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Building a theory of adaptive neuroticism

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by

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SJW (May, 2017)

DEDICATION

To my brother,

who inspires me to seek happiness

in every moment.

ABSTRACT

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Neuroticism is widely believed to be detrimental to health, but the evidence is mixed. Many large-scale studies find null or positive effects of neuroticism on mortality and health. A theory of "healthy neuroticism" was generated to explain these discrepant results. According to this theory, neuroticism can lead an individual down one of two paths: an anxiety and stress-ridden path of maladaptive coping and poor outcomes, or a path of vigilance and proactivity. Trait conscientiousness is thought to be the defining feature of healthy neuroticism, although studies substantiating this claim are few and far between. Meanwhile, other important factors - notably, external cues and emotions - are omitted from these studies altogether.

The current thesis examines the roles of situation and emotion on health in relationship to neuroticism. Specifically, a model of healthy neuroticism is proposed. In this model, individuals high in neuroticism respond to threatening situations by feeling greater anxiety, less depression and less anger. These emotions, in turn, propel individuals to act in adaptive ways. This model is tested in two studies. In the first, mid-life adults ($N = 1,499$) provide daily reports of their affect (nervousness, depression and anger), health symptoms and health behaviors. Using a multi-level modeling approach, emotion scores and health behaviors are estimated from the interaction of trait neuroticism and daily health symptoms. The residuals of the emotion models are then used to estimate the residuals of the behavior models, effectively estimating the 'b' pathway in a mediation model. In the second study, freshman students at a private, Midwestern university

($N = 222$) provide weekly reports of their affect (anxiety and sadness), whether they received grades back on a test or assignment, and academic behaviors (e.g., hours spent studying). Again, a multi-level model was used to estimate emotion and behavior from trait neuroticism and feedback on grades, and the emotions residuals were used to estimate behavior residuals. In addition to the proposed model, each study examined the role of neuroticism on behavior, the interaction of neuroticism and situation on behavior and the interaction between emotion and situation.

Little evidence to support the proposed model was found. Importantly, there was also little evidence that neuroticism or the interaction of neuroticism and situation predicted behavior. Together these results fail to substantiate either the theory of healthy neuroticism or the belief that neuroticism has an impact on health (or academic) behaviors. The current thesis concludes by discussing ways in which personality researchers might improve their methods of measuring emotion and situation and rethink their approach analyzing and discussing the role of neuroticism in predicting or explaining adaptive outcomes.

1. Introduction

Neuroticism is assumed to be a maladaptive trait. There is evidence that neuroticism is associated with poorer relationships, lower income and worse health (Ozer and Benet-Martínez, 2005). Lay people seek interventions to reduce their levels of neuroticism. But the story of neuroticism is not as straight-forward as we would like to believe. While there are certainly causal pathways linking neuroticism to adverse outcomes, we cannot characterize this trait as wholly maladaptive for two reasons. First, negative associations with neuroticism are dogged with methodological issues which can inflate the estimates of these effects. Second, the literature around neuroticism is mixed, including a substantial amount of evidence for null and positive effects of neuroticism. I will propose a new model of the relationship between neuroticism and behavior. In this model, neuroticism predicts adaptive or maladaptive behavior depending upon the situation at hand. Specifically, neuroticism will heighten any negative emotions a person feels in response to a situation, and these emotions will lead to over-sampled engagement in specific behaviors. Whether these behaviors are adaptive or maladaptive depends on whether a negative emotion has any utility as a response to the situation.

The motivation for deriving this model stemmed from research on neuroticism and health. Consequently, the majority of the research presented in this dissertation is situated within the health domain. However, the theoretical links between neuroticism and behavior should be broadly applicable. Therefore, this model should apply to a variety of outcomes, including academic outcomes. The model proposed here will be tested within both the health domain and the educational domain.

1.1 The negative effects of neuroticism

Neuroticism is defined by negative affectivity of many types (Goldberg, 1993), including worry, anger, and emotional instability (Weiss and Costa Jr., 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 et al., 1999) and react more strongly to stressful events than people low in neuroticism (Bolger and Schilling, 2006; Mroczek and Almeida, 2004). Normatively, neuroticism tends to peak in late adolescence (Roberts and DelVecchio, 2000) and decline through adulthood (Roberts and Mroczek, 2008).

Neuroticism has been labeled "a psychological trait of profound public health significance" (Lahey, 2009) because of its associations with a wide range of physical and mental health problems. Neuroticism is indeed linked to higher mortality in a number of studies (for a meta-analysis, see Roberts et al., 2007). People with higher levels of neuroticism have higher rates of chronic diseases, including cardiovascular and pulmonary disease (Weston et al., 2015) and cancer (Nakaya et al., 2003). Neurotic patients report more somatic symptoms (Watson and Pennebaker, 1989), have higher body mass indexes (Terracciano et al., 2009), smoke more cigarettes (Turiano et al., 2015) and drink more alcohol (Larkins and Sher, 2006). Altogether, these results conjure an image of the neurotic person as living a short life filled with unhealthy behaviors and illness.

1.2 Methodological issues

Despite the substantial number of results linking neuroticism to poor health, we must temper our enthusiasm for labeling neuroticism a maladaptive trait. This is because a number of methodological issues plague these results. Each of these issues potentially inflates the strength of the relationship between neuroticism and poor health.

The first methodological issue is the use of self-report measures of behaviors and outcomes. This is problematic in all studies of personality, but especially concerning in the study of neuroticism. This is especially salient in the health domain. Neurotic individuals have biased perceptions of their own health, such that they believe themselves to be less healthy than they are. For example they over-report their weight (Sutin and Terracciano, 2016) and perceive somatic symptoms that have no physical basis (Costa Jr. and McCrae, 1987; Watson and Pennebaker, 1989). Furthermore, neurotic individuals retrospectively inflate their reports of ill-health. Larsen (1992) asked participants to record the somatic symptoms they experienced over the day every evening for a week. At the end of the week, participants were given checklists and asked which symptoms they had experienced and how severe. Neurotic participants remembered experiencing somatic symptoms that, by their own account, they hadn't experienced and rated all their symptoms as being worse than they had when experiencing them. Given this bias, we should expect neurotic individuals to self-report worse health than their emotionally-stable counterparts, even if they are objectively equally healthy. Put another way, self-reports of health may correlate with neuroticism not because of any actual differences in health, but because of perceived differences. Moreover, these perceived differences have real-world implications which can further inflate the relationship between neuroticism and measures of ill-health. Individuals who believe they are unhealthy are more likely to speak with a physician and thus more likely to receive a diagnosis or be prescribed medicine. Thus, even carefully worded self-report questions, like the item "Has a physician ever told you that you have hypertension?" which is used in the Health and Retirement Study, may still be capturing bias in that neurotic individuals may be more likely to see physicians in the first place. Given the inflated effects of self-report studies, it should not be surprising to learn that studies which use informant-reports of personality find no effect of neuroticism on health (**?**).

The second methodological issue is the use of cross-sectional studies or longitudinal studies conducted over short periods of time. This is concerning because, as Friedman (2000) pointed out, while many diseases are associated with neuroticism, "such ties do not always appear in prospective studies" (pp. 1100). Neuroticism is certainly correlated with experiencing symptoms of disease, but this does not imply that neuroticism causes or even predicts diseases. Further complicating the problem is the fact that longitudinal studies must start before the disease onset if they aim to establish a potential causal link from neuroticism to disease. To do that, one must operationally define when disease onset occurs. This is extremely difficult, given the ambiguity around when a disease begins. Most studies define onset as a formal diagnosis: a physician announces that a patient has cardiovascular disease and, lo and behold, onset has occurred (e.g., Goodwin and Friedman, 2006; Weston et al., 2015). But could onset not have occurred when the patient's arteries became sufficiently clogged? And what would constitute "sufficiently"? Does sufficiently clogged occur when the blood flow has slowed by a certain degree? Or when the first bit of gunk clung to an arterial wall? Does the development of heart disease not begin when the patient first started eating greasy food? Or stopped eating vegetables? Or decided he was not going to make exercise a regular part of his day? At what point does he cross the threshold from healthy to unhealthy?

The ambiguity of disease progression leads to a problem where even most longitudinal designs fail to capture personality before the disease has begun to evolve in the body. Take, for example, the prediction of disease by personality up to four years before onset (Weston et al., 2015). This study attempted to predict onset by selecting only individuals who were healthy at the first time point and used personality scores to predict their probability of being diagnosed before the second time point, four years later. While this is certainly a better test than cross-sectional analyses of neuroticism and health, causality still cannot be inferred. Many of these illnesses, such as lung disease, are the product of habits, like smoking, that stretch back more than four years before onset. Some of these behaviors likely began decades before the study was conducted. Possibly many of these participants experienced symptoms prior to diagnosis, meaning that they could have been experiencing symptoms concurrent with the personality assessment. Further complicating the problem is evidence that changes in health can lead to changes in personality (Jackson et al., prep). This means that assessments of neuroticism close to a diagnosis could be capturing the effects of health declines on personality more so than effects of personality on health declines. This problem of assessing personality too close to disease onset inflates the relationship between neuroticism and health. Consequently, many longitudinal studies fail to overcome the problems with cross-sectional analysis of neuroticism and health. Those longitudinal studies that do go back far enough, such as the Hawaii Personality and Cohort Study, which assesses personality in elementary school, find limited effects of neuroticism on health (Hampson et al., 2006).

The third methodological issue is the overlap between the measurement of outcomes and the measurement of neuroticism. Take one study that examined the association between neuroticism and body-mass index (Terracciano et al., 2009). This study used the NEO-PI-R (Costa Jr. and McCrae, 1992) to examine the relationship between personality and weight at both a trait and a facet level. They found that neuroticism is associated with higher BMI. Digging deeper, this relationship was driven completely by the facet of impulsivity. Had they dug deeper still, they would have realized that some of the items included in this measure of neuroticism explicitly ask whether the participant can control their eating and cravings (Goldberg et al., 2006). In other words, it is likely that the items assessing eating behavior are the primary source of shared variance among neuroticism and BMI (Vainik et al., 2015).[1]

To some extent, the use of meta-analytic techniques can help us to to better estimate the true relationship between neuroticism and negative outcomes, if these meta-analyses

[1]The inclusion or exclusion of specific items may account for differences in effects across studies. However, the general content of neuroticism remains relatively consistent across measures, so specific items may not contribute to mixed findings (Goldberg, 1993).

are able to overcome the issues described above. Two such meta-analyses of the relationship between neuroticism and health overcame the self-report and measurement overlap problems by assessing the relationship between neuroticism and mortality (a clearly objective measure of health that includes no items that one could conceivably create to measure of personality). The first of these found that neuroticism was correlated with premature death at $r = .05$ (Roberts et al., 2007). This is smaller in magnitude than the relationship between mortality and conscientiousness ($r = -.09$), another trait which receives a considerable amount of attention for its relationship with health. This effect is even smaller than the relationship between mortality and extraversion ($r = -.07$), a trait which receives comparatively less attention than neuroticism by personality and health researchers. The second, more recent analysis examined the relationship between personality and mortality across seven large (ranging from just under 4,000 participants to a little more than 20,000) longitudinal panel studies (Jokela et al., 2013). This analysis found that the effect of neuroticism on mortality was non-significant ($OR = 1.03$, equivalent to $r = .02$).[2] Again, this is substantially smaller than the effect of conscientiousness ($OR = .88$, $r = -.07$) and even a bit smaller than the effect of extraversion ($OR = .95$, $r = -.03$). Thus, the claim that neuroticism is profoundly significant in terms of health is overblown in proportion to its effect. Despite the substantial *number* of studies linking neuroticism to negative outcomes, the actual *strength* of this relationship is relatively small.

We have addressed the role of neuroticism in predicting adverse outcomes and the methodological problems that plague these findings. Importantly, this is not an argument that neuroticism is not linked to adverse outcomes. Despite the issues discussed here, there is still overwhelming evidence that neuroticism is associated with negative outcomes. However, you can see that the picture of neuroticism as a maladaptive trait is not as clear a picture as it could be. The Roberts et al. (2007) study pointed to a number of studies of

[2] The study only presented odds ratios in the manuscript. To calculate the correlation coefficient, I followed a procedure outlined in The Cochrane Collaboration (2011): the standardized mean difference was estimated from the odds ratio using the formula $z = ln(OR)\frac{3}{\pi^2}$. From this z score, a correlation coefficient was estimated.

mortality which found a null or protective effect of neuroticism. Jokela et al. (2013) calculated significant heterogeneity in the effect ($I^2 = 54\%$) of neuroticism, indicating that about half the variability in estimates across the samples may be due to differences in the samples and not simply error. These mixed results in the literature do more than suggest that neuroticism is only weakly linked with poor health: they suggest that neuroticism may be beneficial.

