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The role of vigilance in the relationship between neuroticism and health: A registered report

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Abstract

The theory of healthy neuroticism, that neuroticism can impact health through both negative and positive pathways, often relies on descriptions of vigilance to illustrate beneficial effects. The current study is among the first to describe the relationship of neuroticism to body vigilance and test the degree to which this relationship impacts health. In an online participant panel ($N = 1055$), neuroticism was associated with one factor of vigilance: sensation awareness belief. This factor had a suppression effect on the relationship between neuroticism and healthy behavior, such that the effect of neuroticism through vigilance was healthy, whereas the direct effect was unhealthy. We discuss the implications of these findings and caution against using vigilance to explain the heterogeneity in neuroticism-health relationships.

Keywords

Neuroticism; Vigilance; Health; Health behaviors; Self-rated health; Cross-sectional; Preregistered

1. Introduction

Neuroticism is a personality trait defined by negative affectivity of many types (Goldberg, 1993), including worry, anger, and emotional instability (Weiss & Costa, 2005). Individuals low in neuroticism are often referred to as “emotionally stable.” People high in neuroticism are both more likely to experience daily stressful events (Gunthert, Cohen, & Armeli, 1999) and react more strongly to stressful events (Bolger & Schilling, 2006; Mroczek & Almeida, 2004).

The relationship between neuroticism and health is somewhat unclear. Many studies have found that neuroticism is associated with worse health, including greater participation in unhealthy behaviors like smoking and drinking (Larkins & Sher, 2006; Turiano, Chapman, Gruenewald, & Mroczek, 2015; Weston & Jackson, 2015), more reported somatic symptoms (Watson & Pennebaker, 1989), have higher body mass indexes (Terracciano et al., 2009),

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jrp.2017.10.005>.

higher rates of chronic diseases (Nakaya et al., 2003; Weston, Hill, & Jackson, 2015), and greater mortality (for a metaanalysis, see Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007).

However, despite a widespread assumption that neuroticism has profound negative effects on health (Lahey, 2009), there are many studies that find small, null and even positive effects. A number of large-scale studies which either find that neuroticism has no effect on mortality (Almada, Zonderman, & Shekelle, 1991; Huppert & Whittington, 2009; Iwasa et al., 2008; Jackson, Connolly, Garrison, Leveille, & Connolly, 2015; Maier & Smith, 1999) or has a protective effect (Brickman, Yount, Blaney, Rothberg, & De-Nour, 1996; Lang, Weiss, Gerstorf, & Wagner, 2012; Ragland & Brand, 1988; Taga, Friedman, & Martin, 2009; Weiss & Costa, 2005). Similarly, the association between neuroticism on health behaviors is not consistently found (Atherton, Robins, Rentfrow, & Lamb, 2014; Hong & Paunonen, 2009), and neuroticism is an inconsistent predictor of disease status (Weston et al., 2015).

It is possible that this heterogeneity is due to neuroticism having positive effects on health in some situations or for some people. “Healthy neuroticism” is believed to describe individuals whose high levels of neuroticism lead them to act in protective ways, whereas other individuals who are high in neuroticism act in maladaptive ways (Friedman, 2000). Healthy neurotic individuals are described as attentive, more likely to notice changes in their health and more likely to seek medical attention than their unhealthy neurotic counterparts. Consequently, healthy neuroticism might be associated with early detection and treatment of health concerns. This would explain the protective effects of neuroticism found throughout the literature.

Examination of this theory has largely been dominated by analyses of the interaction of neuroticism and conscientiousness. Conscientiousness, the thinking goes, is composed of the self-control needed to refrain from unhealthy methods of coping, the industriousness necessary to act quickly when confronted with health problems, and the rule-following required to adhere to medications. The interaction between conscientiousness and neuroticism has been shown to successfully predict lower levels of inflammatory markers (Turiano, Mroczek, Moynihan, & Chapman, 2013), less smoking (Weston & Jackson, 2015) and lower alcohol consumption (Turiano, Whiteman, Hampson, Roberts, & Mroczek, 2012). However, these effects are also inconsistently found; for example, the interaction of conscientiousness and neuroticism on smoking is only found in some samples (Turiano et al., 2012; Weston & Jackson, 2015).

1.1. Vigilance and health

Central to the notion of healthy neuroticism is the concept of vigilance. In his first paper on the subject, Friedman (2000) wrote, “Consider now a classic Woody Allen type neuroticism, however, which leads one to be very *vigilant* about germs, symptoms needing attention, medical developments, and cooperation with treatment. Such a (health nut) neurotic might remain very healthy” (p. 1102, emphasis added). The term “vigilance” then appears in a number writings about healthy neuroticism (e.g., Hampson, 2012; Hill & Roberts, 2016; Mroczek, Spiro, & Turiano, 2009; Murray & Booth, 2015; Smith, Glazer, Ruiz, & Gallo, 2004). Indeed, even studies which have found interactive effects of conscientiousness and

neuroticism on health (Roberts, Smith, Jackson, & Edmonds, 2009; Turiano et al., 2013; Weston & Jackson, 2015) suggest that the combination of these traits may result in vigilance. Oddly enough, vigilance is almost never measured by personality researchers and is not a major component of existing neuroticism scales.

