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Self-reported health bias: The role of daily affective valence and arousal

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Abstract

Objective—The present study addresses gaps in the literature on affect-biased health perceptions by a) investigating health bias while considering both valence and arousal components of affect; b) establishing the presence of, and variability in, affective health bias at the daily level; and c) exploring daily health bias in a non-clinical, community sample of adults.

Design—Participants were 477 adults (aged 33–80 years) who reported daily health events, health satisfaction, and affect for up to 56 days. Health bias was present when the effect of a given day's health events on that day's health satisfaction was significantly moderated by that day's affect. Multilevel modeling was used to investigate fixed and random within-day effects.

Main Outcome Measure—Daily health satisfaction.

Results—Significant interaction effects indicated the presence of health bias on the daily level: positively-valenced affect buffered the negative impact of health events on health satisfaction, whereas negatively-valenced affect exacerbated this association; additionally, valence emerged as the most salient characteristic of positive affect, whereas arousal was a differentiating factor for negative affect.

Conclusion—The results provide evidence that both valence and arousal components of affect are important to consider when investigating day-level health bias, and that these effects can be detected using a general population of adults.

Keywords

Health Bias; Daily Diary; Positive Affect; Negative Affect; Health Satisfaction

Although a portion of the relationship between affect and health is attributable to real effects resulting from neurological and physiological processes underlying positive and negative affect (Powell, Johnston, & Johnston, 2008), affect exerts its most demonstrable effects on indices of perceived health; research has consistently shown that affective states contribute substantial bias to self-reports and self-assessments of physical health (Gijsbers van Wijk & Kolk, 1997; Watson & Pennebaker, 1989). Such *health bias* is indicated when one's affective experience significantly predicts or moderates the relationship between an individual's reports of his or her own health and more objective health assessments. This bias, which has been found for both negative and positive affect at both trait and state levels, can be problematic in the contexts of medical treatment and academic research if not

appropriately understood and accounted for. For example, an individual in a positive mood during a doctor's visit may underreport or downplay symptoms in a manner that would prevent the physician from investigating an issue that would have come to light otherwise; similarly, an individual experiencing a chronically depressed affect may over report or exaggerate physical symptoms, which may lead to unnecessary tests or treatments.

Of particular interest to the present project is the impact of both affective valence and affective arousal on the presence of health bias on the daily level in a community sample of midlife and older adults. The three primary aims of this study are 1) to investigate affect bias within the valence/arousal framework common to a number of prominent theories of affect; 2) to explore affect-related health bias on the daily level; and 3) to assess these processes within a non-symptom-specific context, in order to understand health bias as it naturally manifests in the general population.

Negative affect (NA)—especially of the high-arousal type—is the most studied source of affective bias, with most findings indicating that higher levels of trait NA predict inflated symptom reports and evaluations of self-rated health that are lower than objective health measures indicate (Bogaerts et al., 2005; Karsdorp, Kindt, Rietveld, Everaerd, & Mulder, 2007; Mora, Halm, Leventhal, & Ceric, 2007). Positive affect (PA) has also been found to influence people's self-assessments of health on both state and trait levels, albeit to a lesser extent (Benyamini, Idler, Leventhal, & Leventhal, 2000; Pettit, Kline, Gencoz, Gencoz, & Joiner, 2001; Pressman & Cohen, 2005; Rietveld & Van Beest, 2006). There are very few studies, however, that have considered positive affect alongside negative affect, and when they do, the positive and negative affective dimensions measured tend to be those at the high-arousal end of the spectrum (Watson, 1988; Weisenberg, Raz, & Hener, 1998) or at different state or trait levels (Bogaerts et al., 2005). There is a relative dearth of studies that comprehensively consider the entire range of affective experience in relation to subjective health perception, a reality that represents a divide between theory and measurement. Because many theoretical models of affect (e.g., Feldman Barrett & Russell, 1998; Thayer, 1978; Watson, Wiese, Vaidya, & Tellegen, 1999) describe the affective space in terms of both *valence* (positive/negative, pleasant/unpleasant, approach/avoidance) and *arousal* (activated/deactivated, aroused/unaroused), much of the affective space is often ignored in the health bias literature. The present project, in an attempt to better align affect theory with the conceptualization of health bias, will investigate the differential impact of low- and high-arousal negative and positive affect states on biased health reporting.