1.3 The positive side of neuroticism

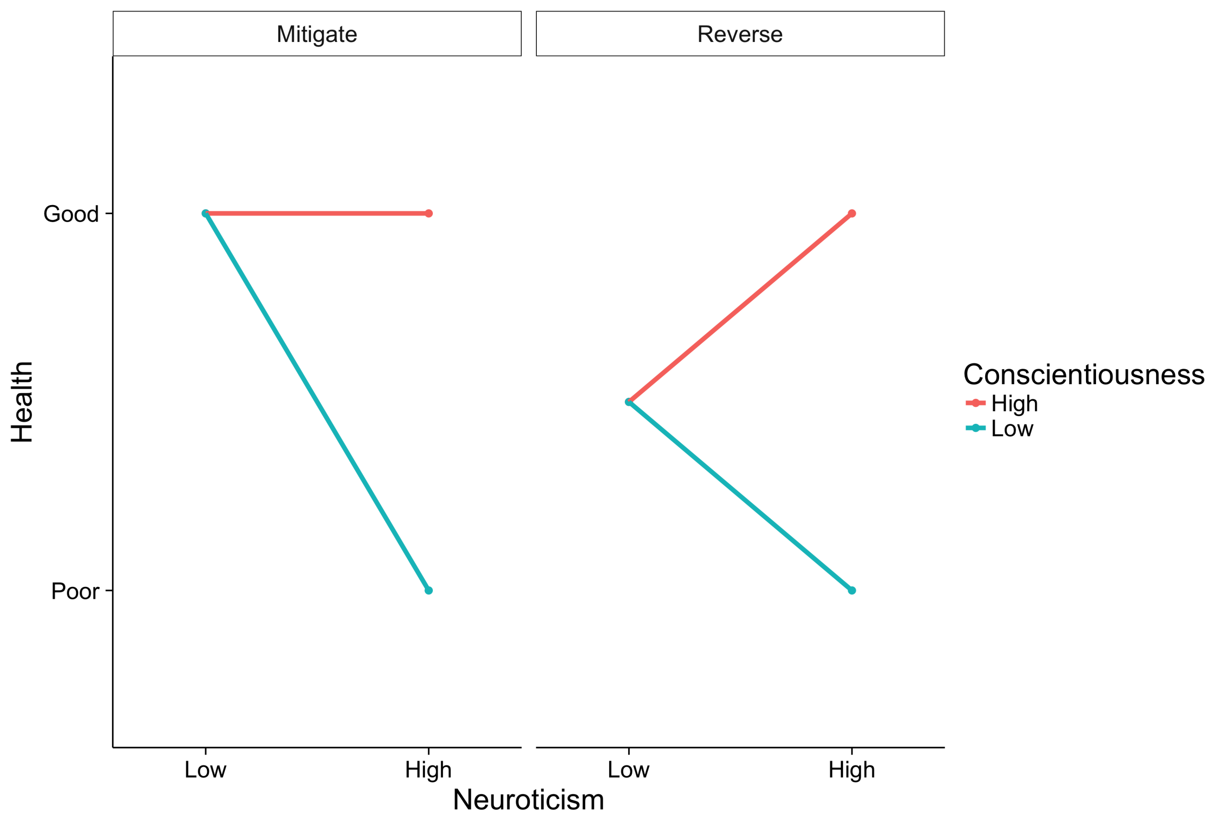
In truth, studies that explore the relationship between neuroticism and outcomes have mixed results. In the health domain, many studies find that this trait predicts morality, However, there are a number of large-scale studies which find that neuroticism has no effect on mortality (Almada et al., 1991; Huppert and Whittington, 2009; Iwasa et al., 2008; Maier and Smith, 1999). Among older adults, neuroticism often has no relationship with health and can at times be protective (Korten et al., 1999; Lang et al., 2012; Weiss and Costa Jr., 2005). Among individuals previously diagnosed with a chronic disease (i.e., heart disease or diabetes), neuroticism is again protective (Brickman et al., 1996; Ragland and Brand, 1988). Neurotic women live longer if they are high socio-economic status (Hagger-Johnson et al., 2012). Individuals who have lost a loved one live longer if they are higher in neuroticism (Taga et al., 2009). Prospectively, the role of neuroticism as a risk factor is more limited, in that it does not broadly predict poor health but is only associated with a few chronic disease (Weston et al., 2015). Overall, the literature on neuroticism and physical health is mixed.

Given the mixed effects of neuroticism, it is problematic to only discuss neuroticism as a maladaptive trait. Mixed results suggest the presence of moderating factors. That is, there are conditions under which neuroticism will be adaptive and other conditions under which neuroticism will be maladaptive. One theory has been developed to identify these conditions. This theory of "healthy neuroticism" posits that neuroticism interacts with other individual differences to produce differences in behavior.

1.4 Healthy neuroticism

In response to the mixed effect of neuroticism on health, the theory of healthy neuroticism has been proposed (Friedman, 2000). This theory states that neuroticism can manifest as adaptive or maladaptive behaviors depending on other characteristics of the individual. While these characteristics were (at the time) unspecified, it was proposed that neurotic individuals fell on a spectrum from health to unhealthy. Individuals low in healthy neuroticism cope with negative emotions by seeking distractions, which are often unhealthy behaviors like smoking or alcohol consumption. When they see signs of poor health, such as a mole, they avoid the problem because they find it too distressing to think about. It was also proposed that individuals low in healthy neuroticism might avoid interpersonal assistance when in need of medical attention. These behaviors would all contribute to health problems, and if treatment is not sought or adhered to, those problems might decline especially rapidly. Healthy neurotics, on the other hand, are too anxious about their health, so they avoid those unhealthy behaviors. When an individual high in healthy neuroticism sees a mole, she runs to her doctor for a biopsy. Moreover, she is vigilant. Because she is anxious about her health, she is constantly on the look out for signs that her health is deteriorating. In addition, individuals high in healthy neuroticism should carefully adhere to medication and treatment instructions, which should increase the effectiveness of those treatments. Overall, healthy neuroticism should be associated with seeking treatment more often, potentially catching medical problems in earlier stages, and greater improvement due to medication adherence.

The theory of healthy neuroticism may capture a distinction between conscientious neurotics and unconscientious neurotics (e.g. Turiano et al., 2013; Weston and Jackson, 2014). That is, the trait which predicts who among the neurotics will be healthy and who will be unhealthy is conscientiousness. This trait has been identified due to its known associations with health. That is, conscientiousness is associated with various health indices and behaviors, including avoidance of risky health behaviors and greater medication adherence (Shanahan et al., 2014). Moreover, conscientiousness is partly defined by self-control. This may allow neurotic individuals to maintain control in the face of stress and avoid risky coping behaviors, such as by not using alcohol to cope with anxiety.

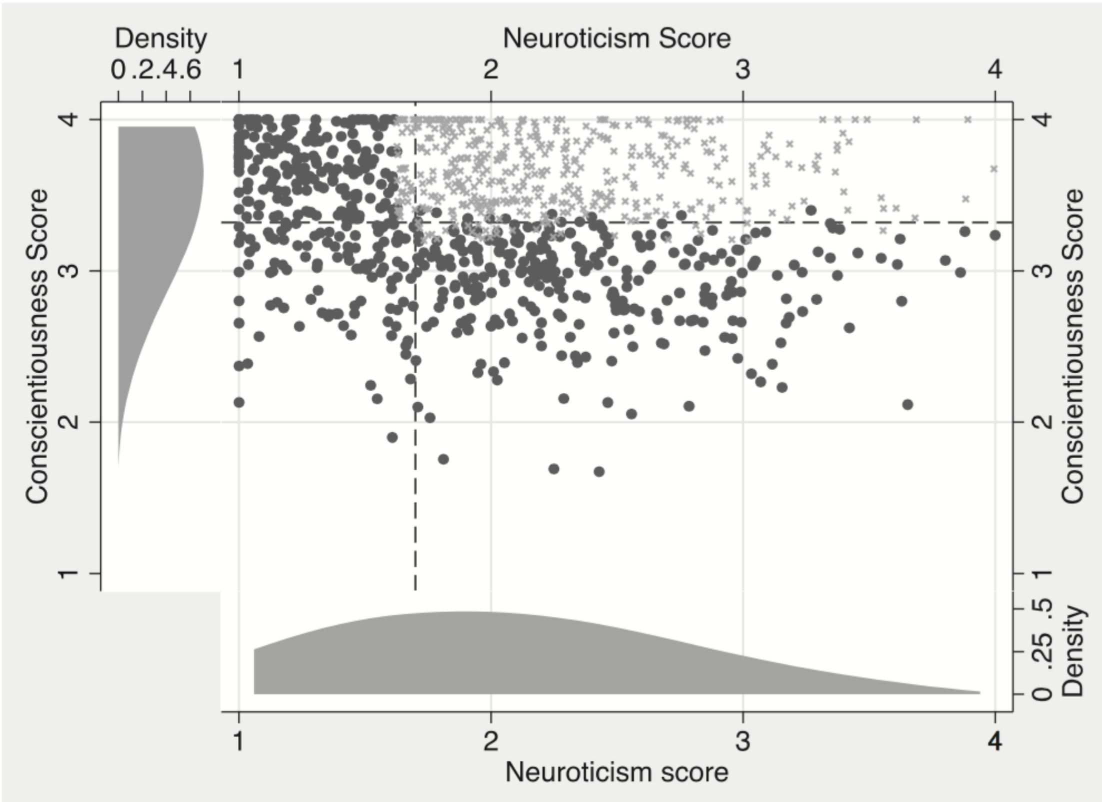


A graphical depiction of two forms of conscientious neuroticism. If conscientiousness mitigates the effect of neuroticism, then conscientious neurotics should experience equivalent health status as conscientious and unconscientious non-neurotics. However, if conscientiousness reverses the effect of neuroticism, then conscientious neurotics should fare equally as well as unconscientious non-neurotics and better than both unconscientious neurotics and conscientious non-neurotics.

Figure 1.1: Conscientious neuroticism

Statistically, conscientiousness is thought to moderate the effect of neuroticism on behaviors and outcomes. The precise form of this interaction is unclear. There are at least two ways in which conscientiousness might change the effect of neuroticism (see Figure 1.1 for graphical illustration of the two forms). In one form, conscientiousness mitigates the effect of neuroticism, such that highly neurotic but conscientious individuals experience the same health outcomes as emotionally-stable but low-conscientious individuals. For example, conscientiousness mitigates the relationship between neuroticism and Interleukin-6 (IL-6), a biological marker of inflammation; neurotic and unconscientious individuals have high, unhealthy levels of IL-6, but conscientious neurotics have levels that are similar to those of conscientious, emotionally stable individuals (Turiano et al., 2013). In the other form, conscientiousness reverses the effect of neuroticism, such that more neuroticism is healthy when conscientiousness is high and unhealthy when conscientiousness is low. For example, high neuroticism predicts the least amount of smoking when paired with high conscientiousness and predicts the greatest amount when paired with low conscientiousness (Vollrath and Torgersen, 2002; Weston and Jackson, 2014).

Conscientious neuroticism in some ways explains null and positive relationships between neuroticism and health in the literature. If conscientiousness mitigates the effect of neuroticism, then over-sampling of neurotic and conscientious participants would yield null effects for neuroticism: that is, the conscientious neurotics who experience average health would outweigh the effects of the unconscientious, unhealthy neurotics. By the same logic, if conscientiousness reverses the effects of neuroticism, then over-sampling conscientious neurotics would yield positive relationships between neuroticism and health outcomes. Given that few researchers report, let alone look at, the bivariate distribution of conscientiousness and neuroticism, it is difficult to determine whether studies might be over-sampling these populations. One exception is Turiano et al. (2013), which graphically displayed the distribution of these two traits in order to argue that a sufficient proportion of their sample could be categorized as conscientious neurotics (see Figure 1.2). This figure demonstrates that conscientious individuals are vastly over-sampled in this study (i.e., the Midlife in the United States [MIDUS] Study) compared to unconscientious neurotics.



This figure demonstrates the potential over-sampling of conscientious, as opposed to unconscientious, neurotics, which may have yielded null findings for the main effect of neuroticism on levels of Interleukin 6.

Figure 1.2: The bivariate distribution of conscientiousness and neuroticism, included in Turiano et al. (2013)

Oversampling of conscientious individuals is likely to happen in any study, especially longitudinal studies, as these individuals are more likely to participate, more likely to return and less likely to have passed way between waves of data collection. The study concluded that conscientiousness mitigates the role of neuroticism. Furthermore, examination of the main effect of neuroticism yielded a null result. This study illustrates well what could be occurring in a number of other studies.

Despite its promise, the conscientious neurotic effect is not consistently found in the literature, much like the effects of neuroticism and health are inconsistent. To be sure, some of this inconsistency is due to the fact that many studies will not have the power to detect these effects. However, even large-scale studies fail to consistently find this effect (e.g., Turiano et al., 2015; Weston and Jackson, 2014).

1.5 Parallels in other domains

Thus far, we have discussed neuroticism only within the health domain. However, many of these findings have parallels in other domains. Just as neuroticism is thought to broadly impact health in a negative way, it is believed that neuroticism has a general negative impact on occupational and academic success. This is due to findings that neuroticism may be linked to smaller salaries (Judge et al., 1999), less occupational attainment, lower satisfaction, and less financial security (Roberts et al., 2003). Neuroticism may predict poorer academic performance (Chamorro-Premuzic and Furnham, 2003; Furnham and Mitchell, 1991), in part because neuroticism is associated with surface (as opposed to deep) learning styles, which are inefficient (Busato et al., 2000; Duff et al., 2004).

Similar to the health domain, the results linking neuroticism to negative outcomes and maladaptive behaviors is mixed. Firstly, the strength of this relationship is again comparatively small. A meta-analyses examining the correlation between neuroticism and occupational outcomes found it to be quite low ($|r|$ range from .05 to .07, compared to the range of conscientiousness, which is from .09 to .13; Barrick and Mount, 1991). The direction of the occupational failure association is also mixed. While the relationship between neuroticism and job performance is generally negative, meta-analytic evidence suggests that neuroticism positively predicts job performance within the occupation of professionals (e.g., engineers, architects, lawyers, accountants, teachers, doctors and ministers; Barrick and Mount, 1991). Despite the findings that suggest neuroticism may be associated with poor academic performance, several recent meta-analyses concluded there was no relationship between neuroticism and academic outcomes (O'Connor and Paunonen, 2007; Poropat, 2009). The overall strength of this association is thought to be around $r = -.03$ (O'Connor and Paunonen, 2007), which is again relatively small. In contrast to health and occupational outcomes, there have not been studies which suggest neuroticism may benefit one's academic performance. However, we should note the curvilinear effect of anxiety on performance (Yerkes and Dodson, 1908) and the relationship between neuroticism and test anxiety (Schmidt and Riniolo, 1999). The lack of a strong correlation is not the same as the lack of a relationship. It is quite possible that if researchers were to search for a curvilinear effect of neuroticism on performance, they may find one.

One key difference between health and the occupational and educational domains is that, following the surge in evidence that neuroticism may not be all bad, there have been almost no attempts to identify the conditions under which neuroticism was harmful and under which it was not. One exception is the suggestion that extraversion may moderate the effect of neuroticism (Entwistle and Cunningham, 2011), similar to the conscientious-neurotic effect.

1.6 Filling the gap

Thus far, we have discussed the perception of neuroticism as a maladaptive trait. This perception is built upon research linking neuroticism to poor outcomes, mainly in the health domain, but also in the occupational and educational domains. However, these findings are riddled with methodological problems, including an over-reliance on self-report, poor use of longitudinal methods and measurement overlap. Importantly, studies which address these problems often find that neuroticism has, at the most, a very small relationship with poor outcomes. In both the health and occupational domains, there is evidence that neuroticism may be beneficial under some circumstances. Health psychologists have proposed the conscientious-neurotic effect, which suggests that individuals who are high in both neuroticism and conscientiousness may not engage in the same maladaptive behaviors as low-conscientious neurotics. However, the evidence for this theory is similarly mixed.