Outside of personality research, health psychologists are studying vigilance, sometimes called body awareness, and its relationship to health. One review found twelve self-report measures of body vigilance (Mehling, Gopisetty, Daubenmier, & Price, 2009). These self-report measures suggest that body vigilance may be comprised of two narrower facets: proprioception, the perceptions of joint angles and muscle tension; and interoception, the processing of sensory input from inside the body, specifically around the organs and tissues; and mindfulness, which is the extent to which a person is deliberate about scanning their body for sensations (Mehling et al., 2009). Importantly, body vigilance appears to be associated with the major themes in the healthy neurotic theory. Vigilance is related to health, although the direction is unclear. One measure is negatively associated with health, including increased clinic visits, longitudinal decreases in self-rated health and cross-sectional illness (Hansell & Sherman, 1991). Another measure interacted with physical impairment in hemodialysis patients to predict medication adherence (Christensen, Wiebe, & Edwards, 1996). Vigilance is related to higher trait anxiety (Schmidt & Lerew, 1997), so it is likely related to trait neuroticism.

1.2. The current study

The current study aims to identify the relationships between neuroticism, body vigilance and health. Given that we are the first study of which we are aware to incorporate all three, we will examine four possible relationships between these constructs. We note that these relationships are not mutually exclusive. We examine these relationships cross-sectionally here, and we acknowledge this is a major limitation of the project. However, we believe that this is an essential first step in a larger program of research. Specifically, because personality researchers have not yet examined vigilance, we must first examine whether it has any relationship to health or neuroticism at all before we can proceed to develop and test models of how and why vigilance is related to these constructs. Despite our cross-sectional design, we believe that our study will contribute to personality research for the following reasons: (1) we move beyond a simple bivariate correlation to examine more complex relationships between these constructs, including mediation and moderation models, (2) we include multiple measures of health, including self-rated health, health status and health behaviors, in order to begin to isolate what particular domains of health are relevant, and (3) given the diversity in body vigilance scales, we do not believe it is appropriate to select only one without a better understanding of how or why vigilance is related to neuroticism. Consequently, we have selected several scales and plan to incorporate these into a single measure of body vigilance.

1.2.1. Hypothesis 1: Neuroticism and body vigilance are related—The relationship between body vigilance, neuroticism and health may take several forms. First, we expect neuroticism and body vigilance to be related, especially given the relationship

between body vigilance and trait anxiety (Christensen et al., 1996). We hypothesize that this relationship will be significant and will have a modest effect size ($r = .20$).

1.2.2. Hypothesis 2: Body vigilance partially explains the relationship

between neuroticism and health—We hypothesize that there will be a significant effect of neuroticism on health through body vigilance. More specifically, if body vigilance is associated with anxiety, which is a component of neuroticism, than perhaps body vigilance is a pathway through which neuroticism is linked to health. Along these lines, body vigilance may suppress the effect of neuroticism in traditional analyses. In other words, neuroticism may show a stronger negative relationship with health after controlling for body vigilance because the remaining components of neuroticism (e.g., negative emotionality, emotional reactivity and perceptions of stress) are generally related to worse health.

1.2.3. Exploratory analysis: Is the relationship between having experienced a health event and neuroticism dependent upon body vigilance?—

It may be the case that neuroticism is unrelated to body vigilance and that body vigilance does not mediate the relationship between neuroticism and health. If this is the case, there may be another way in which vigilance and neuroticism are related. That is, we might expect body vigilance to change the relationship between neuroticism and health. Neuroticism may predict better health when body vigilance is high and worse health when body vigilance is low. Individuals high in neuroticism and body vigilance – after noticing changes in their health or body – may be more likely to seek medical attention or engage in protective behaviors. Individuals high in neuroticism engage in unhealthy behaviors, particularly alcohol consumption, as a method of coping (Kuntsche, von Fischer, & Gmel, 2008; McCrae & Costa, 1986). While all individuals high in neuroticism may be susceptible to engaging in these behaviors, those individuals also high in body vigilance may be more aware of how smoking or drinking affect their body, and they may be consume less of these substances and have better health as a result.

The use of moderation analyses when the predicting and moderating variables are associated is often discouraged as to better distinguish this theoretical model from one describing mediation (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001). In order to avoid this issue, we will only examine whether vigilance moderates the relationship between neuroticism and health if the relationship between neuroticism and body vigilance is lower than $r < .30$. This threshold was chosen arbitrarily. We do not specify hypotheses here, as these analyses are merely exploratory.