Another limitation when it comes to the conceptualization of affect in health bias research is that affect tends to be treated as a trait variable, implying that there are stable individual differences in affective experience that generalize across time and contexts, and can therefore be predictive of other global, between-person constructs and outcomes (Eaton, 2004; Feldman, 1995). Countless studies have indeed identified trait mood features to be associated with personality, behavioral tendencies, stress reactions and coping, and objective health (Ashby, Isen, & Turken, 1999; Pressman & Cohen, 2005; Steptoe, Dockray, & Wardle, 2006; Watson et al., 1999). There is growing evidence, however, that there is substantial intraindividual variability from day to day, not only in the experience of affect, but in the extent to which affect impacts an individual's functioning on a given day (Diener & Larsen, 1984; Whitehead & Bergeman, 2011). There has been some acknowledgement of state effects in affect-related health bias, as proponents of the cognitive-affective model suggest that external cues—information about what to expect and how one should feel emotionally—prompt reactions based on previous experiences with similar contexts (Janssens, Verleden, De Peuter, Van Diest, & Van den Bergh, 2009; Petersen, Van den Berg, Janssens, & Van den Bergh, 2011). Studies with this contextual/state emphasis, however, tend to use experimental manipulations at a single point in time (Wright, Ebrecht,

Mitchell, Asgiansah, & Weinman, 2005) or focus on specific symptoms or diagnoses (Main, Moss-Morris, Booth, Kaptein, & Kolbe, 2003; Zoellner & Craske, 1999), which does not necessarily translate to the more natural occurrence of biased health perceptions on a given day. It is therefore an aim of the present project to extend research on affect-biased health perceptions to daily-level processes in a manner that can capture the natural ebb and flow of everyday life, and which will contribute to a more nuanced understanding of how and when biased health perceptions manifest in the day-to-day experience of individuals.

A final area in which the present project deviates from much of the existing health bias literature is in the breadth of the sample and the generality of measurement; traditionally, the literature on health bias takes a more specific approach, in that particular disease diagnoses or symptom reports define the sample and the measures. This has been important in establishing the presence and impact of affect-imposed biases in perceived health within the context of certain diagnoses, such as asthma (Bogaerts et al., 2005; Janssens et al., 2009), diabetes (Schandry, Leopold, & Vogt, 1996), and heart disease (Karsdorp et al., 2007). The fact that these studies generally do not include sub- or non-clinical samples, however, leaves open the question of whether and how these affect biases in health perceptions manifest in more general contexts. Indeed, such general affect biases may play a role in either a) negative health biases predisposing individuals to experience undue stress and anxiety and/or to seek unnecessary medical treatment, thereby reducing their well-being and burdening the medical system; or b) positive health biases leading people to ignore symptoms and thus delay medical consultation and treatment, which could eventually result in negative health outcomes. This makes it important to investigate the impact of affect on health perception in a non-diagnosis-specific, community population; the focus here is on adults in mid- and later life, as the health biases being investigated become increasingly relevant as health deteriorates with age while utilization of health services increases.

In order to study these processes in a more general sample, it is necessary to use objective and subjective health indicators that permit a broader operationalization of health bias. On the daily level, we have measured the objective piece by asking participants to report on a number of daily health events, such as having a cold or getting a minor cut or bruise; chronic health conditions, such as hypertension, diabetes, and arthritis, are also controlled for. The subjective aspect here is based on participants' reports of how satisfied they are with their overall health that day. Bias results when that day's affect serves to moderate the effect of objective health events on that day's health satisfaction; that is, the extent to which a given day's health events contribute to that day's health satisfaction depends on (or is *moderated* by) that day's affect. These more general measures and conceptualizations provide a picture of daily affect-related health bias that is potentially generalizable to a much broader context than studies focusing on specific symptoms or diagnoses.

Guided by the three aims iterated above, the present project addresses current gaps in the affect-related health bias literature as well as lays the groundwork for future studies. We hypothesize that all four of the affect domains of interest (positive valence/high arousal, positive valence/low arousal, negative valence/high arousal, negative valence/low arousal) will have unique direct effects on daily health satisfaction, and also that they will each moderate the relationship between a given day's health events (e.g., having a cold, cutting one's finger) and that day's overall health satisfaction, demonstrating the presence of day-level bias (both positive and negative) in a community sample of midlife and older adults.

Method

Participants and Procedure

This project uses data from the larger Notre Dame Study of Health & Well-Being (NDHWB), which is an ongoing longitudinal project designed to investigate stress and resiliency processes in the context of adult development and aging. The NDHWB includes 56-day daily diary “burst” assessments, taken in alternate years beginning in Year 1, which ask participants to report daily experiences, perceptions, and moods; the Year 3 daily diary is used here, as an item was added at this time point to ask about health satisfaction on the daily level.

NDHWB participants who agreed to participate in the Year 3 daily diary ($N = 484$) received daily surveys by mail, which they were instructed to complete each night before going to bed and then to return in postage-paid return envelopes supplied by the researchers; participants received \$10 for each week of diaries completed. Note that paper surveys were chosen over online surveys in order to prevent those uncomfortable with or without access to computers from being excluded from the study. Those participants who had data on all of the variables of interest (daily affect, daily health events, daily health satisfaction) on at least one day, and who were not missing on age, were included in the present analysis ($N = 477$). In terms of complete diaries, 156 (33%) participants completed all 56 days, 349 (73%) had at least 50 days complete, and only 4.6% completed fewer than 20 days; the fewest number of diaries completed by a participant included in the present analysis was four. ANOVA tests on the categorical variables and t-tests on the continuous variables revealed that participants did not significantly differ from the full NDHWB sample in demographic variables, health conditions, or global affect.

