.05$, $p < .02$, OR = 3.1, CI = 1.17–8.08; 1.8, CI = 0.72–4.55; and 1). This also makes little difference. Finally, because our subjects were selected for generally good health, few persons were at the lower end of the distribution of self-reported health (zero reported being poor, 5 fair, 46 good, 102 very good, and 40 excellent). Adding self-reported health as an additional factor in the equation with virus, antibody level and NES made little difference ($b = -0.11 \pm 0.05$, $p < .03$, OR = 2.9, CI = 1.08–7.71; 1.8, CI = 0.72–4.53; and 1).

The second question we posed was whether PES was associated with reporting fewer symptoms than one would expect given objective markers of disease. To do this, we created a residualized symptom score by predicting total adjusted self-reported symptoms from objective markers of disease—infection status, total adjusted mucus weights, and average adjusted mucociliary clearance time. A residualized symptom score of 0 would mean that reported symptom level is what is predicted by the objective signs of disease. Scores above 0 indicate more symptoms than expected and those below 0 indicate fewer symptoms than expected.

Of the eight standard control variables, only age predicts residualized symptom scores ($b = -0.01 \pm 0.00$, $p < .04$; others $p > .18$). However, to be conservative, we included all the standard controls in these analyses. (Linear regression is less susceptible to model overfitting then logistic regression.) First, we predicted residualized symptom scores from PES in an equation with all the standard controls. PES was associated with reporting *fewer* symptoms than expected (see Table 2; $b = -0.03 \pm 0.01$, $p < .003$). Using the same statistical model (replacing PES with NES), NES was associated with *more* reported symptoms of illness than expected after removing possible contributions of objectively defined disease (see Table 2; $b = 0.29 \pm 0.12$, $p < .02$). When both PES and NES were entered into the same equation, PES remained significant ($b = -0.02 \pm 0.01$, $p < .04$) but NES did not ($b = 0.15 \pm 0.14$, $p > .27$). We then fit the same equation adding self-esteem, extraversion, optimism, purpose, mastery, and self-reported health. These additional covariates had little effect on the relationship between PES and self-reported symptoms ($b = -0.02 \pm 0.01$, $p < .05$).

Finally, we conducted separate analyses predicting the residualized symptom score from each of the PES subscales (vigor, well-being, and calm) with standard controls and NES included in the equation. Although all three subscales show

TABLE 2. Mean Symptom Bias Score (residualized) by Emotional Style Tertiles and Virus[a]

Virus	Positive Emotional Style		
	Low	Middle	High
Flu	0.18 ($n = 8$)	0.05 ($n = 15$)	−0.05 ($n = 15$)
RV39	0.11 ($n = 56$)	0.00 ($n = 49$)	−0.15 ($n = 50$)
Total	0.12 ($n = 64$)	0.01 ($n = 64$)	−0.13 ($n = 65$)
Virus	Negative Emotional Style		
	Low	Middle	High
Flu	−0.06 ($n = 11$)	0.03 ($n = 15$)	0.15 ($n = 12$)
RV39	−0.12 ($n = 55$)	0.00 ($n = 47$)	0.09 ($n = 53$)
Total	−0.11 ($n = 66$)	0.01 ($n = 62$)	0.10 ($n = 65$)

[a] A score of 0 indicates symptom reports that are exactly what one would expect from objective signs of illness. Positive scores indicate higher symptom scores than expected and negative scores indicate lower scores than expected. These scores are adjusted for the eight standard control variables.

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the expected mean differences across PES tertiles, a significant association was found only for calm (b = −0.08 ± 0.03, $p < .04$) with well-being (b = −0.05 ± 0.03, $p < .09$) approaching significance. Vigor, however, was not associated with the residualized symptom score ($p < .26$).

DISCUSSION

Like in our earlier study, increased PES was associated with decreased verified illness rates. This was true after controlling for age, race, sex, years of education, prechallenge antibody level, BMI, season, virus type, and NES. The reproducibility of the association across the RV39 and Influenza Texas/A (no interaction between PES and virus type; see Table 1) supports the generalizability of the effect and expands on the previous report in which similar results were found for RV23 and RV39. In contrast, NES did not predict verified colds and there was no support for the hypothesis that PES may be beneficial because it lessens or ameliorates the effect of NES (no PES-by-NES interaction).

That PES was not associated with infection but was associated with the expression of signs and symptoms of illness among infected people suggests that the release or synthesis of inflammatory mediators such as proinflammatory cytokines, histamine, or bradykinins responsible for the signs and symptoms of illness may mediate the relation between PES and colds (33). In fact, we found evidence consistent with IL-6 being the link between PES and colds in our previous study (33). However, although we do not report the data here, neither IL-6 nor cortisol (which regulates IL-6 release) plays a mediating role in these data. Even so, we are reluctant to treat these data as a disconfirmation of mediation because the current study has substantially less statistical power ($N = 193$) than the earlier study ($N = 334$). There are other possible mediators. For example, positive emotions might have their influence through biological processes (e.g., release of oxytocin (34)) that are different than those associated with negative emotions and stress.