1.2.4. Exploratory analysis: Is the relationship between neuroticism and body vigilance dependent upon having experienced a major health event?—

Similarly, individuals who have experienced a major health event may have higher body vigilance, especially if they are prone to anxiety. Recall that some studies find a protective effect of neuroticism on longevity. These studies tend to sample from populations who have experienced a health threat, including men who have coronary heart disease (Ragland & Brand, 1988), diabetics, and those who have lost a loved one (Taga et al., 2009). In addition, studies using older adults, who are more likely to have experienced a major health event, also find protective effects of neuroticism (e.g., Korten et al., 1999; Lang et al., 2012; Weiss

& Costa, 2005). Neuroticism may also be associated with healthier behaviors. Individuals high in neuroticism report that they would be likely to engage in a number of adaptive behaviors, like research or seeking social support, after receiving bad health news (Weston & Jackson, 2016).

Just as in the prior exploratory analysis, we avoid fitting a moderation model if the predicting and moderating variable are too overlapping. If the relationship between neuroticism and health is lower than $r < .30$, we will examine whether the relationship between a past major health events and body vigilance depends upon a person's the level of neuroticism. Again, we do not specify hypotheses here.

1.2.5. Preregistration—Analyses and hypotheses for this study were decided upon prior to data collection. The pre-registration for this study can be found at osf.io/fjqtu. Additional materials, including data, analysis code, and exploratory analyses can be found at osf.io/hr7vx.

2. Methods

2.1. Participants and power analysis

Through the Qualtrics participant pool, 1569 participants started our questionnaire. Of these, 142 were screened out due to age constraints and failure to consent, and 372 participants failed our attention checks. This resulted in a final sample of 1055 participants. This gives us 90% power to detect correlations of at least $r = 0.10$.

The average age of the participants was 45.31 years ($SD = 17.25$); 52% self-reported as female and 47% self-reported as male. The rest choose other or did not respond; responses will be categorized as 0 for male and 1 for not-male for the analyses.

2.2. Measures

2.2.1. Neuroticism—Neuroticism was assessed using the fourteen-item neuroticism scale of the 135-item assessment of the SPI-5 (Condon, 2017).¹ Participants are asked to report how well each of the items describes them on a scale from 1 (not accurately at all) to 5 (extremely accurate; $M = 2.74$, $SD = 0.75$). Items are listed in Supplementary File 3. The scale had good internal consistency ($\alpha = 0.88$, $\omega_h = 0.70$).

2.2.2. Health—A number of different health measures measured as outcomes. First **self-rated health** was assessed using a single item: “compared to the average person, how would you describe your health?” Participants respond on a scale from 1 (Poor) to 5 (Excellent; $M = 3.34$, $SD = 0.93$). This item is commonly used as a measure of self-rated health in panel studies and medical research (Hays, Spritzer, Thompson, & Cella, 2015). **Body mass index (BMI)** was measured by asking participants to report their height in inches (ranging from 47

¹Additional personality items were administered during data collection, including a 14-item scale of Conscientiousness and items assessing the narrow traits of Anxiety, Emotional Stability, Impulsivity, Industry, Irritability, Order, Perfectionism and Self-Control. These measures will be used as pilot data for other projects. Exploratory analyses using these measures is presented in Supplementary File 2 and discussed briefly at the close of the Results section here. The full survey administered to participants is available at osf.io/na3g9.

to 85+) and their weight in pounds (options range from 80 to 305+ in increments of 5 lbs). BMI was then calculated by converting to metric units and dividing weight by height squared ($M = 28.80$, $SD = 6.72$).

Chronic condition status was assessed by asking participants to report if they currently have or have ever had any of the following medical conditions: anemia or blood disease, arthritis, asthma, blood clots, cancer, circulation problems, diabetes, glaucoma, heart disease, heart murmurs, high blood pressure, high cholesterol, HIV/AIDS, liver disease, lung problems or emphysema, mental illness or depression, stroke, tuberculosis, ulcers, other. From this, we created two variables. A binary variable (condition) which indicates whether they have or have had any condition (1) or not (0). Of the participants, 68% had at least one health conditions and 39% had at least two conditions. We created a count variable that indicates how many conditions a participant has experienced ($M = 1.46$, $SD = 1.60$).

Finally, we assessed the following health behaviors. **Exercise** is measured by asking participants to report how many days in the last month they engaged in vigorous exercise ($M = 9.89$, $SD = 8.63$). **Diet** is measured by asking participants to rate the quality of their diet from 1 (extremely unhealthy) to 5 (extremely healthy; $M = 3.44$, $SD = 0.92$). **Smoking** will be measured as a binary variable (1 - Yes, currently smoke, 0 - No, do not currently smoke). Of the participants, 11% are current smokers.