Ultimately, the field has failed to comprehensively describe the effect of neuroticism on major outcomes, most notably health outcomes. Researchers make broad claims about the maladaptive nature of neuroticism that is not supported by the data. Those who acknowledged the mixed effects have turned to the healthy neuroticism theory, but this too does not adequately describe the mixed effects found in the literature. Current attempts to describe these mixed effects rely on a between-persons theory of neuroticism; that is, some neurotics behave adaptively and some behave maladaptively. Given the little support of this theory, I propose we turn to a new conceptualization of adaptive neuroticism: a within-person theory. Neurotics act adaptively in some situations and maladaptively in others. The key then to disentangling these effects is identifying the situations in which neuroticism should be adaptive.

If we are to examine the role of neuroticism in response to specific situations, we must also consider state-level neuroticism. A person's reaction to a situation can be partially described by their state-level personality. A student may have high trait levels of conscientiousness, but if his response to an upcoming exam is to attend a party instead of study, his state-level of conscientiousness is both lower than his general trait and more predictive of his behavior. Trait neuroticism is the tendency to feel anxiety, anger, and sadness, so state neuroticism is the negative emotions a person is feeling and how strongly. In other words, state-level neuroticism is simply emotion. Thus, both situation and emotion need to be incorporated into a comprehensive theory of the relationship between neuroticism and behavior. The absence of these two factors likely explains the gap in understanding of neuroticism's impact on outcomes.

1.7 The role of situations

The theory of conscientious neuroticism implies that the division between adaptive and maladaptive neuroticism is at the level of the person: some neurotic individuals behave in healthy ways, while some neurotic individuals behave in maladaptive ways. However, as discussed above, the attempt to identify a trait (conscientiousness) which distinguishes between people has met with little success. I propose that the division truly lies at the level of the situation: given some situations, neuroticism predicts adaptive behaviors and given other situations, neuroticism predicts maladaptive behaviors. I arrive at this theory by examining the difference between studies which found positive effects of neuroticism compared and those which found negative effects.

Those studies that find positive relationships between neuroticism and health sample populations who are more likely to have recently faced a situation highlighting a potential health threat. Older adults should be more aware of possible threats to their health as their risk for development of illness increases. Indeed, studies which demonstrate null or positive effects for neuroticism often use samples of older adults (e.g., Korten et al., 1999; Weiss and Costa Jr., 2005), even showing that these effects are specific to older adults (Lang et al., 2012). Type A personality, which is often identified as neuroticism, predicts greater mortality generally, except in men who have had coronary heart disease and are thus especially aware of their cardiovascular health (Ragland and Brand, 1988). Neuroticism predicts lower rates of renal deterioration in diabetics, who are acutely aware of their health behaviors (Brickman et al., 1996). Finally, these effects are not isolated to those who have experienced a health event but extend to those who have lost a loved one (Taga et al., 2009) and so may be more aware of their own health. These positive health outcomes may be partially explained by changes in behavior. Weston and Jackson (2014) found the conscientious neurotic effect predicted smoking behavior in some patients diagnosed with chronic disease. However, the effect did not hold for the same participants in the years before they were diagnosed. Moreover, this effect was only found for chronic diseases with direct ties to smoking: diabetes, pulmonary disease and cardiovascular disease. Given the lack of a pre-diagnosis effect, combined with specificity for diseases whose prognosis is substantially affected by continued smoking, it seems likely that a behavior-relevant event must occur to trigger adaptive behavior in neurotic individuals.

1.8 The role of emotions

Once we incorporate situations into our theory of neuroticism, we are faced with a new challenge. Recall that trait neuroticism is the tendency to experience negative emotions (including experiencing these emotions more frequently and with greater intensity). While a person may be more prone to feeling multiple negative emotions overall, they will not feel all these emotions in a given situation. More to the point, a neurotic person is generally more likely to feel anxiety, depression and anger than the average person. However, she will not feel those emotions all the time or to the same degree. When preparing for a major exam, she may feel more negative than a less neurotic friend. But when attending a birthday party, she will (hopefully) experience only positive emotions. But her emotional response to a particular situation is important because it directly influences her behavioral response (Allen et al., 1992). Consequently, we must determine the extent to which she feels negatively in a situation to begin to predict her behavior. Moreover, the specific emotions she can feel come with specific cognitive biases, notably attentional, memory and perceptual biases (discussed in more detail below), which can alter her likelihood of engaging in specific behaviors at that moment. So we cannot simply look at her general emotionality, but we must examine her experience of multiple emotions in response to a situation. Consequently, three distinct emotions are examined: anxiety, depression and anger.

Anxiety, depression and anger are known to predict various health outcomes (Achat et al., 2000; Carnethon, 2003; Jonas, 1997; Kubzansky et al., 1997; Whooley et al., 2008).

These components are more often examined as emotional states, rather than enduring individual differences. State emotion and trait emotionality are certainly not mutually exclusive; neuroticism is often characterized as the increased tendency to feel particular emotions (Goldberg, 1993). But the role of emotions is often ignored in discussions of personality and prediction. This is problematic for developing a theoretical understanding of neuroticism, as emotions are believed to serve adaptive functions (Darwin, 1965; Hess and Thibault, 2009).

Importantly, each of these emotions has been linked to health through physiological pathways, specifically through activation of the sympathetic-adrenal medulla (SAM), in the case of anxiety and anger, and the pituitary-adrenal cortex (PAC), in the case of depression. The physiological response associated with these emotions is not purely detrimental to health; Mayne (1999) compellingly argues that short-term SAM and PAC activation allows organisms to recover from negative stimuli and show an increased production of "natural killer" immune cells, which destroy cancerous and virally infected cells. Individuals with moderate or high levels of neuroticism should experience SAM and PAC activation more frequently than individuals low in neuroticism, which in turn should improve their immune systems. However, chronic activation of these biological systems wears the body down. Neurotic individuals are also more likely to experience chronic negative affect, thus the benefits they receive from short-term emotion and penalties they receive from more chronic emotions might come out to a wash.

Cognitive characteristics of anxiety, depression and anger

Negative emotions, in general, allow us to adaptively cope with threats (Williams et al., 1988) by changing the way we interpret and process information. Examining these cognitive processes can help us to understand the behavioral relationships between these emotions and health, which in turn will allow us to hypothesize the situations under which these emotions may be adaptive. Anxiety allows us to address impending threats. This can be seen by examining the cognitive processes associated with anxiety. When we become anxious, our attention is more easily directed towards threatening stimuli in our environment (Atkinson and Litwin, 1960). Persons high in trait anxiety or diagnosed with anxiety disorders show increased attentional bias for threatening stimuli (MacLeod et al., 1986; Mineka and Sutton, 1992). Moreover, anxious individuals are likely to perceive neutral stimuli as more threatening (MacLeod and Mathews, 1988). Anxiety is also characterized by high arousal (Barrett, 1998). By noticing threats more quickly and having the energy to act, anxious individuals can respond to a threat before it happens, for example, by avoiding the threat or by taking action to reduce its likelihood. Thus, it should be no surprise that anxiety is associated with failure-avoidance motivation (Pekrun, 1988). In summary, anxiety's function is to propel us to avoid threats by directing our attention towards potential threats and providing the energy and motivation necessary to actively avoid those threats.

If anxiety is a forward-looking emotion, then depression is a backward-looking one (Mineka and Sutton, 1992). Again, the cognitive processes associated with depression illuminate the function of this emotion. Contrary to anxiety, depression is not associated with biased attention towards stimuli in the current environment (Mathews and MacLeod, 1994). Instead, depression is associated with biased memories, specifically for negative and self-referential memories (Blaney, 1986; MacLeod and Mathews, 1991). Depression is also charactered by low arousal (Barrett, 1998). Instead of avoiding future threats, depression leads people to ruminate on past traumas or harms (Blaney, 1986). Together, these cognitive processes coalesce into brooding. Brooding keeps a negative experience in the front of one's mind, reinforcing the desire to avoid the experience again. Moreover, brooding encourages individuals to reexamine the event and identify possible causes. This can help the person avoid similar situations in the future. The low arousal of brooding works to slow individuals down and reduce the likelihood they jump into another harmful experience by accident. The (cognitive) distinction between anxiety and depression is perhaps best characterized, in this context, as the former focuses on danger and threat while the latter focuses on negative self-evaluations and loss (Beck and Clark, 1988).

Like anxiety, anger is associated with attentional and perceptual biases but not memory biases (Wilkowski and Robinson, 2007) and its adaptive role appears to be detection of threats (Easterbrook, 1959). Unlike depression, which is very self-focused, anger predicts cognitive biases which are centered on others. Individuals high in trait anger attend to hostile stimuli more than individuals low in anger (Smith and Waterman, 2003, 2004) and are more likely to attribute ambiguous actions as hostile aggression (de Castro et al., 2002). Importantly, anger is thought to be provoked by perceived mistreatment (Buss, 1961; Spielberger et al., 1985). Overall, it appears that the adaptive role of anger is to alert organisms to threats perpetrated by others. This can help individuals detect threats from others and, given the potential for greater arousal (Barrett, 1998), motivate individuals to address the threat. An important distinction between anxiety and anger is their relationship to approach and avoidance motivation systems. Anger is believed to relate to approach motivation, whereas anxiety is avoidance motivated (Carver and Harmon-Jones, 2009). While anxiety might motivate an individual to avoid a threat (for example, studying to avoid failing a test), anger may motivate an individual to address the threat after it has occurred (for example, by arguing with the professor about why the grade should be changed). We now turn to potential behavior consequences of the different cognitive biases and motivations of these emotions.

Behavioral consequences of anxiety, depression and anger

We can use the cognitive characteristics of anxiety, depression and anger to understand why these emotions are associated with health behaviors. Individuals high in anger are also more likely to cope with negative emotions through unhealthy behaviors. They are more likely to consume alcohol (Houston, 1986; Leiker and Hailey, 1988; Shekelle et al., 1983) and smoke (Dembroski et al., 1989; Shekelle et al., 1983; Siegler et al., 1992).

Angry individuals are also more likely to engage in behaviors that put others at risk, like driving after drinking (Houston, 1986; Leiker and Hailey, 1988), presumably because their negative emotionality is directed towards others. Finally, because angry individuals perceive threats from others, they are less trusting, and consequently are slower to seek medical treatment and are less likely to comply with a doctor's instructions (Suls and Sanders, 1989).

The negative self-evaluations of depression lead to a lower sense of purpose in life, which in turn gives an individual less motivation to care for themselves. The lack of motivation, combined with the characteristic anhedonia of depression, implies that when individuals experience depression, they should engage less in active behaviors that improve or sustain their health (Harlow and Newcomb, 1986). Consequently, depression is also linked to lower adherence to medication, poorer dietary compliance, and lower levels of physical exercise (Kim et al., 2003; Whooley et al., 2008). In addition, depressed individuals experience more frequent stressors, and thus must engage in coping strategies more often than those who are not depressed. These individuals may cope through substance use (Cooper et al., 2000, 1995; Kim et al., 2003; Swendsen and Merikangas, 2000). On a positive note, the expression of depression may signal to close others the need for social support (Stiff et al., 1988), which in turn serves as a substantial buffer against the health consequences of stress (Cohen and Wills, 1985).

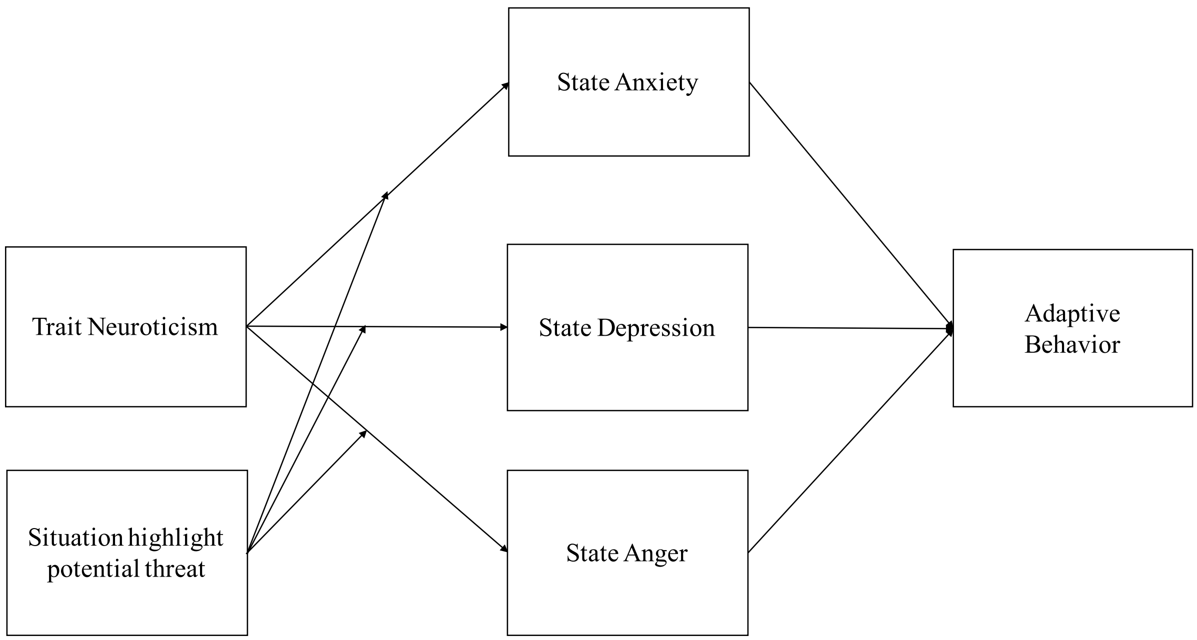
Given the future-orientation of anxiety, anxious individuals may display greater vigilance for signs of health problems (Friedman, 2000). Specifically, anxious individuals should notice changes in their health and perceive those changes as indicators of illness or disease. For example, an anxious person should be more likely to notice a new mole on their skin, due to their attention to stimuli, and more likely to perceive it as an indicator of cancer, due to their perception of neutral stimuli as threatening. As a consequence, anxious individuals should be more likely to detect cancer and other illnesses at early stages. This suggests that anxiety – and by extension, neuroticism – may be protective when there is a real threat to health, such as early stage cancer. Some support has been found for this anxious-vigilance hypothesis. Anxious women are more likely to examine themselves monthly as recommended (Brain et al., 1999; Lerman et al., 1993; McCaul et al., 1998) and to receive mammograms (Caplan et al., 1996).