The 477 participants used in the present study ranged in age from 33–80 years ($M = 63.4$, $SD = 8.8$), and were 62% female; 85% were Caucasian and 9.5% were African American, with the rest identifying as Hispanic/Latin American, Asian, or “other”. Regarding marital status, 49% of participants were married, 25% were separated or divorced, 15% were widowed, and 11% were single. Participants were fairly well-educated, with 97.5% having graduated from high school and 62.5% having some sort of post-secondary education; 31% had a college degree or higher. Income characteristics were as follows: 17.5% earn less than \$15,000 annually, 18% earn between \$15,000 and \$24,999, 24.5% earn between \$25,000 and \$39,999, 25.5% earn between \$40,000 and \$74,999, and 14.5% earn \$75,000 or more. These demographic characteristics reflect those of the Northern Indiana population from which participants were drawn. In terms of health status, the average participant rated his or her overall health as “good,” and reported an average of 2 chronic health complaints (e.g., high blood pressure, arthritis) and an average of 3 somatic health complaints (e.g., back pain, headaches) in the Year 3 global questionnaire.

SAS version 9.3 software was used for all analyses (SAS Institute, Inc., 2011).

Measures

Daily Affect—A form of the Positive and Negative Affect Scale (Watson, Clark, & Tellegen, 1988), with the 20 original high-arousal items (e.g., angry, excited) augmented with 7 conceptually moderate- and low-arousal affect terms selected by the researchers (e.g., relaxed, depressed),¹ assessed positive and negative affect (PA/NA) on the daily level. The original scale format was adapted for daily use by using a “Today I felt...” prompt, followed

¹There were originally 8 items added by the researchers (4 negative and 4 positive), but one positive item—*satisfied*—was omitted from the present analysis due to its similarity to the dependent variable, *health satisfaction*.

by a list of the 13 positive and 14 negative affect descriptors. Participants rated each item on the extent to which they felt each over the course of a given day, from 1 (*Not at All*) to 5 (*Extremely*). Exploratory and confirmatory factor analyses were used to develop the affect scales used here, as described in the Results section below. The final affect scales were low-arousal negative affect (LNA; $\alpha = 0.83$), which comprised 5 items (e.g., *depressed*, *miserable*); high-arousal negative affect (HNA; $\alpha = 0.92$), which included 7 items (e.g., *afraid*, *distressed*); and positive affect (PA; $\alpha = 0.95$), a 13-item scale including both low- and high-arousal items (e.g., *proud*, *excited*). A 10% missing data rule was applied to each affect scale; that is, missing item values for participants missing 10% of items for a given scale were replaced using mean substitution, resulting in a complete scale score for that day; whereas scale scores for participants missing > 10% of items were scored as missing that variable on that day. Completion rates across person-days for each affect scale are as follows: 87% for LNA, 88% for HNA, and 88% for PA.

Daily Health Events—Each day, participants reported whether or not any of eight health-related events (four positive events, four negative events) happened that day (Yes/No). Negative health events included *I had to see a doctor* and *I had a cold or flu*; positive health events included *I exercised to improve my health* and *I ate a healthful diet*. Negative health events endorsed were given a value of 1, whereas each positive health event endorsed was given a value of -1; the possible range of the daily health events variables was thus from -4 to 4, with a score of zero indicating the occurrence of either zero health events or of equal numbers of positive and negative health events. All health event items were drawn from the Inventory of Small Life Events (ISLE; Zautra, Guarnaccia, & Dohrenwend, 1986). The health events scale was coded as missing on a given day if participants failed to respond “Yes” or “No” for any health events; this resulted in health event data being 89% complete across person-days.

Daily Health Satisfaction—After endorsing any health events that occurred on a given day, participants were asked “Overall, how satisfied were you with your health today?” They rated this statement on a scale from 1 (*Not at All*) to 5 (*Extremely*). The “satisfied” item was used as a daily measure of overall health perceptions, and demonstrated an 88% completion rate.

Chronic Health Covariate—As part of the global questionnaire packets completed in Year 3, participants filled out checklist consisting of 14 chronic health items drawn from Belloc, Breslow, and Hochstim (1971); items included long-term health ailments such as hypertension, arthritis, diabetes, and cancer. Items endorsed (“checked”) were given a score of 1, and those not endorsed were given a score of zero; the total number of items endorsed represents an individual’s chronic health score, with higher values indicating more chronic health problems.

Results

Descriptive Results

The means, standard deviations, and within-day correlations of each variable are shown in Table 1. Note that there are three affect variables represented (PA, LNA, HNA), reflecting the 3-factor affect structure that emerged as described below.