Alcohol consumption was assessed using two items: “During the past month, on how many days did you drink alcohol?” and, “during the past month, how many times did you consume 4 or more drinks on one occasion?” These variables were correlated $r = 0.53$, so we average these variables to represent alcohol consumption ($M = 4.36$, $SD = 5.88$).

Drug use was assessed using the item “during the past month, how many times did you use illicit drugs?” ($M = 0.81$, $SD = 4.00$). Finally, **medication non-adherence** was assessed by asking participants “during the past month, on how many days did you miss a dose of your prescription medication(s)?” Participants are first asked if they take prescription medications, and they only receive the adherence question if they were “yes.” A total of 607 participants take prescription medications and, on average, they missed 0.96 days in the last month ($SD = 2.71$).

A confirmatory factor analysis was used to combine the health behaviors (with the exception of medication non-adherence) into a single measure. The RMSEA of this model is 0.06, so we extracted the estimated latent factor score for each participant and use this as a single measure of health behaviors.² The loadings for the items are as follows: exercise (unstandardized = 1.00, standardized = 0.45), diet (0.16, 0.68), smoking (−0.02, −0.21), alcohol (0.09, 0.06), illicit drug use (−0.13, −0.13).

2.2.3. Body vigilance—Scales were identified using a meta-analysis of body vigilance scales (Mehling et al., 2009). Of these, scales were included in the current study if they were written in English, published in an academic journal and focused on bodily sensations and

²We also examined each of the health behaviors separately, and we note throughout the text how these results differed from the ones presented here. Those analyses can be found in Supplementary File 1.

changes (as opposed to spiritual connectedness with the body or disassociation). We were unable to find the items for two scales and ruled out an additional three based on our criteria. As a result, we used items from the Body Awareness Questionnaire (BAQ, Shields, Mallory, & Simon, 1989), the Private Body Consciousness subscale of the Body Consciousness Questionnaire (PBCS, Miller, Murphy, & Buss, 1981), the Scale of Body Awareness (SBA, Hansell & Sherman, 1991), the Body Responsiveness Questionnaire (BRQ, Daubenmier, 2005), and the Body Vigilance Scale (BVS, Schmidt & Lerew, 1997). All items were rated on a scale from 1 (strongly disagree) to 5 (strongly agree), with the exception of items from the SBC and the third item of the BVS, which are rated on scale from 1 (Never) to 5 (Always).

2.3. Analyses

2.3.1. To what extent are neuroticism and body vigilance related?—We assessed the relationship between neuroticism and body vigilance two ways. First, we calculated the strength and significance of the bivariate correlation between neuroticism and body vigilance. Second, we calculated the partial correlation, controlling for age and gender. We used bootstrapping with 1000 iterations in both cases, because we expected some of the outcome variables to be highly skewed. We used the percentile method to calculate the confidence interval.

2.3.2. Does body vigilance partially explain the relationship between neuroticism and health?—We used mediation models to examine the extent to which vigilance accounts for the relationship between neuroticism and health. We bootstrap the parameter estimates, again with 1000 iterations. Estimates of all effects were standardized, either by using standardized variables in the case of continuous outcomes or by standardizing using recommendations by MacKinnon and Dwyer (1993). These models controlled for age and gender.

2.3.3. Exploratory analyses

Does body vigilance moderate the relationship between neuroticism and health?: These analyses were only run in the case when the relationship between body vigilance and neuroticism is less than $r < .30$. For these analyses, we used regression to estimate the interaction between neuroticism and body vigilance on health. We used standardized variables to obtain standardized coefficients.

Do major health events change the relationship between neuroticism and body vigilance?: We only ran these analyses if the relationship between neuroticism and having experienced a major health event was below $r < .30$. We look to see whether experiencing a major health event is associated with greater vigilance and, if so, if that effect is greater for individuals high in neuroticism.³ For these analyses, we returned to the simple moderating model.

³We acknowledge that we are using cross-sectional data to examine an inherently longitudinal problem. However, given that this is the first study to examine the relationship of vigilance to neuroticism and health simultaneously, we view these analyses as an exploration into whether a greater track of research should be pursued on this question. We hope readers will also value the need to examine whether any relationship exists before investing in studies to address *why and how* that relationship exists.

3. Results

3.1. Creating a measure of body vigilance

We assessed the fit of 38 factor analyses which represent the extraction from 1 to 38 factors using the psych package (Revelle, 2017), which includes a function to run through these factor analyses and report and plot fit statistics. We looked for a local minimum in the very simple structure (VSS) fits. The local minimum for VSS was at 2 factors. BIC had an “elbow” at 3 factors and a minimum at 6. Complexity plateaued at 3 factors and jumped at 6. Finally, MAP achieved a minimum at 3 factors. We manually factored at these different levels of specificity (i.e., 2 factors, 3 factors and 6 factors) and examined the solutions, in terms of factor content, loadings and internal consistencies. We noticed that the three-factor solution contained the most interpretable factors and the best structure (i.e., items tended to have large loadings on one factor and small loadings on the others), with the exception of three items. We removed those three items (BVS4, BRQ01, BRQ05), and re-factored the solution. VSS suggested 2 factors, BIC had an elbow at 2, complexity plateaued at 2, and MAP achieved a minimum at 2. Consequently, we extracted two factors. The solution is presented in Table 1.