However, avoidance of future threats can also manifest as refusing to acknowledge the threat. Anxious individuals may be equally afraid of receiving a diagnosis as they are of actually having an illness, and so avoid being diagnosed by refusing to seek even routine health care. Following this, neuroticism shows a bell-curve relationship with health care screening (Armon and Toker, 2013). In this study, healthy individuals were recruited after receiving a routine health examination. Those individuals who had average levels of neuroticism were more likely to return for a second visit within seven years. However, individuals either very low or very high in neuroticism were not likely to return for a second screening. These findings suggest that while individuals with moderate levels of neuroticism or anxiety may feel motivated to address potential threats, those with very high levels are more worried about receiving the news and will avoid the diagnosis as a means of avoiding the underlying health problem. In addition, anxiety and vigilance towards other domains (e.g., vigilance for problems at work or in relationships) may have an adverse effect on health. For example, the college student who worries about failing an upcoming final may address this threat by pulling an all-nighter. His health will suffer from a lack of sleep. Anxious individuals may also attempt to avoid addressing threats through substance use (Bonnet et al., 2005; Patton et al., 1998), which have an obvious negative impact on health, academic performance and other domains. [3]

[3]Given the relationship between substance use and these three emotions, we might expect that trait neuroticism also predicts smoking and alcohol consumption. Many studies have found this to be true (e.g., Eysenck and Eaves, 1980; Mroczek et al., 2009; Terracciano and Costa Jr., 2004; Turiano et al., 2012; Weston and Jackson, 2014). Yet, like all other findings regarding neuroticism and health, these effects are not reliably found (Atherton et al., 2014; Hong and Paunonen, 2009).

1.9 A new model of adaptive neuroticism

The current dissertation seeks to define and test a new model of adaptive neuroticism, one which incorporates within-person variability in lower-order structures of neuroticism and situations over time. The model is depicted graphically in Figure 1.3.



This model suggests that trait levels of neuroticism are best used to predict within-person emotional responses to threatening situations. Neuroticism will predict adaptive behaviors when the situation at hand suggests a probable future threat and the individual feels greater levels of anxiety and lower levels of depression in response to that situation.

Figure 1.3: A theory of adaptive neuroticism.

Specific situations trigger specific states

Individuals find themselves in different situations over time. Some of these situations highlight the potential for future harm; when individuals find themselves in such a situation, they should feel certain emotions, namely anxious or angry. Conversely, when individuals are not in a threatening situation, they should feel less anxious. They should also be more likely to feel depressed or angry, not because all situations that are non-threatening are also depressing or provoke anger, but because *some* non-threatening situations can be depressing or provoke anger. But more than just eliciting emotions, we should think of these situations as triggering state responses based on the individual's trait. So, while in general, individuals should feel more anxious in threatening situations, neurotic individuals should feel more anxious than anyone else. This is consistent with trait-activation theory (Tett and Guterman, 2000), which states that the expression of a trait requires activation by trait-relevant situational cues. In other words, individuals high in neuroticism should not behave or feel neurotic at all times; rather, when the situation can elicit negative emotionality, those in high in neuroticism should behave and feel the most "neurotic." This explains why neuroticism predicts more negative reactivity to (Mroczek and Almeida, 2004) and perception of average situations (Rauthmann et al., 2015).

Specific states predict specific behaviors

When individuals feel anxious in response to potential future harm, they engage in behaviors which can reduce the likelihood of experiencing harm, or adaptive behaviors. Because neurotic individuals will feel more anxious, they should be more likely to engage in adaptive behaviors in response to potential future threat. For example, if an individual susceptible to migraines feels a headache approaching, they should become anxious. This anxiety should motivate them to take medication right away, to reduce the likelihood of experiencing a full migraine.

On the other hand, when individuals experience greater levels of depression and anger, they should be less likely to engage in adaptive behaviors, if the threat is health related. Instead, individuals who experience these states should be more likely to act in unhealthy ways. For example, depressed individuals should be less likely to exercise, and depressed or angry individuals may use a substance, like alcohol, to reduce their negative affect.

1.10 The current study

The current study aims to test this model of adaptive neuroticism. To do so, it will use longitudinal daily-diary or weekly-diary studies which track individuals across short periods of time: weeks, or even days. Testing the model over this short time-frame is essential for capturing the daily behaviors which, over time, could improve or sustain the health of individuals. Moreover, these daily diaries allow for individuals to experience a variety of situations and events, which may elicit a number of states and behaviors. In addition, the use of daily-diaries allows us to tease apart facets of neuroticism within-persons. That is, we can determine whether anxiety, depression, and anger are as strongly correlated at a state-level as they are at a trait-level. This will allow us to isolate the mechanisms by which neuroticism can lead to adaptive or maladaptive behaviors. Finally, while the motivation for the model is grounded in the health domain, the cognitive biases and motives accompanying these lower-order structures of neuroticism should apply equally in other domains. So the model of adaptive neuroticism should work to explain behavior in other domains. Consequently, the current study will test this model in both the health domain and the educational domain.

2. Study 1: Health Behaviors

2.1 Study 1 Methods

2.1.1 Participants

Data were drawn from the national panel study, the Midlife in the United States study (MIDUS; for a review, see Brim et al., 2004). Participants were recuited into this study between the years 1995 and 1996 through the use of random digit dialing. Participants were eligble for the survey if they were non-institutionalized, English-speaking adults (between the ages of 25 and 74) living in the United States. Researchers also identified eligible siblings and twins within this sample.

Of the full MIDUS sample, a subset participated in the National Study of Daily Experiences (NSDE). This sample includes 1,499 participants from 1,285 households. On average, participants (53.57% female) were 45.84 years old (SD = 12.56). White Americans are over represented at 89.39% of the sample, while African Americans make up only 5.60% of the sample. The remainder of the sample contains Native Americans, Asians and Pacific Islanders, Others, Multiracials and nonresponders. The sample is also well-educated: 90.79% of the sample completed high school, 30.89% of the sample completed college and 9.27% of the sample had a graduate degree.

2.1.2 Measures

Neuroticism

Personality traits were measured as part of the general MIDUS survey. For these measures, participants were given an adjective and asked to rate how well the word described them on a scale from 1 (*Not at all*) to 4 (*A lot*). Neuroticism was measured with the items *moody*, *worried*, *nervous* and *calm* (reverse scored). Respones were averaged to create a final trait score for each participant ($M = 2.22, SD = 0.66$). This four-item measure shows fair reliability ($\alpha = 0.74$) and has been used in other panel studies, including the Health and Retirement Study.

Situation, emotional and behavioral measures were conducted as part of the NSDE. Participants who were included in this study were called on the telephone every night for eight consecutive nights. Participants completed between 1 and 8 daily reports, with the average number of reports being 7.00 ($SD = 1.41$).

Situation: Physical symptoms

Each day, participants were asked to rate how much of the time that day they had experienced a number of physical symptoms, from 1 (*None of the time*) to 5 (*All of the time*). These symptoms included aches (i.e., headache, backache, muscle soreness; $M = 1.76$, $SD = 1.13$), cold and flu (i.e., cough, sore throat, fever, chills, flu; $M = 1.32$, $SD = 0.88$), stomach problems (i.e., nausea, diarrhea, poor appetite and other stomach problems; $M = 1.15$, $SD = 0.56$), chest pain or dizziness ($M = 1.07$, $SD = 0.36$), other physical symptoms or discomforts ($M = 4.12$, $SD = 0.32$). In addition, women were asked if they had experienced any menstrual-related symptoms ($M = 1.20$, $SD = 0.71$) or hot flashes ($M = 1.11$, $SD = 0.44$). It seems more important to assess changes in a person's health, such as new symptoms, than differences in health between people. Consequently, physical symptoms were person-centered.

Each of the physical symptoms will serve as situations which suggest possible future threat. A physical symptom, such as an ache, alerts an individual to health problem. This may be a relatively minor problem, such as a cold, or a more major problem, like an infection or a cancerous growth. Moreover, the health threat may be avoided with action (e.g., if the threat is a cold, the individual might get more sleep). Without further investigation, the symptom itself is ambiguous. The individual cannot discern whether he is under grave or minor threat and he cannot know whether his actions will lead to any change. In such a situation, his best course of action is to assume that his actions can mitigate the threat.

Emotion

Participants were given a number of items to assess emotion each day. For each item, participants were asked to rate how much of the time that day they had felt that emotion, from 1 (*None of the time*) to 5 (*All of the time*). Three of these items are used here: nervous ($M = 1.24, SD = 0.60$), depressed ($M = 1.24, SD = 0.62$); and angry/irritable ($M = 1.36, SD = 0.67$). Emotions will be grand-mean centered for these analyses. Person-mean centering was not used, because the theory under consideration asks not only how individuals respond when they feel more anxious, but whether neurotic individuals feel more anxious than less neurotic individuals.

Behavior: Health Behavior

Each day, participants were asked to report whether they engaged in a number of health behaviors. Participants reported on how much time (in hours) they engaged in *vigorous exercise* ($M = 0.81$, $SD = 1.64$). Participants reported how many *cigarettes* they had smoked in the last day. Of participants who were smokers ($N = 579$), the average number of cigarettes smoked was 14.05 ($SD = 12.57$). If non-smokers are included (i.e., each of the non-smokers is given a value of 0 for every day they complete the survey), the average number of cigarettes smoked is 4.19 ($SD = 9.47$).

Participants reported how many *alcoholic drinks* they had consumed in the last day. Of participants who were drinkers ($N = 1,130$), the average number of drinks consumed was 0.67 ($SD = 1.47$). If non-drinkers are included, the average number of drinks consumed is 0.51 ($SD = 1.53$). Participants also report on how much time (in hours) they spend *sleeping* ($M = 7.13$, $SD = 1.46$). Participants are more likely to sleep and consume alcoholic drinks later in the evening, after the daily evening phone interview. Consequently, the reports of these behaviors for the following day are used in the analyses, instead of the concurrent day. For example, a participant's report on the Wednesday interview for his amount of sleeping and alcohol consumption will be compared to his report on Tuesday of physical symptoms and emotion. This is because these behaviors are more likely to have occurred on Tuesday evening, after the Tuesday report.

These behaviors will serve as adaptive (in the case of exercise) or maladaptive (in the case of smoking and drinking) health behaviors. When faced with an ambiguous but potentially threatening situation (i.e., a somatic symptom) an individual should increase their engagement in adaptive behaviors and decrease their engagement in maladaptive behaviors. Certainly, there will be some differentiation between the specific situations and behaviors. Dizzy individuals should probably not exercise and so we should not expect the same increase in exercise in the face of that situation.

2.1.3 Analyses

Four different models will be constructed for each of the behaviors. These models build incrementally on each other. The first model, a simple one-predictor regression, represents the typical method of assessing neuroticism in the health domain, and the final and fourth model represents the most nuanced method of analyzing these data. By estimating each of these models, the relationship between neuroticism and behavior can be examined from multiple angles, providing a more thorough understanding of how

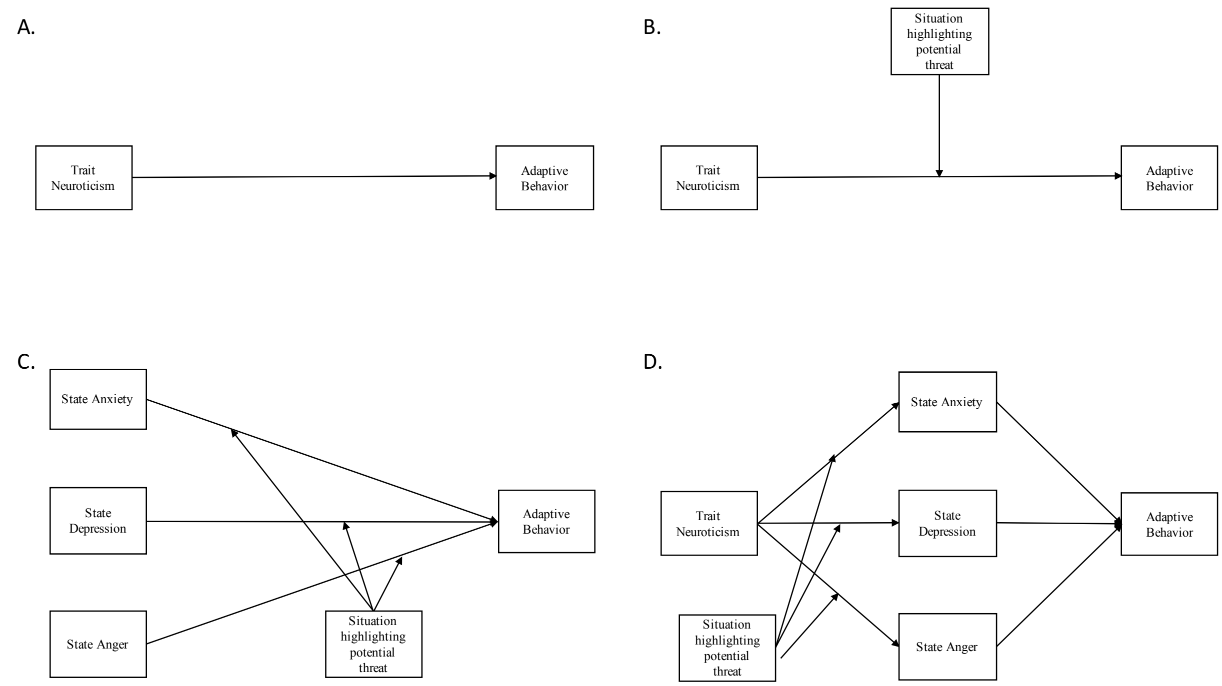


Figure 2.1: Four models to be tested. These models progress from most parsimonious to most complex.

neuroticism may predict behavior.