Factor Analyses on Affect

Exploratory factor analyses (EFA’s) were run on the day-level affect data, and the first two factors of the *unrotated* factor solutions—which provide information on the valence (Factor 1) and arousal (Factor 2) properties of each affect item (Feldman, 1995; see Table 2 for the

arousal loadings for Day = 1)—were used to create the initial affect scales intended to capture the four quadrants of the affective space (LNA, LPA, HNA, and HPA). After examining the loading values for Factor 2 (arousal) on six randomly selected days and comparing those values to conceptual expectations of which items should be low- vs. high-arousal in nature, we arrived at the scale breakdown shown in Table 2, each of which demonstrates appropriate reliability.

Upon examination of the correlations among the low- and high-arousal affect scales, however, the correlation between LPA and HPA was high ($r = .87$), leading us to combine the two PA scales into a single variable, resulting in a 3-factor treatment of daily affect. As shown in Table 3, Confirmatory Factor Analysis (CFA) revealed that, indeed, the 3-factor affect structure fit the data significantly better than the 2-factor (valence-only) model, and more parsimoniously than the 4-factor structure that was initially conceptualized (that is, the additional factor of the 4-factor model did not significantly improve model fit, resulting in the 3-factor model being selected as the “best-fitting” model for the data). Thus, the MLM analyses described below test for the differential impact of PA, LNA, and HNA on the relationship between a given day’s health events and that day’s health satisfaction.

Application: Within-Day Direct Effects Models

The daily health bias models were tested using a multi-level modeling (MLM) approach, which permits the modeling of both day-level (Level 1) and person-level (Level 2) fixed effects, as well as within-person variability across days (indicated by random effects). All daily independent variables (EVENT, PA, LNA, HNA) were centered around each person’s individual mean across days, and a mean term for each in—which values are averaged across days for each person is—included as a fixed effect at Level 2 to control for between-person differences². The terms of primary interest were the Level 1 main effects of the independent variables, as well as the AFFECT*EVENT interaction effects, which most directly inform the moderating health bias hypotheses. All models also included covariate terms at Level 2 for the impact of age³ and chronic health on the intercept.

The unconditional model of daily health satisfaction (Model A)—omitting all predictor variables and estimating only a random intercept—demonstrates that there is significant within-person variance to be accounted for ($ICC^4 = 0.63$, indicating that 37% of the total variance is attributable to within-person sources); this justifies the estimation of both random and fixed effects for the daily predictor variables. Based on this information, we ran two sequences of models: the first sequence (shown in Table 4) tested for the simple main effects of the three affect scales apart from the others; this information was then used to arrive at the optimal order in which to add the affect terms in the second sequence of models, which was designed to establish a final “best-fitting” model to inform our daily health bias hypotheses (shown in Table 5).

Series 1: Individual Models—Concerning the fixed effects in the first sequence of models (Table 4), we first find that there is a statistically significant effect of the age term ($p < .0001$), meaning that daily health satisfaction increases with age (Model B). The age term maintains its significance throughout the analysis. Model C demonstrates that the chronic

²The Level 2 mean terms are not depicted in the results tables due to their control status; with the exception of the mean HNA term, these effects were significant throughout at $p < .05$.

³The extent to which age moderated the direct and interaction effects of interest was tested initially, but nothing emerged as significant.

⁴ICC = intraclass correlation, which indicates how much of the total variance is attributable to between-person sources; subtracting this value from 1.0 gives the proportion of variance attributable to within-person sources, which is of primary interest here. The ICC is calculated as follows, where ($\sigma^2_{\text{intercept}}$) is the random variance of the intercept and (σ_e^2) is the estimate of the random residual: $\sigma^2_{\text{intercept}} / (\sigma^2_{\text{intercept}} + \sigma_e^2)$

health covariate also significantly predicts daily health satisfaction, with a greater number of global chronic health complaints related with lower daily satisfaction with health; the chronic health term remains significant for all models. The terms of theoretical interest to the present project enter the picture in the next model (Model EVENT), which demonstrates the significant negative direct effect of health events on health satisfaction ($p < .0001$). The pseudo-Rsquare statistic⁵ revealed that the random effect of EVENT accounted for an additional 13.5% of the within-person variance in health satisfaction compared to Model C. The next three models in Table 4 are those testing for the individual main effects of each affect scale, omitting all others (Models PA, LNA, and HNA). All of these demonstrated significant fixed effects, as follows: higher levels of PA on a given day were associated with better health satisfaction that day; higher levels of LNA or HNA, on the other hand, were linked with poorer health satisfaction.

Random effects revealed that, when compared with the EVENT Model, the PA, LNA, and HNA terms explained 17.1%, 8.4%, and 6.5% of within-person variance in daily health satisfaction, respectively. Likelihood ratio tests⁶ comparing each of the affect models with the EVENT model revealed that each represented a significant improvement in model fit. Based on model fit indices, Model EVENT improved most with the addition of the PA term, followed by the LNA term and the HNA term; this was therefore the order of terms added in the second series of models.