Two of the PES component subscales (vigor and well-being) showed associations with verified disease similar to the total PES, whereas the third (calm) was not significantly associated, although the direction of the association was upheld. This suggests that the association of PES and colds may primarily reflect activated positive affect. However, subscales with more items and a broader representation of the different types of positive emotion are essential to verifying this association.

The failure of NES to predict colds is consistent with our previous work. Although we have twice found that *state* negative affect predicts greater disease susceptibility (35,36), our two attempts to predict colds from NES (also called neuroticism or negative affectivity) both found no associations (16,37). These results are also consistent with similar work in risk for cardiovascular disease that indicated NES predicted angina (based on self-reported symptoms) but not risk for verified cardiovascular disease (38).

Also consistent with our earlier work (16), PES was associated with reporting fewer symptoms than expected given objective markers of disease. In this case, higher PES might result in more positive interpretations of ambiguous sensations. As found before (35,37–39), NES was also associated with a bias in symptom reporting with increased scores associated with increased symptom reports. What was striking here is that the PES effect was larger than and independent of NES. In contrast, the NES effect was substantially decreased (and no longer significant) when PES was added to the equation. These data raise the question of whether the existing literature on NES and the reporting of "unfounded" symptoms might actually be explicable in terms of PES. That is, feeling fewer positive emotions may be more important than feeling more negative ones in predicting self-reported symptoms. When we looked at the role of the separate PES subscales, the effect was primarily driven by calm with well-being playing a lesser role, indicating that unactivated as well as activated positive affect play a role in this association.

The evidence we report for the associations of trait affectivity with both objective illness and symptom bias provides strong support for the independence and importance of PES. It is striking that studies of the roles of negative emotional styles such as anger, anxiety, and depression in health do not control for the possible role of correlated positive emotions. Take depression, for example. Depression is recognized as a risk factor for all-cause mortality, cardiovascular mortality, and recurrence of myocardial infarction (reviews in (40,41)). We think of depression as a marker of negative emotions. However, clinical depression is characterized by both high negative affect and low positive affect (42). In fact, in studies that have created separate scales from positive and negative items of the Center for Epidemiological Studies of Depression Scale, positive affect predicted survival (43) and the incidence of stroke (2), whereas negative affect did not predict in either case. Hence, we need to take more seriously the possibility that PES is a major player in disease risk, even in situations that we have attributed in the past to NES.

A major purpose of this study was to see if the associations between PES and both colds and symptoms were retained when we controlled for social and cognitive dispositions associated with PES, including optimism, extraversion, mastery, purpose, and self-esteem. These variables were proposed as being responsible for "spurious" associations between PES and health, in which they act as "causal" factors driving both greater PES and better health (1). These factors were, in fact, moderately correlated with PES. However, adding them as control variables (covariates) had little impact on the associations between PES and the health outcomes. In short, it is the "pure" affect that accounts for these relationships.

Finally, we wanted to address whether the PES–illness associations could be attributed to self-rated health, an established predictor of morbidity and mortality. Here we controlled for self-rated health using a measure used widely in epidemiologic studies and found that PES still predicted illness and symptom reporting biases. Moreover, as mentioned

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previously, we found that one of the subscales of PES that did not contain any items thought to indicate health status (well-being subscale) was associated with risk for developing a cold as was the one subscale that was potentially confounded with health (vigor, e.g., "full of pep"). In predicting symptoms, all the subscales showed the same mean differences, but it was calm that showed the largest association and vigor that showed the smallest. In summary, both the analyses controlling for self-reported health and the subscale analyses support an effect of PES that is independent of any overlap between markers of positive affect and perceived (self-reported) health.

A limitation of the study was the use of only three subscales to represent the range of affect in both PES and in NES. A broader representation of individual emotions (subscales) in these scales may provide a clearer understanding of the characteristics of these measures that are associated with health outcomes. There was also a relatively small sample size for studies of this type. It is possible that a larger sample may have resulted in somewhat different conclusions about whether the various cognitive factors were associated with colds, although this would not influence the conclusions regarding their failure to provide alternative explanations for the PES effects.

CONCLUSIONS

In summary, we found that the tendency to express positive emotions was associated with greater resistance to developing a cold. We also found that PES was associated with fewer self-reported symptoms after removing the possible contributions of objective illness. Both of these associations were independent of NES, the cognitive and social dispositions associated with PES, and self-reported health. These results indicate that positive emotions play a larger and more important role in disease risk and health complaints than previously believed.

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