Relationship of neuroticism and behavior

First, the basic relationship of neuroticism to the individual health behaviors will be established. This first model represents the most traditional method of assessing the effect of neuroticism on health. The zero-order relationship will be estimated, as well as the relationship after controlling for covariates, age and gender. See Panel A in Figure 2.1. An example, predicting smoking, is shown below.

Level 1: Day Level

$$Smoking_{jk} = \beta_{0k} + e_{jk} \tag{2.1}$$

Level 2: Person level

$$\beta_{0k} = \gamma_{00} + \gamma_{01}(Neuroticism_k) + \mu_k \tag{2.2}$$

Moderation of neuroticism by situation

Next, the relationship between neuroticism and behavior will be moderated by situation. This model represents a more nuanced approach to studying the relationship between neuroticism and health behaviors by incorporating the potential for different situational effects, as described in the introduction. See Panel B in Figure 2.1. An example of the equations estimated is shown here, with smoking as the example outcome.

Level 1: Day Level

$$Smoking_{jk} = \beta_{0k} + \beta_{1k}(Symptoms_{jk}) + e_{jk} \tag{2.3}$$

Level 2: Person level

$$\begin{aligned} \beta_{0k} &= \gamma_{00} + \gamma_{01}(Neuroticism_k) + \mu_{0k} \\ \beta_{1k} &= \gamma_{10} + \gamma_{11}(Neuroticism_k) + \mu_{1k} \end{aligned} \tag{2.4}$$

Moderation of emotion by situation

Third, neuroticism will be replaced by the negative emotions – anger, sadness and anxiety – that were measured within-person. This model is incorporated as it covers the elements deemed necessary and yet missing from the current study of neuroticism and health (i.e., emotions and situations) but omits the overall trait of neuroticism. See Panel C in Figure 2.1.

Level 1: Day Level

$$\begin{aligned} Smoking_{jk} = \beta_{0k} + \beta_{1k}(IsDepressed_{jk}) + \\ \beta_{2k}(IsAnger_{jk}) + \beta_{3k}(Symptoms_{jk}) + \\ \beta_{4k}(IsDepressed_{jk})(Symptoms_{jk}) + \\ \beta_{5k}(IsAnger_{jk})(Symptoms_{jk}) + e_{jk} \end{aligned} \tag{2.5}$$

Level 2: Person level

$$\begin{aligned} \beta_{0k} &= \gamma_{00} + \mu_{0k} \\ \beta_{1k} &= \gamma_{10} \\ \beta_{2k} &= \gamma_{20} \\ \beta_{3k} &= \gamma_{30} \\ \beta_{4k} &= \gamma_{40} \\ \beta_{5k} &= \gamma_{50} \end{aligned} \tag{2.6}$$

Mediation model

Fourth and finally, the proposed mediation model will be tested. See Panel D in Figure 2.1.

A three-level[1] hierarchical linear modeling will be used to test the theoretical model. Level one will be the prediction of a rating from the emotion category (see Equation 2.7). Two dummy codes will be incorporated to indicate which emotion is the outcome. These coefficients will represent the average differences in ratings of nervousness (anxiety), depression and anger. Next, emotion will be nested within days (Level 2). At this level, the emotion coefficients will be predicted by the amount of time a physical symptom was present. Only two coefficients (for example, π_{0jk} and π_{1jk}) will be allowed to vary across days (see Equation 2.8). This was done for two reasons: 1) there are not enough observations in the data to freely estimate all coefficients in this model and 2) there is no theoretical reason that the difference in ratings of emotion should be systematically predicted by day in the study. To determine which two coefficients should be allowed to vary, each possible combination of two will be tested, and the coefficient with the least variance will be excluded. Days will then be nested within person (Level 3). At this level, neuroticism will be used to predict all coefficients: intercepts, mean levels of anxiety, differences between anxiety and the other emotions and the interaction between each of the emotions and degree of physical symptoms. All coefficients will be allowed to vary at this level (see Equation 2.9). Residuals from this model will be calculated by generating predicted values from the fixed effects estimated and subtracting these from the observed scores. These residuals will become predictors to test the second half of the model.

Level 1: Emotion level

[1]It must be noted that this three-level model ignores a source of dependence among the data points: household. Within the data, there are 1,285 households, 203 of which contain two participants and 4 of which contain three or more participants. To determine whether it was necessary to nest participants in households for the analyses, I estimated the hierarchical linear model described in this subsection with a fourth, household, level and allowed the intercept to vary at this level. I estimated this model for each of the seven symptoms. The *ICC* of household ranged from 0.08 to 0.15 (M = 0.11). Given the relatively small variance explained by household, I chose to drop this level for the sake of parsimony.

$$Rating_{ijk} = \pi_{0jk} + \pi_{1jk}(IsDepression_{ijk}) + \pi_{2j}(IsAnger_{ijk}) + e_{ijk} \tag{2.7}$$

Level 2: Day level

$$\begin{aligned}
\pi_{0jk} &= \beta_{00k} + \beta_{01k}(Symptoms_{jk}) + r_{0jk} \\
\pi_{1jk} &= \beta_{10k} + \beta_{11k}(Symptoms_{jk}) \\
\pi_{2jk} &= \beta_{20k} + \beta_{21k}(Symptoms_{jk})
\end{aligned} \tag{2.8}$$

Level 3: Person level

$$\begin{aligned}
\beta_{00k} &= \gamma_{000} + \gamma_{001}(Neuroticism_{k}) + \mu_{0k} \\
\beta_{01k} &= \gamma_{010} + \gamma_{011}(Neuroticism_{k}) + \mu_{1k} \\
\beta_{10k} &= \gamma_{100} + \gamma_{101}(Neuroticism_{k}) \\
\beta_{11k} &= \gamma_{110} + \gamma_{111}(Neuroticism_{k}) \\
\beta_{20k} &= \gamma_{200} + \gamma_{201}(Neuroticism_{k}) \\
\beta_{21k} &= \gamma_{210} + \gamma_{211}(Neuroticism_{k})
\end{aligned} \tag{2.9}$$

This model will be run three times, once with each emotion serving as the reference group, to estimate the pathways from neuroticism and situation to emotion, and to formally test whether neuroticism, situation and their interaction predict these emotions differently (shown in Figure 2.2).

A similar set of equations will be used to predict the effect of neuroticism and situation on the behaviors. Because each behavior is measured using a different scale (e.g., number of hours, number of drinks, etc.), separate models will be used to estimate each behavior. Consequently, two-level (instead of three-level) models will be used. An example of the smoking model is described below.

Level 1: Day Level

$$Smoking_{jk} = \beta_{0k} + \beta_{1k}(Symptoms_{jk}) + r_{jk} \tag{2.10}$$

Level 2: Person level

$$\begin{aligned} \beta_{0k} &= \gamma_{000} + \gamma_{01}(Neuroticism_k) + \mu_k \\ \beta_{1k} &= \gamma_{010} + \gamma_{11}(Neuroticism_k) + \mu_k \end{aligned} \tag{2.11}$$

After using neuroticism and situation to estimate both emotion and behavior, the residuals of these two models will be used to estimate the pathways from emotion to behavior. This procedure imitates traditional mediation models, by estimating the pathways from the mediators (emotions) to the outcome (behavior) after controlling for the predictors (neuroticism and situation).

For all models, bootstrapping will be used to estimate the coefficients (the median value estimated by the bootstrapping procedure) and the confidence intervals (using the percentile method).

Level 1: Day Level

$$Behavior_{ij} = \beta_{1j}(Nervous_{ij}) + \beta_{2j}(Depression_{ij}) + \beta_{3j}(Anger_{ij}) + e_{ij} \tag{2.12}$$

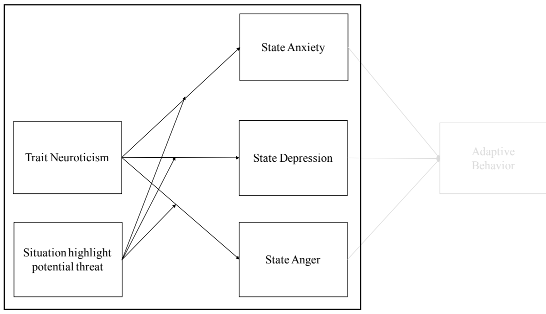
Level 2: Person Level

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + \mu_{0j} \\ \beta_{1j} &= \gamma_{10} + \mu_{1j} \\ \beta_{2j} &= \gamma_{20} + \mu_{2j} \\ \beta_{3j} &= \gamma_{30} + \mu_{3j} \end{aligned} \tag{2.13}$$

This entire model estimate procedure will be used to estimate the models with each of the situations or physical symptoms (aches, throat problems, stomach issues, dizziness, menstrual pains, hot flashes and other) leading to each of the health behaviors (exercise, sleep, smoking and drinking) through the emotions, resulting in a total of 28 models.

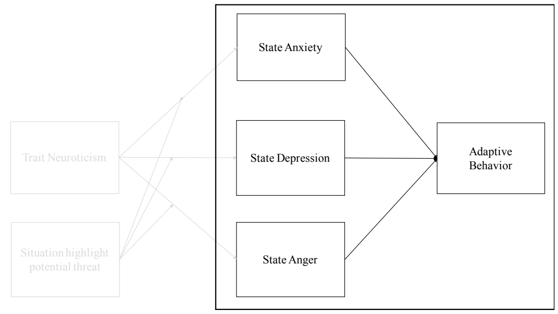
2.1.4 Hypotheses

It is hypothesized that individuals high in neuroticism will experience higher levels of each emotion overall. That is, the mean level of anger, anxiety and depression should increase as participants increase in trait neuroticism. Experiencing more physical symptoms is expected to increase experiences of anxiety and decrease experiences of anger and depression. Finally, greater anxiety in the face of physical symptoms is hypothesized to increase participation in healthy behaviors (sleeping and exercising) and decrease



These pathways will be estimated using three hierarchical linear models. Residuals from this model will be saved, and these residuals will be used to test the second half of the model.

Figure 2.2: The first half of the model, predicting emotion by situation and neuroticism.



These pathways will be estimated using the residuals from models predicting emotion and behavior from the interaction of neuroticism and situation.

Figure 2.3: The second half of the model, predicting behavior from emotion.

participation in unhealthy behaviors (drinking and smoking). Greater levels of anger and depression are hypothesized to have the opposite effect on health behaviors.

2.2 Study 1 Results

All analyses in this document were performed using R. The version number and packages loaded are listed in Appendix A.

Three methods were used to calculate correlations. When calculating correlations between person-level variables, the scores on each variable were used and the sample size was the number of people who had completed both measures. When calculating correlations between day-level variables, the scores on each variable were used and the sample size was the number of observations that had scores on measures. When calculating correlations between one day-level variable and one person-level variable, the average day level score and the score on the person-level variable was used, and the sample size was the number of people who had completed the day-level variable once and had completed the person-level variable. A full correlation matrix can be found in Table 2.1.

Neuroticism was positively correlated with greater experience of feeling nervous ($r = 0.35$), depressed ($r = 0.33$), and angry ($r = 0.32$). Neuroticism was also positively associated with smoking cigarettes ($r = 0.04$), but was not associated with drinking alcohol ($r = 0.01$), vigorous exercise ($r = -0.01$) or hours of sleep ($r = 0.01$). The three emotions were correlated with the health behaviors. Specifically, nervousness was positively associated with smoking ($r = 0.05$) and negatively associated with sleep ($r = -0.03$). Depression was positively associated with smoking ($r = 0.09$) and exercise ($r = 0.02$) and negatively associated with sleep ($r = -0.02$). Anger was positively associated with both exercise ($r = 0.03$) and sleep ($r = -0.03$). Cigarette smoking, alcohol consumption and hours of sleep were not correlated with any of the symptoms. However, vigorous exercise was positively associated with a number of symptoms: aches ($r = 0.05$), hot flashes and feeling flushed ($r = 0.03$) and other physical symptoms and discomforts ($r = 0.03$). Vigorous exercise was also positively correlated with the composite physical symptom score ($r = 0.04$).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Gender																		
2. Age	-0.01																	
3. SRH	-0.07*	0.13*																
4. Neuroticism	0.10*	-0.15*	-0.23*															
5. Nervous	0.06*	-0.08*	-0.16*	0.35*														
6. Depressed	0.08*	-0.05	-0.20*	0.33*	0.39*													
7. Angry	0.07*	-0.29*	-0.14*	0.32*	0.36*	0.40*												
8. Ache	0.03	0.00	-0.06*	0.02	0.06*	0.08*	0.08*											
9. Cold/Flu	0.01	0.01	-0.01	-0.01	0.02*	0.05*	0.03*	0.11*										
10. Stomach	0.01	-0.02	0.00	-0.01	0.07*	0.09*	0.07*	0.12*	0.16*									
11. Dizzy	0.04	-0.01	-0.03	0.02	0.08*	0.06*	0.05*	0.07*	0.08*	0.16*								
12. Menstrual		0.01	-0.03	0.02	0.04*	0.04*	0.05*	0.05*	-0.01	0.03	0.01							
13. Flush		0.02	0.00	-0.07	0.03*	0.05*	0.06*	0.03*	0.10*	0.07*	0.04*	0.05*						
14. Other	0.01	0.05	0.00	-0.03	0.06*	0.04*	0.04*	0.03*	0.03*	0.02*	0.01	-0.02	0.01					
15. All	-0.01	-0.02	-0.01	0.01	0.10*	0.12*	0.09*	0.69*	0.56*	0.49*	0.32*	0.40*	0.29*	0.23*				
16. Cigarettes	-0.22*	0.04	-0.19*	0.04	0.05*	0.09*	0.01	0.01	0.00	0.01	0.01	-0.01	0.00	0.00	0.02			
17. Alcohol	-0.27*	0.02	-0.05	0.01	0.01	0.01	0.03	-0.01	-0.01	-0.02	-0.01	0.00	0.02	0.00	-0.03	0.09*		
18. Exercise	-0.14*	-0.04	0.03	-0.01	0.00	0.02*	0.03*	0.05*	0.00	0.00	0.01	0.01	0.03*	0.03*	0.04*	0.19*	0.03	
19. Sleep	0.02	0.07*	-0.06*	0.01	-0.03*	-0.02*	-0.03*	0.01	0.01	-0.01	0.00	0.02	0.02	0.01	0.01	-0.05	0.03	-0.04*