Series 2: Nested Models—The second sequence of models, in which one term was added at a time in a nested fashion, proceeded as shown in Table 5. The addition of the main effects for each affect term (Models D–F) demonstrated a significant improvement in model fit, with each affect variable having a significant direct effect on daily health satisfaction in the hypothesized direction, even when controlling for the effects of the other affect variables (Model F). In terms of random effects, the direct effect of LNA explained an additional 2.2% of within-person variance over that explained by the health event and PA terms (Model D/Model PA); the addition of the HNA term explained an additional 1.8%.

The addition of the interaction terms was first done individually (Models G–I), followed by a sequential approach similar to that taken with the direct effects terms (Models J–K). The individual interaction models demonstrate that all three AFFECT*EVENT terms have significant fixed effects in the hypothesized directions in the event that no other interaction terms are included, even when accounting for the direct effects of all affect variables. Random effects revealed that each of the interaction terms explains an additional within-person variance beyond that captured by terms already in the model: 1.8% for PA*EVENT, and 1.4% for both LNA and HNA interaction terms. Beginning with the PA*EVENT interaction model (Model G), the other two interaction terms were added in the same nested fashion as they had been for the direct effects. When the LNA*EVENT term was added (Model J), it was not significant, and explained only an additional 0.9% of within-person variance; all other terms in the model retained their significance. The LNA moderation term was therefore dropped from the model, and the HNA interaction term (Model K) was added; as was the case for LNA, the HNA*EVENT term was not significant, although the PA

⁵The pseudo-Rsquare statistic is a measure of the amount of within-person variability a given random effect accounts for, and is calculated using the following formula, where (σ_{e1}^2) is the within-person residual of the restricted model, and (σ_{e2}^2) is the within-person residual of the full model: $\sigma_{e1}^2 - \sigma_{e2}^2 / \sigma_{e1}^2$

⁶The likelihood ratio test is a test of overall model fit which compares the difference in the $-2LL$ values between two models to a critical value of the chi-square distribution corresponding to the difference in the degrees of freedom (df) in each model. For example, the critical value corresponding to a change in df of 5 (based on the difference in the number of estimated parameters between Model EVENT and Model PA, for example) at a significance value of 0.05 is 16.75; the difference between the $-2LL$ values must be higher than this in order for the fuller model to be considered significantly better than the more restricted model.

moderation term and all direct effects remained significant. Model G—the PA moderation model—was therefore retained as the best-fitting model for the data.

Discussion

Regarding the first aim, which was to investigate affect bias within the valence/arousal framework common to a number of prominent theories of affect, the results partially support the theoretical assumption that both valence (positive vs. negative affects) and arousal (activated vs. non-activated affects) dimensions play an important role in when and how affect impacts cognitive processes, behavior, and well-being outcomes (Feldman, 1995; Feldman Barrett & Russell, 1998; Thayer, 1978; Watson et al., 1999). Each of the three affect scales—PA, LNA, and HNA—demonstrated significant direct fixed effects on daily health satisfaction, even when controlling for the effects of the other two. Specifically, the within-person findings revealed that when a given day's actual health events are accounted for, individuals feel less satisfied with their health on days when they experience levels of low- or high-arousal negative affect that are above their own average—even when positive affect is controlled—whereas they feel more satisfied with their health on days when they are above their own average in positive affect, irrespective of whether it is low or high arousal in nature. In the moderation analyses, arousal emerged as less influential, as valence—specifically positive valence—appeared to be the most salient dimension of affect in the context of health bias.

In the case of NA, model fit indices supported the conclusion that modeling valence and arousal dimensions of affect separately is more optimal than collapsing them into a single affect scale or ignoring arousal in favor of valence; for PA, however, a single-factor model was more appropriate than a 2-factor arousal conceptualization. The fact that the negatively-valenced affect items separated into two distinct—albeit moderately correlated—low- and high-arousal scales, whereas the positively-valenced affect items did not, indicates that in our sample, arousal is a salient and defining characteristic of negative mindsets, but not for positive ones; rather, valence is the primary defining characteristic of the positive affective space. This makes sense, as enthusiasm and relaxation are likely to be perceived as similarly “good” or “positive” despite their differing levels of arousal, whereas the elevated arousal associated with distress is likely to make its salience and perception of being “bad” or “negative” greater than that of lower-arousal negative affects such as feeling lonely. These findings may also be a result of the affect items included, making it important for future studies to further investigate the structure of the affective space in midlife and older adults. Regardless, the results provide additional evidence for the importance of including lower-arousal affect items along with the traditional high-arousal terms in order to get the most accurate picture of the affective processes at hand.