The first factor was characterized by items such as, “How much do you wonder about why your body feels the way it does?” and, “How much do you think about how your body feels?” We labeled this factor as Sensation Awareness Belief, as it seemed to reflect the perception that one thinks about and is aware of changes in their body more than the average person. The second factor was characterized by items like, “I can accurately predict what time of day lack of sleep will catch up with me,” and, “I am aware of a cycle in my activity level throughout the day.” We labeled this factor as Change Awareness Belief, as it seemed to reflect the perception that one could accurately predict changes in their body more than the average person. We also note that these items reflected changes in diurnal rhythms. These factors were correlated $r = 0.59$.

Sensation awareness belief was negatively associated with self-rated health ($r = -0.17$, $p = 0.00$), but was uncorrelated with body mass index ($r = 0.06$, $p = 0.72$), chronic condition status ($r = 0.06$, $p = 0.74$) and healthy behavior ($r = -0.05$, $p = 1.00$).

Change awareness belief was positively associated with self-rated health ($r = 0.07$, $p = 0.35$) and healthy behavior ($r = 0.12$, $p = 0.00$) but was unassociated with body mass index ($r = 0.01$, $p = 1.00$) and chronic condition status ($r = 0.00$, $p = 1.00$).

3.2. To what extent are neuroticism and body vigilance related?

Neuroticism was significantly and positively associated with sensation awareness belief ($r = 0.37$ 95% CI = [0.31, 0.43]), even after controlling for age and gender ($r = 0.28$ [0.22, 0.35]). Neuroticism was not significantly associated with change awareness belief $r = 0.06$ [0.00, 0.13], even after controlling for age and gender ($r = 0.00$ [-0.07, 0.07]).

3.3. Does body vigilance partially explain the relationship between neuroticism and health?

Next, we examined the extent to which the two factors of body vigilance mediated the relationship between neuroticism and health. As a reminder, our health outcomes are self-rated health, body mass index, chronic condition status, a health behavior factor, and medication non-adherence.

Sensation awareness belief showed a suppressor effect on healthy behavior. The standardized indirect effect of neuroticism through sensation awareness was 0.07 ([0.02, 0.14]), which indicates that the indirect effect of neuroticism was positive. The direct effect of neuroticism on healthy behavior was negative ($-0.78[-0.98, -0.57]$). This finding is in harmony with the broader theory of healthy neuroticism: that is, when a person's neuroticism leads to vigilance, that person acts in healthy or protective ways. (The current analyses of course do not demonstrate causality; we only take these significant effects as evidence that this relationship may exist and warrant further study.)

However, not all effects of vigilance served to make those high on neuroticism more healthy. Specifically, there was an indirect effect of neuroticism through sensation awareness belief on the likelihood of having a chronic condition (standardized estimate = 0.02 [0.01, 0.04]). This indirect effects were in the same direction as the direct effects. In other words, sensation awareness belief was associated with worse health, not greater. Change awareness belief did not moderate any of the neuroticism-health relationships.⁴ Results for both sets of models are shown in Table 2.

Finally, both vigilance factors were entered into the mediation models simultaneously. We caution against over-interpretation of this model, as the two vigilance factors are highly correlated. These analyses are included primarily because the pre-registration of this study noted that if more than one vigilance factor was extracted, a mediation model using all factors would be estimated. It was not expected that the factors would be so highly correlated.

There were no indirect effects of neuroticism through change awareness belief because this factor was unrelated to neuroticism. Consequently, the indirect effects estimated in the models can be interpreted as the indirect effect of neuroticism through sensation awareness belief controlling for change awareness belief. After controlling for change awareness belief, sensation awareness belief only mediated the effect of neuroticism on self-rated health and chronic condition status. Specifically, sensation awareness belief was associated with worse self-rated health (standardized indirect effect = $-0.06[-0.09, -0.03]$) and greater likelihood of a diagnosis (0.09 [0.04, 0.14]). This effect may be interpreted to mean that our model is misspecified: including two strongly correlated mediators may not be appropriate. Had we anticipated this complication, we would not have preregistered the use of nor estimated this particular model.

⁴When examining the individual health behaviors, there were also small suppressor effects of sensation awareness belief for smoking and healthy eating, but not for exercise, alcohol consumption or drug use. There was no effect of change awareness belief on the relationship between neuroticism and any health behaviors.