*$p < .05$; SRH = self-rated health, Other = other symptoms, All = all symptoms

Table 2.1: Correlations between Study 1 variables

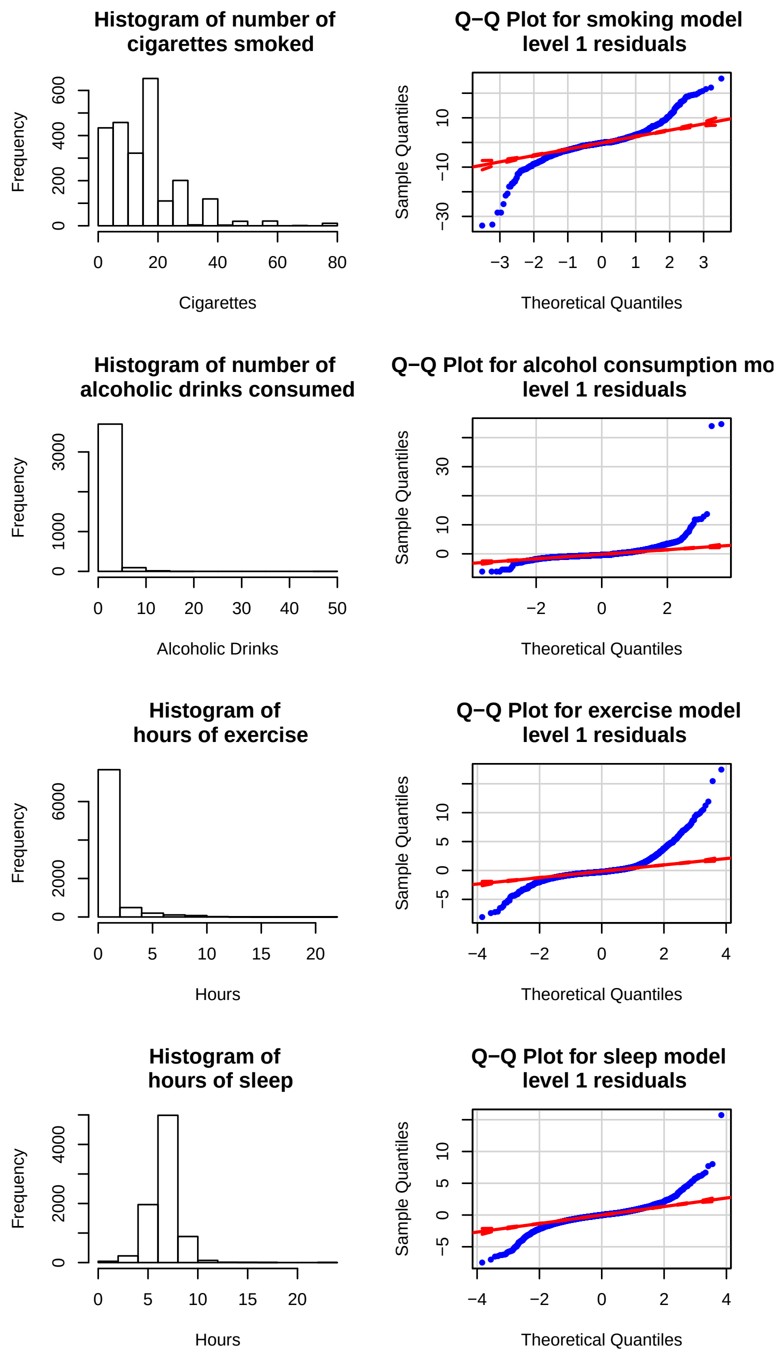
2.2.1 Model 1: Neuroticism predicting behavior

The first model tested is the simple model predicting behavior from neuroticism. Multilevel models are used for this, with days nested within person. The effect of this is to estimate a "true score" of behavior for each participant from their behavior across days. All models control for age, gender and the self-rated health of the participant.[2] After estimating the models, simple diagnostics were run. Relevant plots are presented in Figure 2.4. These include histograms of the outcome measures and Q-Q normality plots of the residuals. Both sets of diagnostics indicate that all outcomes of interest are highly skewed and the residuals are non-normally distributed.

Given the violation of the normality assumptions of regression, bootstrapping with 1,000 iterations was used to estimate the coefficients and their significance. The use of bootstrapping overcomes problems with skewed distributions and allows for unbiased estimation of the coefficients and their uncertainty. The median of the resulting distribution was used as the coefficient estimate, and the percentile method was used to estimate the 95% confidence interval. If this interval did not contain 0, the coefficient was determined to be statistically significant. This bootstrapping approach was applied to all models in this thesis, to address the continued problems of non-normally distributed outcomes and for consistency across methods. Results are presented in Table 2.2.

The results of these models were consistent: neuroticism was not a significant predictor of health behaviors after controlling for age, gender and self-rated health. More specifically, neuroticism did not predict the number of cigarettes smoked by smokers ($B = 0.56$, 95% CI $= [-0.96, 2.19]$) the number of alcohol drinks consumed by drinkers

[2] All models were tested with and without these covariates and with the predictor variable(s) interacting with each of the covariates. The use of these covariates did not change the results of the study, and in many cases changed the size of the coefficients by less than one tenth of a unit. There was one exception: removing self-rated health did allow for neuroticism and nervousness to predict cigarette smoking. I decided to keep self-rated health in for two reasons. First, this provided the most conservative test of the models. Second, the symptom variables were within-person centered, which does more closely reflect an individual's experience of changes in their health but also removes between-person variability in health. By adding self-rated health to the model, we can better account for between-person variability in general health.



Diagnostic plots of health study models of neuroticism predicting behavior show that assumptions of normality have been violated. Bootstrapping is employed to address this problem.

Figure 2.4: Diagnostic plots of health study models

($B = 0.04$, $[-0.12, 0.20]$), the number of hours exercised ($B = 0.01$, $[-0.10, 0.12]$), or the number of hours slept ($B = 0.02$, $[-0.07, 0.10]$) in an average day.

	Health Behaviors			
	Cigarettes	Drinks	Vigorous Exercise	Sleep
	(1)	(2)	(3)	(4)
Intercept	23.58* (15.92,31.47)	1.68* (0.97,2.35)	1.15* (0.60,1.68)	6.99* (6.58,7.39)
Neuroticism	0.56 (-0.96,2.19)	0.04 (-0.12,0.20)	0.01 (-0.10,0.12)	0.02 (-0.07,0.10)
Gender	-4.81* (-6.93,-2.59)	-0.74* (-0.93,-0.55)	-0.33* (-0.48,-0.19)	0.05 (-0.06,0.16)
Age	0.05 (-0.04,0.15)	0.001 (-0.01,0.01)	-0.004 (-0.01,0.002)	0.01* (0.003,0.01)
Self-Rated Health	-2.29* (-3.69,-1.02)	-0.10 (-0.21,0.02)	0.05 (-0.03,0.13)	-0.07* (-0.13,-0.01)
Observations	2,332	3,735	8,348	8,018
Log Likelihood	-7,637.90	-7,831.25	-15,606.77	-13,487.09

Note: $^{*}p < .05$

Table 2.2: Predicting health behaviors from trait neuroticism (Model 1)

2.2.2 Models 2 and 3: The interaction of neuroticism or emotion and situation in predicting behavior

Next, models two and three were estimated. In model two, situation (i.e., physical symptoms) interacts with neuroticism to predict behavior. In model three, situation interacts with each of the daily negative emotions (nervousness, depression and anger) to predict behavior. Separate models are created for each combination of situations and behavior. Each model controls for age, gender and self-rated health. Results are grouped by physical symptom, to aid with description and interpretation.

The results for models two and three predicting behavior from symptoms of aches and pain (interacting with trait neuroticism and daily negative emotion) are presented in Table 2.3. Neuroticism and aches did not significantly interact to predict any of the health behaviors. Aches also did not interact with feeling nervous, depressed or angry to predict health behaviors.

The results for models two and three predicting behavior from cold and flu symptoms (interacting with trait neuroticism and daily negative emotion) are presented in Table 2.4.

Neuroticism and cold/flu symptoms did not significantly interact to predict any of the health behaviors. Cold and flu symptoms also did not interact with feeling nervous, depressed or angry to predict health behaviors.

The results for models two and three predicting behavior from stomach and digestive issues are presented in Table 2.5. Neuroticism and stomach and digestive issues did not significantly interact to predict any of the health behaviors. Digestive issues also did not interact with feeling nervous, depressed or angry to predict health behaviors.

The results for models two and three predicting behavior from chest pain and dizziness are presented in Table 2.6. Neuroticism and dizziness did not significantly interact to predict any of the health behaviors. Dizziness also did not interact with feeling nervous, depressed or angry to predict health behaviors.

The results for models two and three predicting behavior from menstruation-related symptoms are presented in Table 2.7. As a reminder, only women were included in these analyses. Neuroticism and menstruation symptoms did not significantly interact to predict any of the health behaviors. Being angry interacted with these symptoms to predict cigarette smoking ($B = -0.99$, $[-1.94, -0.03]$). More specifically, feeling angry had no effect on smoking when menstrual symptoms were low; when menstrual symptoms were one group standard deviation below an individual's mean, the slope of angry on smoking was not significantly different from 0 ($B = 0.17$ $[-0.65, 0.97]$). Yet when menstrual symptoms were high, one group standard deviation above an individual's mean, being angry lead to a reduction in cigarette smoking ($B = -0.92$ $[-1.70, -0.08]$)[3]. This effect was in the opposite direction hypothesized: it was expected that feeling angry would lead to unhealthy behaviors, especially when feeling angry was a response to a health situation. Here, being angry in response to health symptoms lead to healthier behavior.Menstruation symptoms did not interact with feeling nervous or depressed to predict health behaviors.

[3]Simple slopes were calculating by recentering the symptom variable - either by subtracting the group standard deviation from the within-person centered variable, to center at a "high" level or by adding the standard deviation to center at a "low" level, re-estimating the model and then running the bootstrap procedure to estimate the coefficients and confidence intervals.

The results for models two and three predicting behavior from hot flashes and feeling flushed are presented in Table 2.8. Again, only women were included. Neuroticism and hot flashes did not significantly interact to predict any of the health behaviors. Hot flashes also did not interact with feeling nervous, depressed or angry to predict health behaviors.

The results for models two and three predicting behavior from other, unlisted symptoms are presented in Table 2.9. Being nervous interacted with other symptoms to predict cigarette smoking ($B = 1.30$, $[0.11, 2.57]$). More specifically, feeling nervous had no effect on smoking when symptoms were low; when symptoms were one group standard deviation below an individual's mean, the slope of nervous on smoking was not significantly different from 0 ($B = 0.30$ $[-0.27, 0.80]$). Yet when symptoms were high, one group standard deviation above an individual's mean, being nervous lead to a increase in cigarette smoking ($B = 0.94$ $[0.44, 1.48]$). This interaction is shown in Figure 2.5.

Other symptoms also interacted with depression to predict alcohol consumption ($B = 0.42$, $[0.08, 0.79]$). When symptoms were low, depression lowered the consumption of alcohol ($B = -0.16$ $[-0.34, 0.02]$). When symptoms were high, the effect of feeling depressed on alcohol was not significantly different from 0 ($B = 0.06$ $[-0.07, 0.21]$). Other symptoms did not interact with other emotions to predict health behaviors.

The results for models two and three predicting behavior from the composite representing all symptoms are presented in Table 2.10. Neuroticism and physical symptoms did not significantly interact to predict any of the health behaviors. Symptoms did interact with depression to predict the healthy behaviors, exercise ($B = -0.22$, $[-0.43, -0.01]$) and sleep ($B = -0.27$, $[-0.44, -0.09]$).

In terms of exercise, the relationship between depression and exercise was non-significant when symptoms were low ($B = 0.05$ $[-0.04, 0.14]$). When symptoms were high, the relationship was negative ($B = -0.05$ $[-0.13, 0.03]$). This interaction is shown in Figure 2.5. As far as sleeping, the relationship between depression and hours of sleep was positive when symptoms were low ($B = 0.07$ $[-0.01, 0.15]$). When symptoms were high, the slope was negative ($B = -0.06\ [-0.12, 0.01]$) Interestingly, these simple slopes were never significantly different from 0, although they were significantly different from each other. The direction of this effect was mainly in the hypothesized direction: depression was expected to lead to worse health behaviors, especially when a participant felt depressed in response to a health situation. Here, when participants felt depressed after experiencing symptoms, they did engage in worse health behaviors (i.e., less sleeping).

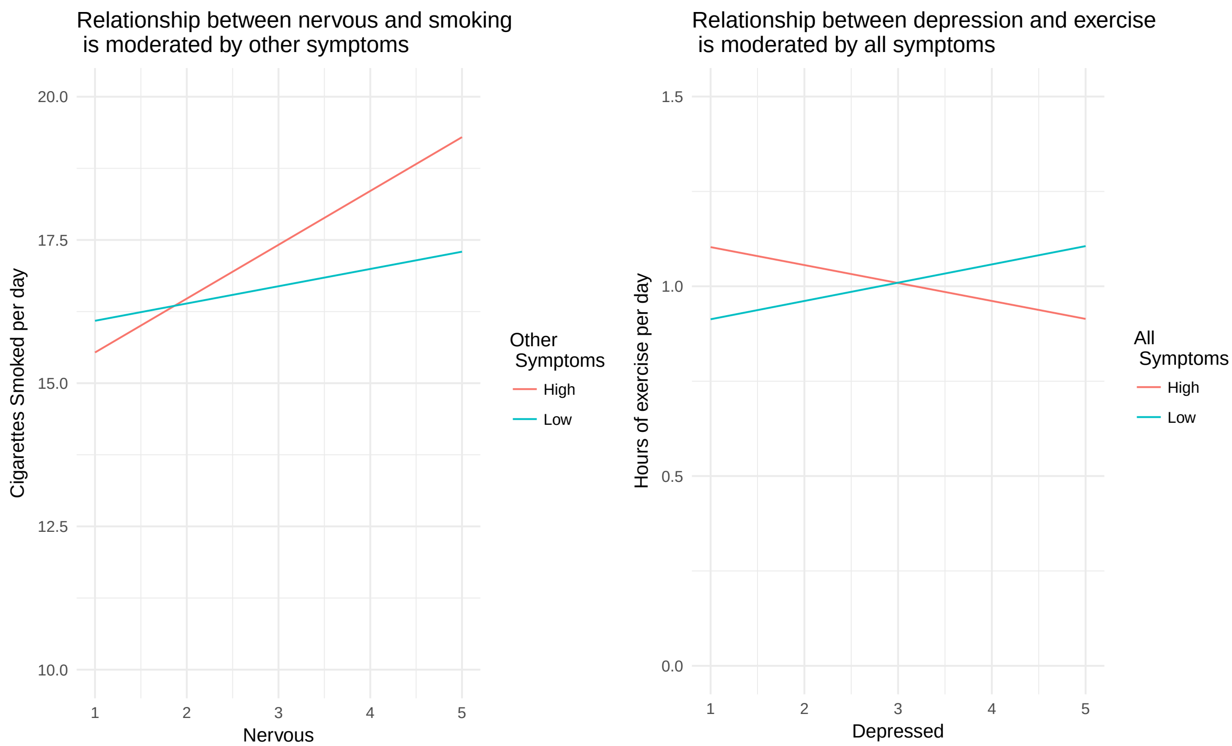


Figure 2.5: Interaction between nervousness and other symptoms and between depression and all symptoms as estimated in model 3.