The second aim—to explore affect-related health bias on the daily level, attempting to get at the day-in, day-out variability that global studies are unable to capture—is perhaps the most applied. That is, establishing the presence of affect-biased health perceptions on the daily level, and treating it in a manner that acknowledges the substantial within-person variability in affective experience, translates to a variety of everyday decisions based on subjective health evaluations (e.g., whether one should go to a doctor, take a given medication, or exercise) as well as to clinical or academic health assessments relying on self-report for accurate data. The moderation analyses revealed that affect-related health bias as conceptualized here does exist on the daily level, and that all affective domains can contribute to this bias. Specifically, on days when participants reported low- and high-arousal negative affects that were above their own average, the detrimental impact of that day's negative health events (e.g., having a cold) on health satisfaction was more pronounced; whereas days when they experienced above-average levels of positive affects,

the negative link between health events and health satisfaction was reduced. These findings fit well with what has been found on the global level for both NA-related health bias (Karsdorp et al., 2007; Watson & Pennebaker, 1989) and PA-related health bias (Benyamini et al., 2000; Pressman & Cohen, 2005), as well as existing daily studies (Main et al., 2003; Zoellner & Craske, 1999); but the significant intraindividual variability present for these bias effects points to the importance of considering the impact of health bias within the context of everyday life, and not only as resulting from trait-level personality characteristics.

Additionally, the fact that the LNA and HNA interaction terms become non-significant when the PA interaction is included indicates that positive emotions may have a counterbalancing influence on the biasing effect of negative emotions in the context of health satisfaction; this “undoing” effect of PA aligns well with existing theoretical literature (Ashby et al., 1999; Fredrickson, 1998) and empirical findings (Papousek et al., 2010). Related to this, some have observed stability or improvement in overall self-rated health across time while actual physical health declines; they suggest that an emergence of such positive health bias reflects an adjustment in one’s definition and/or expectations of “health” (Benyamini, Blumstein, Murad, & Lerner-Geva, 2011). It is important to recognize, however, that too much PA may be detrimental, as the resulting health bias may lead to poor health monitoring and/or reckless health behaviors. The reality is that the “ideal” affective state for accurate subjective health reporting is likely characterized by a balance of negative and positive emotions, with the negative emotions lending attention and awareness to health concerns while positive emotions keep that vigilance from translating into negatively-biased health perceptions. Our findings also revealed that the PA interaction term maintains its absolute value and significance when the negatively-valenced interactions are included; this highlights the persistent biasing influence of positive emotions, and charges future projects to consider positively-valenced affects in addition to the negatively-valenced affects that dominate the health bias literature. In an applied sense, the overwhelming salience of PA bias found here suggests that it may be sufficient to monitor or control for only the most salient term the—PA term in this case—when evaluating the presence of daily health bias, particularly for settings in which time and/or resources for such “extra steps” may be limited.

Briefly, although the focus here was on the day-level health bias effects, we did control for global processes by including mean terms in the models (average health events and affect across the 56 days), which are thought to tap more stable, trait-level aspects of these variables. These between-person terms were consistently significant in the hypothesized directions, which aligns with the more global processes established in the literature (Pressman & Cohen, 2005; Watson & Pennebaker, 1989); an important next step will be to explore how these interindividual differences inform the intraindividual day-level processes investigated here. Relatedly, the emergence of PA as the primary contributor to daily health bias stands in contrast to the strong biasing effects of NA in the existing global health bias literature (Karsdorp et al., 2007; Mora et al., 2007), and may point to level differences in health bias processes; that is, trait negative affect may be a more salient predictor of global-level biased health evaluations, whereas positive affect is more likely to impact day-level health perceptions. Again, future studies should investigate this possibility.

The third aim—which set out to investigate these processes within a broader, non-clinical context—required a deviation from the traditional measures and operationalizations of the health bias literature, as one cannot use diagnosis-specific indicators when the interest is in the manifestation of affect-related health bias in a broader, population-based context. The reality is that health bias is not dependent on receiving a diagnosis, although there may be diagnosis-specific expectations or processes that come into play (Main et al., 2003). By using broader objective and subjective health indicators (i.e., the occurrence of everyday

health events and a general subjective health satisfaction item) in a more representative, non-clinical sample of midlife and older adults, these findings are evidence that affective arousal and valence serve to bias daily subjective evaluations of health even in the absence of a defining diagnosis or symptom. The significant age term, which was used as a covariate here, also indicates that everyday evaluations of health satisfaction may be different depending on where one is in the lifespan; this is an important direction for future projects to pursue, particularly within the framework of Socioemotional Selectivity Theory (Carstensen, 1995).