3.4. Exploratory analyses

3.4.1. Does body vigilance moderate the relationship between neuroticism and health?—Given the size of the correlation between change awareness belief and neuroticism, we chose to analyze the degree to which this factor of body vigilance moderated the relationship between neuroticism and health. We used simple regression analyses, controlling for age and gender. The interaction between neuroticism and change awareness belief did not predict any of the health behaviors or outcomes. Specifically, it did not predict self-rated health (standardized coefficient [std b] = 0.04 [−0.03, 0.10]), BMI (std b = −0.03 [−0.10, 0.04]), chronic condition status (std b = 0.10 [−0.04, 0.24]), healthy behavior (std b = 0.14 [−0.06, 0.32]),⁵ or mediation non-adherence (std b = 0.02 [−0.05, 0.08]). A full table of results is available in Supplementary File 1.

3.4.2. Do major health events change the relationship between neuroticism and body vigilance?—The bivariate relationship between neuroticism and likelihood of chronic conditions is smaller than $r = .30$ (the point bi-serial correlation is 0.05). Therefore, we analyzed the degree to which the relationships between neuroticism and the body vigilance factors was changed by the presence of a chronic disease. Again, we use a simple regression format, with neuroticism and number of chronic conditions interacting to predict each of the vigilance factors. We control for age and gender. When neuroticism and chronic condition status were entered into regression simultaneously (without the interaction term), both neuroticism (standardized coefficient [std b] = 0.26 [0.20, 0.33]) and condition status were positively associated with sensation awareness belief (std b = 0.22[0.11, 0.33]). Neither was associated with change awareness belief (std $b_{neuroticism}$ = −0.01[−0.07, 0.06]; std $b_{conditionstatus}$ = 0.08[−0.04, 0.20]). The interaction of neuroticism and condition status was then added to these models. This term did not predict either sensation awareness belief (std $b_{interaction}$ = 0.07[−0.06, 0.19]) or change awareness belief (std $b_{interaction}$ = 0.11[−0.02, 0.24]). Using the number of chronic conditions, instead of the binary status variable, did not change the overall results. These analyses can be found in Supplementary File 1.

3.4.3. Additional analyses—In the course of this study, we examined the data in ways not pre-registered. Specifically, we collected additional measures of neuroticism-related narrow traits (e.g., anxiety, emotional stability), and used a bifactor model to examine the unique relationships between those narrow traits body vigilance. We also assessed conscientiousness (and related narrow traits) to examine the interaction between neuroticism and conscientiousness on vigilance. The inclusion of these measures were included in our pre-registration. These analyses can be found in Supplementary File 2.

We found that conscientiousness was associated with both factors of vigilance, but these factors did not account for the relationship between conscientiousness and health. The interaction of conscientiousness and neuroticism did not predict greater levels of vigilance. Finally, after accounting for general trait neuroticism, both factors of vigilance were associated with lower emotional stability and irritability and greater perfectionism, and

⁵This interaction did predict healthy eating (std b = 0.07 [0.00, 0.13]) and alcohol consumption (std b = 0.08 [0.01, 0.15]). Plots of these effects are shown in Supplementary File 1.

sensation awareness belief was associated with greater anxiety. After accounting for general trait conscientiousness, sensation awareness belief was associated with greater levels of perfectionism and lower levels of industry, order and self-control. Change awareness was unassociated with narrow traits related to conscientiousness.

4. Discussion

The present study is the first to our knowledge to examine the relationship of neuroticism to two factors of body vigilance - sensation awareness belief and change awareness belief - and the degree to which this relationship explains the neuroticism-health link. We find partial support for the theory that vigilance may account for the heterogeneity of neuroticism's relationship to health. Two major findings emerged. First, neuroticism is positively associated with one factor of body vigilance, sensation awareness belief, to the degree that was hypothesized (i.e., $r = .20$). The relationship between neuroticism and body vigilance is a necessary condition for the notion that neuroticism may be healthy if it inspires people to vigilant towards their health. Second, body vigilance showed a suppression effect on the neuroticism-health behavior relationship such that, through vigilance, neuroticism may be associated with healthier behaviors, and after accounting for vigilance, neuroticism is associated with unhealthier behaviors.

The relationship between neuroticism and sensation awareness belief provides evidence in favor of the theory that neuroticism is associated with vigilance. Increased vigilance or attention towards the body may explain why individuals high in neuroticism report more somatic complaints absent of greater rates of disease (Larsen, 1992; Smith, O'Keeffe, & Allred, 1989). Prior explanations were that individuals high in neuroticism reported unfounded symptoms (Costa & McCrae, 1987); however, it may be the case that individuals high in neuroticism are more likely to notice symptoms of present underlying causes.