	Dependent variable:							
	Cigarette Smoking		Alcohol Consumption		Vigorous Exercise		Hours of Sleep	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.56		0.04		0.01		0.02	
	(−1.00, 2.37)		(−0.11, 0.19)		(−0.11, 0.12)		(−0.07, 0.11)	
Aches	−0.39	0.19	0.09	0.01	0.10	0.17*	0.04	0.03
	(−1.31, 0.53)	(−0.52, 0.92)	(−0.18, 0.38)	(−0.20, 0.22)	(−0.08, 0.27)	(0.05, 0.29)	(−0.11, 0.18)	(−0.08, 0.14)
Neuroticism x Aches	0.23		−0.06		0.01		−0.01	
	(−0.15, 0.61)		(−0.18, 0.06)		(−0.07, 0.08)		(−0.08, 0.05)	
Nervous		0.62*		0.01		−0.06		−0.07*
		(0.19, 1.02)		(−0.11, 0.13)		(−0.12, 0.01)		(−0.13, −0.02)
Depressed		0.81*		−0.02		0.01		−0.01
		(0.39, 1.24)		(−0.16, 0.10)		(−0.05, 0.08)		(−0.07, 0.04)
Angry		−0.29		0.06		0.07*		0.01
		(−0.71, 0.08)		(−0.05, 0.17)		(0.01, 0.13)		(−0.04, 0.07)
Nervous x Aches		0.28		−0.05		0.03		−0.01
		(−0.12, 0.67)		(−0.19, 0.08)		(−0.05, 0.10)		(−0.08, 0.05)
Depressed x Aches		−0.16		−0.02		−0.05		−0.03
		(−0.52, 0.19)		(−0.15, 0.11)		(−0.12, 0.01)		(−0.09, 0.03)
Angry x Aches		−0.17		0.04		−0.01		0.02
		(−0.56, 0.20)		(−0.08, 0.16)		(−0.08, 0.05)		(−0.03, 0.08)
Observations	2,331	2,322	3,733	3,717	8,340	8,317	8,013	7,990

Note: $^{*}p < .05$

Table 2.3: Predicting health behaviors from neuroticism and emotions by ache symptoms (Models 2 and 3)

	Dependent variable:							
	Cigarette Smoking		Alcohol Consumption		Vigorous Exercise		Hours of Sleep	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.57 (−1.05, 2.16)		0.04 (−0.11, 0.20)		0.01 (−0.10, 0.12)		0.02 (−0.06, 0.10)	
Cold/Flu	1.37 (−0.35, 3.13)	0.34 (−0.83, 1.39)	−0.06 (−0.46, 0.35)	−0.02 (−0.34, 0.28)	−0.18 (−0.41, 0.06)	0.04 (−0.13, 0.20)	0.10 (−0.10, 0.32)	0.03 (−0.12, 0.19)
Neuroticism x Cold/Flu	−0.51 (−1.19, 0.21)		0.02 (−0.15, 0.19)		0.09 (−0.02, 0.18)		−0.05 (−0.14, 0.04)	
Nervous		0.75* (0.32, 1.17)		0.002 (−0.12, 0.12)		−0.05 (−0.12, 0.02)		−0.07* (−0.13, −0.02)
Depressed		0.65* (0.22, 1.07)		−0.02 (−0.16, 0.11)		0.02 (−0.05, 0.08)		−0.01 (−0.06, 0.04)
Angry		−0.27 (−0.67, 0.13)		0.06 (−0.05, 0.16)		0.08* (0.02, 0.14)		0.01 (−0.04, 0.06)
Nervous x Cold/Flu		−0.31 (−0.91, 0.28)		−0.02 (−0.19, 0.14)		−0.02 (−0.12, 0.08)		−0.002 (−0.09, 0.09)
Depressed x Cold/Flu		0.31 (−0.19, 0.78)		−0.04 (−0.18, 0.13)		−0.05 (−0.13, 0.03)		−0.02 (−0.09, 0.05)
Angry x Cold/Flu		−0.20 (−0.75, 0.36)		0.05 (−0.12, 0.22)		0.05 (−0.04, 0.14)		−0.01 (−0.09, 0.08)
Observations	2,331	2,322	3,733	3,717	8,340	8,317	8,013	7,990

Note: $^{*}p < .05$

Table 2.4: Predicting health behaviors from neuroticism and emotions by cold and flu symptoms (Models 2 and 3)

	Dependent variable:							
	Cigarette Smoking		Alcohol Consumption		Vigorous Exercise		Hours of Sleep	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.48 (−1.21, 2.14)		0.05 (−0.12, 0.20)		0.01 (−0.10, 0.12)		0.02 (−0.07, 0.10)	
Digestion issues	−0.13 (−1.98, 1.64)	0.71 (−0.59, 2.14)	−0.05 (−0.60, 0.49)	0.17 (−0.20, 0.52)	−0.27 (−0.61, 0.03)	−0.13 (−0.33, 0.09)	0.12 (−0.21, 0.45)	0.18* (0.0002, 0.38)
Neuroticism x Digestion issues	0.14 (−0.52, 0.83)		−0.02 (−0.23, 0.19)		0.12 (−0.01, 0.24)		−0.05 (−0.18, 0.07)	
Nervous		0.70* (0.28, 1.10)		0.01 (−0.11, 0.14)		−0.05 (−0.12, 0.01)		−0.07* (−0.12, −0.01)
Depressed		0.80* (0.38, 1.20)		−0.02 (−0.16, 0.11)		0.03 (−0.05, 0.10)		−0.01 (−0.07, 0.05)
Angry		−0.27 (−0.66, 0.10)		0.07 (−0.05, 0.18)		0.07* (0.004, 0.13)		0.01 (−0.04, 0.06)
Nervous x Digestion issues		−0.26 (−0.81, 0.33)		−0.08 (−0.27, 0.12)		0.05 (−0.06, 0.16)		0.05 (−0.05, 0.15)
Depressed x Digestion issues		−0.11 (−0.63, 0.42)		−0.02 (−0.20, 0.15)		−0.02 (−0.13, 0.08)		−0.09 (−0.18, 0.002)
Angry x Digestion issues		−0.03 (−0.68, 0.58)		−0.06 (−0.23, 0.11)		0.05 (−0.07, 0.16)		−0.07 (−0.16, 0.03)
Observations	2,331	2,322	3,733	3,717	8,340	8,317	8,009	7,986
Note:								$^{*}p < .05$

Table 2.5: Predicting health behaviors from neuroticism and emotions by stomach and digestion symptoms (Model 2 and 3)

	Dependent variable:							
	Cigarette Smoking		Alcohol Consumption		Vigorous Exercise		Hours of Sleep	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.47		0.03		0.01		0.02	
	(−1.23, 2.08)		(−0.12, 0.19)		(−0.11, 0.12)		(−0.07, 0.10)	
Dizziness	0.69	0.60	0.51	0.28	0.20	0.22	0.28	0.40*
	(−2.81, 4.14)	(−1.57, 2.74)	(−0.32, 1.34)	(−0.26, 0.84)	(−0.36, 0.70)	(−0.13, 0.54)	(−0.22, 0.79)	(0.07, 0.71)
Neuroticism x Dizziness	−0.18		−0.21		−0.04		−0.10	
	(−1.59, 1.16)		(−0.55, 0.16)		(−0.25, 0.18)		(−0.31, 0.09)	
Nervous		0.69*		0.01		−0.05		−0.06*
		(0.29, 1.10)		(−0.12, 0.13)		(−0.12, 0.02)		(−0.12, −0.01)
Depressed		0.74*		−0.03		0.01		−0.02
		(0.30, 1.14)		(−0.16, 0.10)		(−0.05, 0.08)		(−0.07, 0.04)
Angry		−0.32		0.06		0.07*		0.01
		(−0.70, 0.08)		(−0.06, 0.17)		(0.01, 0.13)		(−0.05, 0.05)
Nervous x Dizziness		−0.34		0.03		−0.004		−0.08
		(−1.42, 0.72)		(−0.32, 0.39)		(−0.20, 0.22)		(−0.25, 0.12)
Depressed x Dizziness		0.07		−0.05		−0.14		−0.06
		(−1.10, 1.14)		(−0.30, 0.21)		(−0.32, 0.05)		(−0.23, 0.10)
Angry x Dizziness		−0.05		−0.12		0.07		−0.09
		(−1.22, 1.12)		(−0.46, 0.22)		(−0.11, 0.24)		(−0.26, 0.08)
Observations	2,327	2,322	3,725	3,716	8,332	8,318	8,003	7,990
Note:								$^{*}p < .05$

Table 2.6: Predicting health behaviors from neuroticism and emotions by chest pain and dizziness (Model 2 and 3)

	Dependent variable:							
	Cigarette Smoking		Alcohol Consumption		Vigorous Exercise		Hours of Sleep	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.63 (−1.39, 2.79)		0.13 (−0.03, 0.28)		−0.01 (−0.17, 0.15)		0.07 (−0.05, 0.20)	
Menstrual symptoms	−0.47 (−2.60, 1.68)	0.68 (−1.08, 2.40)	−0.06 (−0.46, 0.41)	0.07 (−0.26, 0.38)	0.11 (−0.24, 0.46)	0.10 (−0.12, 0.31)	0.15 (−0.21, 0.52)	0.04 (−0.20, 0.30)
Neuroticism x Menstrual symptoms	0.18 (−0.68, 1.03)		0.02 (−0.15, 0.19)		−0.03 (−0.17, 0.10)		−0.05 (−0.19, 0.10)	
Nervous		0.33 (−0.26, 0.91)		−0.001 (−0.11, 0.11)		−0.04 (−0.12, 0.04)		−0.05 (−0.13, 0.05)
Depressed		0.96* (0.33, 1.61)		−0.13 (−0.27, 0.01)		−0.02 (−0.11, 0.07)		−0.02 (−0.10, 0.08)
Angry		−0.38 (−0.94, 0.12)		0.06 (−0.05, 0.17)		0.07 (−0.005, 0.15)		−0.04 (−0.12, 0.04)
Nervous x Menstrual symptoms		0.84 (−0.02, 1.73)		−0.15 (−0.31, 0.04)		−0.01 (−0.13, 0.10)		−0.02 (−0.14, 0.11)
Depressed x Menstrual symptoms		−0.12 (−1.05, 0.86)		−0.03 (−0.22, 0.17)		−0.02 (−0.13, 0.10)		−0.07 (−0.21, 0.07)
Angry x Menstrual symptoms		−0.99* (−1.94, −0.03)		0.10 (−0.08, 0.27)		−0.02 (−0.12, 0.09)		0.08 (−0.06, 0.23)
Observations	844	842	1,196	1,190	2,878	2,871	2,829	2,822

Note: *$p < .05$; only women were included in these analyses

Table 2.7: Predicting health behaviors from neuroticism and emotions by menstrual symptoms (Model 2 and 3)

	Dependent variable:							
	Cigarette Smoking		Alcohol Consumption		Vigorous Exercise		Hours of Sleep	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.39 (−1.68, 2.44)		0.17* (0.02, 0.33)		0.04 (−0.09, 0.17)		0.03 (−0.09, 0.13)	
Hot Flashes	0.03 (−3.62, 3.28)	1.22 (−0.75, 3.18)	0.50 (−0.29, 1.27)	0.11 (−0.48, 0.65)	0.08 (−0.55, 0.68)	0.47* (0.06, 0.86)	0.09 (−0.57, 0.70)	0.17 (−0.23, 0.56)
Neuroticism x Hot Flashes	−0.01 (−1.27, 1.28)		−0.20 (−0.51, 0.11)		0.01 (−0.22, 0.26)		0.004 (−0.25, 0.28)	
Nervous		0.58* (0.14, 1.07)		−0.06 (−0.16, 0.04)		−0.03 (−0.12, 0.04)		−0.08* (−0.15, −0.01)
Depressed		0.87* (0.39, 1.36)		−0.05 (−0.15, 0.05)		0.03 (−0.05, 0.12)		−0.02 (−0.11, 0.05)
Angry		−0.25 (−0.72, 0.23)		0.05 (−0.04, 0.14)		0.06 (−0.01, 0.13)		−0.01 (−0.08, 0.06)
Nervous x Hot Flashes		0.35 (−0.72, 1.41)		−0.20 (−0.46, 0.06)		−0.14 (−0.38, 0.11)		−0.04 (−0.29, 0.18)
Depressed x Hot Flashes		−0.50 (−1.43, 0.47)		−0.07 (−0.33, 0.19)		0.06 (−0.13, 0.25)		−0.13 (−0.33, 0.08)
Angry x Hot Flashes		−0.65 (−1.63, 0.37)		0.17 (−0.08, 0.42)		−0.18 (−0.40, 0.03)		0.13 (−0.12, 0.33)
Observations	1,191	1,187	1,690	1,683	4,316	4,306	4,309	4,300
Note:					$^{*}p < .05$; only women were included in these analyses			

Table 2.8: Predicting health behaviors from neuroticism and emotions by hot flashs and feeling flushed (Model 2 and 3)