As in all research, there are limitations of this study, which in turn present opportunities for future projects to further investigate these processes. First, concerning the first aim, our scales of valence and arousal—although quantitatively derived, theoretically confirmed, and statistically reliable—are limited to the affect items included in the daily diary survey, and therefore may not represent the entire affective space. Although we have established that the affect scales have factor validity, face validity, and predictive validity, the reliability alphas indicate that the low-arousal negative affect items were particularly under-represented; this may be a limitation in the present context, but this information enables future projects to account for this issue by including a greater number and breadth of lower-arousal negative affect items than may initially seem necessary. A second limitation concerns our measure of objective health; although designed to eliminate as much subjectivity as possible, it is still self-reported in the sense that participants had to endorse whether or not a given event happened. This is likely to make the objective–subjective health relationship, which is the foundation of health bias, more confounded than it would be in a more specific context in which the objective measure is lung function or heart rate; a measure of chronic health conditions and diagnoses was included as a covariate in the analyses in an attempt to strengthen the day-level objective health variable. A related potential limitation is the use of an item asking about health satisfaction as a measure of the subjective health, rather than a more explicit overall perceived health item; the satisfaction item was used because an overall health assessment item (e.g., how would you rate your health today) would not likely yield enough intraindividual (day-to-day) variability for the daily-level analyses conducted here. Future projects may be able to overcome this limitation by including a brief daily health perception scale, rather than relying on a single item. Finally, although substantial effort was made to ensure participant compliance with the daily surveys, the paper format does hold potential for back- or forward-filling of surveys; the varied distribution of missing days, however, indicates that this is not a prevalent issue, and should not significantly impact the nature of the data.

Despite these limitations, the results of the present study provide initial evidence that both valence and arousal components of affect are important to consider when it comes to investigating health bias, and that these health bias effects operate to some degree within an everyday, non-clinical context for the general population of adults. The findings also shed light on the differential salience of arousal for negatively- vs. positively-valenced affects. These findings bring awareness to the fact that affect—whether state or trait in nature—can bias individuals' thinking about and evaluation of their health even before specific symptoms or diagnoses are present. This biased thinking is not only detrimental in clinical or academic settings that depend on accurate self-reported health information, but is also likely to impact day-to-day medical and lifestyle behaviors, potentially influencing either disease risk (in the case of positive affectivity bias) or quality of life (in the case of negative affectivity bias). It is therefore important for future studies to investigate the impact of day-level affective health bias on long-term health behaviors and outcomes, as well as to consider between-person factors—such as activity level and social support resources (Benyamini et al., 2011)—that may moderate that association. Finally, the findings lend a more nuanced perspective of positive emotions, which—although often under-studied and

under-valued in terms of influence—are almost invariably considered in a positive (beneficial) light; the fact that such emotions can also cause potentially harmful bias is therefore important to keep in mind when designing future studies in the area.

The results of this study present a number of directions for future inquiry, providing rationale for future projects to continue investigating the presence and impact of non-clinical health bias—as influenced by the entire affective spectrum—in the everyday context, in order to better understand the short- and long-term ramifications of these processes.

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Table 1

Means, standard deviations, and correlations of variables.

Variable	M	SD	Lo	Hi	1.	2.	3.	4.	5.	6.
1. Health Satisfaction	3.5	0.9	0	5	--					
2. Health Events	-0.7	1.1	-4	4	-.17	--				
3. Low-Arousal NA	6.7	3.0	5	25	-.14	.13	--			
4. High-Arousal NA	9.6	4.5	7	35	-.13	.13	.67	--		
5. PA (Combined)	42.0	11.1	13	65	.24	-.21	-.42	-.34	--	
6. Chronic Health	1.8	1.4	0	7	-.22	.16	.19	.16	-.10	--
7. Age	63.4	8.8	33	80	.19	-.08	-.17	-.13	.15	.17

Note: Variable 1 is the Dependent Variable; all means, standard deviations, and ranges, along with the correlations with age and chronic health, reflect those of the raw (uncentered) variables; the correlations between day-level variables were computed using person-centered variables (variables 2–5). Significant correlations are in bold ($p < .05$).

Table 2

Initial breakdown of affect scales with arousal loadings.

	Negative Valence	Arousal Loading on Day 1	Positive Valence	Arousal Loading on Day 1
Low Arousal	Depressed	0.32	Active	0.27
	Hostile	0.35	Cheerful	0.30
LoNA alpha = 0.83	Irritable	0.34	Proud	0.32
LoPA alpha = 0.90	Lonely	0.17	Relaxed	0.15
	Miserable	0.33	Self-Assured	0.30
			Strong	0.35
High Arousal	Afraid	0.46	Alert	0.43
	Distressed	0.37	Attentive	0.35
HiNA alpha = 0.92	Jittery	0.40	Determined	0.41
HiPA alpha = 0.93	Nervous	0.45	Enthusiastic	0.33
	Scared	0.43	Excited	0.46
	Upset	0.42	Inspired	0.38
	Worried	0.36	Interested	0.42

Note: Arousal loadings for Day 1 are presented as an example; the development of the initial four scales was based on the arousal loadings for 6 randomly-selected days, which were similar to those shown here.

Table 3

Confirmatory factor analyses on Day 1 Affect: Comparison of 2-, 3-, and 4-Factor models.

Model	# of Parameters	DF	Chi-Square	CFI	AIC	BIC	RMSEA	# of MI's
Two-Factor Affect	58	267	822.92	.93	938.92	1174.08	.070	7
Three-Factor Affect	59	266	806.73	.93	924.73	1163.94	.069	6
Four-Factor Affect	60	265	806.64	.93	926.64	1196.91	.069	4

$p < .0001$. Best-fitting, most parsimonious model highlighted in bold.