Together, these findings suggest that further study of vigilance in regards to the relationship of neuroticism and health may be warranted. We see several potential avenues for such investigation. For example, the measures used in the present study capture only belief in one's increased vigilance or accuracy; future studies should examine the extent to which neuroticism is related to actual levels of vigilance or increased accuracy in report bodily sensations. It is also important to consider how or why neuroticism and vigilance are associated. For example, vigilance is often described as a by-product of anxiety. However, in our exploratory analyses (see Supplementary File 2), we note that multiple narrow traits, including irritability and perfectionism, may be associated with body vigilance, even after accounting for general levels neuroticism. More work needs to be done to accurately describe the components of neuroticism which are related to vigilance. Finally, the current study focused only on body vigilance, as this should be directly related to health outcomes. However, neuroticism may demonstrate relationships with other forms of vigilance, such as vigilance towards external threats, within a romantic relationship, or general, trait-like forms of vigilance. These forms of vigilance may have additional impacts on health and well-being.

We are both excited and cautious to be the first study, to our knowledge, to find a suppression effect of vigilance on the relationship between neuroticism and health behaviors. Excited because this is consistent with the theory of healthy neuroticism: vigilance may indeed be a pathway from neuroticism to healthy behaviors. Cautious because of the novelty of such a finding. Given the wealth of research demonstrating the relationship between neuroticism and unhealthy behaviors, we should be skeptical of any result in the opposite direction. In addition, the size of this effect was small. Consequently, we would not conjecture that vigilance explains all, or even most, of the heterogeneity in the relationship between neuroticism and mortality, the set of findings that sparked the healthy neuroticism search in the first place. Finally, this effect was only one of more than twenty conducted for this study. For these reasons, replication is needed before basing additional research on this effect. Finally, neuroticism may have a positive impact on health behaviors through vigilance, but this will not outweigh the negative effects of neuroticism through other pathways, like increased stress (Bolger & Schilling, 2006), poor coping and emotion regulation (Boyes & French, 2010; Gunthert et al., 1999), and less social support (Schmidt & Riniolo, 1999).

The current study may be limited in its ability to detect the true relationship between vigilance, neuroticism and health in several important ways. The use of cross-sectional data prevents us from examining the causal pathways that likely underlies the relationship between neuroticism and health. We can say that neuroticism and vigilance are related, but we really wish to test whether neuroticism predicts or leads to vigilance. Future studies should utilize longitudinal methods to better estimate these causal processes. However, the effects often become weaker over time (Collins & Graham, 2002); given the small effect sizes found in the current study, longitudinal research on this topic may pose difficulties. Another limitation is that all measures in the current study were collected through self-report. Future studies should aim to assess both health and body vigilance in more objective ways. For example, one could ask participants to self-report their heart rate and compare this to actual heart rate as an assessment of sensation awareness. Again, we note that relationships can be inflated through same-method collection methods, and so we would not expect multi-method approaches to yield larger effect sizes.

Overall, the present study is the first to our knowledge to examine the role of body vigilance in explaining the neuroticism-health relationship. We find evidence that neuroticism is at least partially associated with vigilance, and that this association may explain some neuroticism-health links. However, body vigilance seems an unlikely candidate to explain the positive effects of neuroticism on health. We recommend that personality-health psychologists continue to revise the theory of “healthy neuroticism.”

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Factor solution for body vigilance items.

	text	MR1	MR2	com	h2
SBA04	How much do you wonder about why your body feels the way it does?	0.840	-0.160	1.070	0.590
SBA01	How much do you think about how your body feels?	0.790	-0.070	1.010	0.570
SBA02	How much do you try to figure out how your body works?	0.730	-0.030	1	0.520
SBA03	How much do you notice changes in how your body feels?	0.660	0.080	1.030	0.500
BVS3	On average, how much time do you spend scanning your body for sensations?	0.620	0.050	1.010	0.410
BVS2	I am very sensitive to changes in my internal bodily sensations.	0.610	0.190	1.190	0.520
BVS1	I am the kind of person who pays close attention to internal bodily sensations.	0.560	0.330	1.330	0.500
BRQ06	It is important for me to know how my body is feeling throughout the day.	0.540	0.320	1.340	0.460
PBCS01	I am sensitive to internal bodily tensions.	0.410	0.220	1.520	0.310
BRQ03	My mind and my body often want to do different things.	0.370	-0.090	1.110	0.110
PBCS03	I can often feel my heart beating.	0.370	0.120	1.210	0.190
BAQ01	I notice differences in the way my body reacts to various foods.	0.350	0.180	1.490	0.220
BRQ07	I enjoy becoming aware of how my body feels.	0.340	0.300	1.970	0.310
BAQ14	I notice specific body responses to changes in the weather.	0.310	0.340	1.890	0.230
BRQ02	My bodily desires lead me to do things that I end up regretting.	0.300	-0.130	1.360	0.070
PBCS04	I am quick to sense the hunger contractions of my stomach.	0.390	0.350	1.950	0.220
BRQ04	I suppress my bodily feelings and sensations.	0.340	-0.020	1.020	0.050
BAQ08	I can accurately predict what time of day lack of sleep will catch up with me.	-0.090	0.600	1.040	0.310
BAQ09	I am aware of a cycle in my activity level throughout the day.	0.060	0.590	1.020	0.380
BAQ15	I can predict how much sleep I will need at night in order to wake up refreshed.	-0.100	0.570	1.070	0.280
BAQ07	I can distinguish between tiredness because of hunger[sic] because lack of sleep.	-0.030	0.550	1	0.290
BAQ11	As soon as I wake up[sic] I know how much energy I'll have during the day.	-0.030	0.490	1.010	0.230
BAQ16	When my exercise habits change, I can predict[sic] how that will affect my energy level.	0.070	0.480	1.050	0.270
BAQ02	I can always tell when I bump myself whether or not it will become a bruise.	0.060	0.470	1.030	0.250
BAQ12	I can tell when I go to bed how I will sleep that night.	-0.060	0.440	1.040	0.170
BAQ05	I know in advance when I'm getting the flu.	0.130	0.440	1.160	0.260
BAQ06	I know I'm running a fever without taking my temperature.	-0.030	0.430	1.010	0.170
BAQ17	There seems to be a best time for me to go to sleep at night	-0.080	0.410	1.070	0.140