Note: Results reflect the estimation of additional error covariances which had Modification Indices (MI's) 30 in the initial model; the number of error covariances estimated in each model is depicted in the right-most column. The following error covariances were estimated in all three models: interested/inspired, active/enthusiastic, hostile/irritable, scared/afraid; the 3-factor model also included relaxed/cheerful and distressed/upset; the 2-factor model also estimated irritable/miserable, hostile/irritable, relaxed/cheerful, and nervous/jittery.

Table 4

Fixed effects and model fit of individual main effect models predicting Daily Health Satisfaction.

Parameter	Model A	Model B	Model C	Model EVENT	Model PA	Model LNA	Model HNA
Intercept	3.51 (.03)	2.32 (.24)	2.32 (.23)	2.32 (.22)	0.88 (.18)	3.58 (.23)	3.40 (.23)
Age		0.02 (.004)	0.02 (.004)	0.02 (.003)	0.01 (.003)	0.01 (.003)	0.01 (.003)
Chronic Health			-0.17 (.002)	-0.13 (.002)	-0.10 (.002)	-0.08 (.002)	-0.09 (.002)
EVENT				-0.19 (.01)	-0.13 (.01)	-0.17 (.01)	-0.17 (.01)
Affect					0.03 (.001)	-0.08 (.006)	-0.04 (.003)
Pseudo R ²				13.5%	17.1%	8.4%	6.5%
Parameters	3	4	5	9	14	14	14
-2LL	41709.0	41685.6	41630.1	38717.2	34251.6	36739.0	37047.4
AIC	41715.0	41693.6	41640.1	38735.2	34279.6	36767.0	37075.4
LR Test	--	23.4	55.5	2912.9	4465.6	1978.2	1669.8

Note: Model A is the intercept-only model, Model B adds the age covariate, and Model C adds the covariate for Global Chronic Health. The EVENT model adds the main effect of daily health events (EVENT); the rest of the models are the separate main effect models for each affect scale (PA = combined positive affect, LNA = low-arousal negative affect, HNA = high-arousal negative affect). "Affect" is a generic term referring to the affect term relevant to each model. Significant effects are bold ($p < .01$), and standard deviations are shown in parentheses. Pseudo R² = the percentage of variability explained by each additional variable. LR Test = likelihood ratio test; bold type indicates a significantly better-fitting model. AIC permits the comparison of non-nested models, with lower values indicating better model fit. Level 2 effects of mean terms are not shown for simplicity.

Table 5
Fixed effects and model fit of sequential (nested) models predicting Daily Health Satisfaction.

Parameter	Model D	Model E	Model F	Model G	Model H	Model I	Model J	Model K
Intercept	0.88 (.18)	1.75 (.22)	1.75 (.22)	1.81 (.22)	1.75 (.22)	1.76 (.22)	1.84 (.22)	1.81 (.22)
EVENT	-0.13 (.01)	-0.13 (.01)	-0.13 (.01)	-0.12 (.01)	-0.13 (.01)	-0.13 (.01)	-0.12 (.01)	-0.12 (.01)
PA	0.03 (.001)	0.03 (.001)	0.03 (.001)	0.03 (.001)	0.03 (.001)	0.03 (.001)	0.03 (.001)	0.03 (.001)
LNA	-0.03 (.004)	-0.02 (.005)	-0.02 (.005)	-0.02 (.005)	-0.01 (.005)	-0.02 (.005)	-0.02 (.005)	-0.02 (.005)
HNA		-0.01 (.003)	-0.01 (.003)	-0.01 (.003)	-0.01 (.003)	-0.01 (.003)	-0.01 (.003)	-0.01 (.003)
PA*EVENT				0.005 (.001)			0.005 (.001)	0.005 (.001)
LNA*EVENT					-0.01 (.004)		-0.003 (.004)	
HNA*EVENT						-0.01 (.003)		-0.0006 (.003)
Pseudo R ²	17.1%	2.2%	1.8%	1.8%	1.4%	1.4%	0.9%	0.9%
Parameters	14	20	27	34	34	34	42	42
-2LL	34251.6	33621.0	33459.3	33249.8	33364.0	33327.8	33197.9	33181.9
AIC	34279.6	33661.0	33513.3	33317.8	33432.0	33495.8	33281.9	33263.9
LR Test	4465.6	630.6	161.7	209.5	95.3	131.5	51.9	67.9

Note: Model D is the same as Model PA in Table 4; D–F add main effects sequentially according to the strength of individual effects; G–I investigate individual moderation effects; and J–K add interaction terms sequentially. PA = combined positive affect, LNA = low-arousal negative affect, HNA = high-arousal negative affect. Significant effects are bold ($p < .01$); bold italics reflect $p < .05$, and standard deviations are shown in parentheses. Pseudo R² = the percentage of variability explained by each additional variable. LR Test = likelihood ratio test; bold type indicates a significantly better-fitting model. Level 2 effects of mean terms and are not shown for simplicity.