	text	MR1	MR2	com	h2
BAQ18	I notice specific bodily reactions to being overhungry.	0.200	0.400	1.440	0.280
BAQ04	I am always aware of changes in my energy level when I eat certain foods.	0.370	0.400	1.760	0.340
BAQ13	I notice distinct body reactions when I am fatigued.	0.370	0.380	1.800	0.320
BAQ03	I always know when I've exerted myself to the point where I'll be sore the next day.	0.140	0.370	1.280	0.210
PBCS05	I am very aware of changes in my body temperature.	0.360	0.350	1.830	0.280
PBCS02	I know immediately when my mouth or throat gets dry.	0.180	0.310	1.580	0.190
BAQ10	I don't notice seasonal rhythms and cycles in the way my body functions.	-0.160	-0.180	1.950	0.090

Table 2

Mediation of neuroticism-health relationships by sensation and change factors of body vigilance. All coefficient estimates are standardized. Bootstrapped confidence intervals are presented. All models control for age and gender.

Outcome	Total	Direct	Indirect	a Path	b Path
<i>Mediator: Sensation Awareness Belief</i>					
Self-Rated Health	-0.34* [-0.42, -0.27]	-0.32* [-0.4, -0.24]	-0.02 [0.04, 0.00]	0.28* [0.22, 0.34]	-0.10* [-0.17, -0.02]
Body Mass Index	0.09* [0.02, 0.16]	0.07 [0.00, 0.15]	0.02 [0.00, 0.04]	0.28* [0.21, 0.34]	0.09* [0.02, 0.16]
Has Chronic Condition	0.11* [0.07, 0.15]	0.09* [0.05, 0.13]	0.02* [0.01, 0.04]	0.29* [0.22, 0.35]	0.08* [0.04, 0.12]
Healthy Behavior	-0.70* [-0.89, -0.5]	-0.78* [-0.98, -0.57]	0.07* [0.02, 0.14]	0.28* [0.21, 0.34]	0.21* [0.03, 0.42]
Medication Nonadherence	0.09* [0.02, 0.17]	0.10* [0.02, 0.17]	0.00 [-0.03, 0.02]	0.28* [0.21, 0.34]	0.01 [-0.06, 0.09]
<i>Mediator: Change Awareness Belief</i>					
Self-Rated Health	-0.34* [-0.42, -0.28]	-0.35* [-0.42, -0.28]	0.01 [-0.01, 0.02]	0.00 [-0.07, 0.06]	0.07* [0.01, 0.14]
Body Mass Index	0.09* [0.03, 0.16]	0.10* [0.03, 0.17]	-0.01 [-0.02, 0]	0.00 [-0.06, 0.07]	0.03 [-0.04, 0.1]
Has Chronic Condition	0.11* [0.07, 0.16]	0.11* [0.07, 0.16]	0.00 [-0.01, 0.00]	0.00 [-0.07, 0.07]	0.02 [-0.01, 0.06]
Healthy Behavior	-0.70* [-0.90, -0.50]	-0.72* [-0.92, -0.51]	0.01 [0.02, 0.05]	0.00 [-0.06, 0.07]	0.42* [0.22, 0.61]
Medication Nonadherence	0.09* [0.02, 0.17]	0.10* [0.02, 0.18]	-0.01 [-0.02, 0.00]	0.00 [-0.06, 0.07]	-0.03 [-0.10, 0.04]