	Cigarette Smoking		Alcohol Consumption		Vigorous Exercise		Hours of Sleep	
Dependent variable:	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.46 (−1.27, 2.12)		0.04 (−0.12, 0.19)		0.01 (−0.10, 0.12)		0.02 (−0.07, 0.10)	
Other symptoms	0.13 (−2.42, 2.97)	−2.49* (−4.53, −0.24)	0.12 (−0.65, 0.94)	−0.15 (−0.82, 0.52)	0.35 (−0.14, 0.81)	0.16 (−0.21, 0.49)	0.26 (−0.08, 0.61)	0.07 (−0.23, 0.33)
Neuroticism x Other symptoms	−0.06 (−1.21, 1.08)		−0.06 (−0.41, 0.27)		−0.07 (−0.27, 0.14)		−0.10 (−0.25, 0.06)	
Nervous		0.64* (0.20, 1.08)		0.01 (−0.12, 0.13)		−0.05 (−0.12, 0.01)		−0.08* (−0.14, −0.03)
Depressed		0.76* (0.31, 1.20)		−0.05 (−0.18, 0.08)		0.01 (−0.06, 0.07)		−0.02 (−0.08, 0.04)
Angry		−0.30 (−0.73, 0.05)		0.06 (−0.05, 0.17)		0.07* (0.02, 0.13)		0.01 (−0.04, 0.06)
Nervous x Other symptoms		1.30* (0.11, 2.57)		−0.01 (−0.40, 0.40)		−0.02 (−0.22, 0.17)		0.07 (−0.10, 0.24)
Depressed x Other symptoms		0.31 (−0.85, 1.50)		0.42* (0.08, 0.79)		−0.02 (−0.22, 0.18)		−0.01 (−0.17, 0.15)
Angry x Other symptoms		−0.01 (−1.26, 1.20)		−0.28 (−0.64, 0.04)		0.07 (−0.13, 0.28)		−0.05 (−0.20, 0.11)
Observations	2,326	2,322	3,719	3,715	8,326	8,318	7,997	7,989

Note: $^{*}p < .05$

Table 2.9: Predicting health behaviors from neuroticism and emotions by other symptoms (Model 2 and 3)

	Dependent variable:							
	Cigarette Smoking		Alcohol Consumption		Vigorous Exercise		Hours of Sleep	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.52 (−0.99, 2.28)		0.04 (−0.11, 0.20)		0.01 (−0.09, 0.12)		0.02 (−0.07, 0.10)	
All symptoms	0.94 (−3.04, 4.94)	1.12 (−1.22, 3.31)	0.25 (−0.64, 1.20)	0.20 (−0.51, 0.88)	0.07 (−0.52, 0.64)	0.56* (0.15, 0.94)	0.18 (−0.29, 0.66)	0.42* (0.09, 0.75)
Neuroticism x All symptoms	−0.03 (−1.61, 1.51)		−0.20 (−0.60, 0.19)		0.13 (−0.11, 0.38)		−0.08 (−0.28, 0.12)	
Nervous		0.66* (0.18, 1.07)		0.02 (−0.10, 0.15)		−0.05 (−0.12, 0.01)		−0.06* (−0.12, −0.01)
Depressed		0.77* (0.35, 1.22)		−0.01 (−0.16, 0.12)		0.01 (−0.06, 0.08)		0.005 (−0.05, 0.06)
Angry		−0.25 (−0.65, 0.11)		0.07 (−0.05, 0.18)		0.05 (−0.01, 0.12)		0.01 (−0.05, 0.06)
Nervous x All symptoms		0.01 (−1.26, 1.25)		−0.27 (−0.71, 0.16)		0.06 (−0.18, 0.30)		−0.01 (−0.22, 0.20)
Depressed x All symptoms		0.12 (−0.96, 1.21)		−0.03 (−0.40, 0.32)		−0.22* (−0.43, −0.01)		−0.27* (−0.44, −0.09)
Angry x All symptoms		−0.64 (−1.88, 0.71)		0.05 (−0.34, 0.41)		0.02 (−0.22, 0.26)		−0.01 (−0.21, 0.18)
Observations	2,331	2,322	3,733	3,717	8,342	8,319	8,014	7,991

Note: $^{*}p < .05$; symptom items were averaged to create a single physical symptom measure.

Table 2.10: Predicting health behaviors from neuroticism and emotions by all symptoms (Model 2 and 3)

Overall, models 1-3 are largely consistent. Neuroticism does not appear to be a predictor of health behaviors. This is inconsistent with the general belief that neuroticism is predictive of poor health in part because individuals high in neuroticism are more likely to engage in riskier behaviors. Moreover, health symptoms did not interact with neuroticism to predict health behaviors. There is little support here that individuals high in neuroticism may act differently when in different situations. In other words, they do not appear to behave more or less healthy when experiencing symptoms of potential health problems. Finally, there is little evidence that situation interacts with emotion to predict behavior. Some models yielded results, with a total of five coefficients reaching statistical significance. It should be noted too that in four out of the five significant interactions, emotion predicted engaging in more unhealthy behaviors (e.g., nervousness predicted more smoking) when health symptoms were high and that four of the five interactions involved depression. In other words, there is evidence that different negative emotions do differentially predict behavior, and depression – not anxiety or nervousness – appears to be the culprit when it comes to predicting unhealthy behavior. However, the probability of finding five or more significant coefficients with an error rate of .05 is 34.80%, and so these significant interactions are more likely due to chance than to any true, systematic effect of situation and emotion.

Models 1-3 did not support a pattern of neuroticism predicting behavior, even when neuroticism interacted with situation or was broken down into its state-level parts. This was expected. As I have proposed, neuroticism as a trait is not a predictor of behavior, nor can a simple interaction with situation explain the variability in health behaviors. Similarly, examining emotion devoid of the context of traits also fails to capture the individual differences which influence behavior continuously over time, compounding and accentuating differences in health. Instead, I believe we must model a more complex chain. Neuroticism should predict emotions in response to situations. When there is a threat, neuroticism should predict anxiety; otherwise, neuroticism should predict depression. These emotions in turn predict behaviors. The integration of these components should allow us to examine the dependent nature of emotion and behavior on situation, as well as determine the extent to which the effects of neuroticism on health are due to negative emotions.

2.2.3 Model 4: The integration of neuroticism, situation and emotion to predict behavior

Finally, the proposed model (shown previously in Figure 1.3) was tested. For each physical symptom, the interaction of neuroticism and that daily symptom was used to predict daily emotion. A separate model was constructed to predict daily behavior. The residuals of the model used to predict emotion were then used to predict the residuals of the behavior model. As before, bootstrapping with 1,000 samples was employed to estimate the coefficients of these models and their confidence intervals.

In addition to estimating pathways in this model, the direct and indirect effects of neuroticism, symptom and their interaction were also estimated. For these estimates, a second bootstrapping procedure was used. First, the model with neuroticism and symptom interacting to predict behavior was run. These pathways were extracted as 'total effects.' Then, using the same sampled data set, a second model was estimated. This model was the same as the first (with neuroticism, symptom and their interaction as predictors) but with the addition of the three emotion variables as predictors. The pathways for neuroticism, symptom and their interaction was extracted from this model as the 'direct effects.' To estimate indirect effects, direct effects were subtracted from total effects. This bootstrapping procedure was run with 1,000 iterations. Median values for direct, total and indirect effects were used as final estimates, and the percentile method was used to extract confidence intervals. All models control for gender, age and self-rated health. The full results of this procedure are displayed in Appendix B. Because the symptoms were within-person centered, the effects of neuroticism were relatively stable across the models. For example, in the models containing head and backaches, neuroticism had a significant indirect effect on smoking ($est = 0.21$ [0.10, 0.34]) and a significant direct effect on smoking ($est = 0.37$ [0.02, 0.72]). These estimates were consistent across the models, with variations at the hundredth of a point. Neuroticism had a small direct effect on alcohol consumption in the models with women only, i.e., with menstrual symptoms ($est = 0.15$ [0.06, 0.25]) and hot flashes ($est = 0.18$ [0.10, 0.26]), but this may have been due to the restricted sample. Neuroticism had no direct or indirect effect on exercise. Neuroticism had an inconsistent indirect effect on sleep. This effect was only seen in models for dizziness, hot flashes, and other symptoms, and was very small ($est = -0.02$ [−0.03, 0.00]).

The results for the model using headaches and backaches is shown in Table 2.11. The rows for neuroticism, situation and their interaction include the coefficients from these predictors *to the emotions*. The rows for the behaviors include the coefficients *from the emotions* to these behaviors. As you can see, at a person's average levels of aches, neuroticism significantly predicted feeling greater levels of nervousness ($B = 0.18$ [0.16, 0.21]), depression ($B = 0.18$ [0.15, 0.21]), and anger ($B = 0.18$ [0.15, 0.21]). The interaction between neuroticism and aches was significant, such that as participants reported greater aches, the relationship between neuroticism and the emotions became stronger. The first half of the theoretical model is supported by these findings: individuals high in neuroticism respond more strongly to a negative situation (i.e., feeling aches) by experiencing more nervousness ($B = 0.03$ [0.00, 0.05]), depression ($B = 0.05$ [0.02, 0.07]) and anger ($B = 0.04$ [0.01, 0.06]). The next question is whether, as a result of these emotions, individuals high in neuroticism then act healthier. Consistent with the hypothesis, greater anger predicted greater levels of exercise ($B = 0.06$ [0.00, 0.122]). Counter to this hypothesis, as nervousness increased, so did cigarette smoking ($B = 0.69$ [0.29, 1.09]). Cigarette smoking also increased as depression increased ($B = 0.72$ [0.31, 1.10]).

This pattern of results was largely stable across all symptoms. Cold and flu symptoms strengthened the relationship between neuroticism and nervousness ($B = 0.04$ [0.01, 0.08])

Coef	Nervous	*Emotions as outcomes* Depressed	Angry
Neur	0.184 [0.156, 0.211]*	0.182 [0.154, 0.212]*	0.183 [0.153, 0.210]*
Ache	-0.017 [-0.073, 0.040]	-0.041 [-0.100, 0.018]	-0.015 [-0.072, 0.040]
Ache x Neur	0.028 [0.003, 0.052]*	0.048 [0.024, 0.072]*	0.037 [0.013, 0.061]*
	Nervous	*Emotions as predictors* Depressed	Angry
Cigarettes	0.690 [0.292, 1.089]*	0.719 [0.308, 1.097]*	-0.300 [-0.700, 0.110]
Drinks	0.026 [-0.093, 0.154]	-0.071 [-0.232, 0.095]	0.087 [-0.024, 0.197]
Sleep	-0.058 [-0.118, 0.006]	-0.026 [-0.121, 0.070]	-0.005 [-0.065, 0.050]
Vigorous Exercise	-0.056 [-0.121, 0.009]	0.003 [-0.066, 0.069]	0.061 [0.003, 0.122]*

$^{*}p < .05$

Table 2.11: Predicting emotions and behaviors from neuroticism and ache symptoms (Model 4)

and anger ($B = 0.04$ $[0.00, 0.07]$; see Table 2.12 for a full summary of this model). Again, the increase in negative emotions lead to an increase in negative health behaviors: more smoking was associated with greater nervousness ($B = 0.71$ $[0.30, 1.13]$) and greater depression ($B = 0.72$ $[0.31, 1.16]$). Greater anger was associated with more exercise ($B = 0.08$ $[0.01, 0.14]$).

Coef	Nervous	*Emotions as outcomes* Depressed	Angry
Neur	0.183 [0.156, 0.209]*	0.182 [0.154, 0.21]*	0.182 [0.155, 0.207]*
Cold and flu	-0.063 [-0.14, 0.019]	0.029 [-0.046, 0.107]	-0.034 [-0.114, 0.045]
Cold and flu x Neur	0.043 [0.008, 0.076]*	0.013 [-0.021, 0.044]	0.035 [0.005, 0.069]*
	Nervous	*Emotions as predictors* Depressed	Angry
Cigarettes	0.706 [0.297, 1.126]*	0.718 [0.311, 1.162]*	-0.284 [-0.645, 0.092]
Drinks	0.031 [-0.092, 0.160]	-0.073 [-0.234, 0.099]	0.083 [-0.035, 0.194]
Sleep	-0.055 [-0.126, 0.009]	-0.029 [-0.118, 0.064]	-0.003 [-0.06, 0.057]
Vigorous Exercise	-0.053 [-0.122, 0.015]	0.018 [-0.051, 0.083]	0.075 [0.012, 0.136]*

$^{*}p < .05$

Table 2.12: Predicting emotions and behaviors from neuroticism and cold and flu symptomps (Model 4)

Digestive issues (shown in Table 2.13) strengthened the relationship between neuroticism and nervousness ($B = 0.11$ $[0.06, 0.16]$) and anger ($B = 0.10$ $[0.04, 0.15]$). The resulting depression and anger again affected smoking and exercise, respectively: greater depressed was associated with more smoking ($B = 2.68$ $[0.95, 4.28]$) and greater anger was associated with more exercise ($B = 0.07$ $[.01, 0.14]$).

Coef	Nervous	*Emotions as outcomes* Depressed	Angry
Neur	0.179 [0.152, 0.207]∗	0.178 [0.152, 0.203]∗	0.178 [0.150, 0.203]∗
Digestive issues	-0.192 [-0.322, -0.065]∗	0.056 [-0.080, 0.191]	-0.128 [-0.264, 0.004]
Digestive issues x Neur	0.114 [0.064, 0.163]∗	0.030 [-0.023, 0.080]	0.095 [0.045, 0.148]∗
	Nervous	*Emotions as predictors* Depressed	Angry
Cigarettes	-0.077 [-0.928, 0.861]	2.679 [0.953, 4.276]∗	-0.331 [-1.161, 0.451]
Drinks	0.030 [-0.100, 0.160]	-0.068 [-0.223, 0.089]	0.086 [-0.033, 0.202]
Sleep	-0.060 [-0.127, 0.005]	-0.019 [-0.115, 0.07]	-0.004 [-0.062, 0.047]
Vigorous Exercise	-0.057 [-0.123, 0.011]	0.021 [-0.048, 0.084]	0.072 [0.007, 0.138]∗

$^{*}p < .05$

Table 2.13: Predicting emotions and behaviors from neuroticism and stomach and digestion symptoms (Model 4)

The interaction between dizziness and neuroticism was only predictive of anger: again, dizziness strengthened the association between the two ($B = 0.10$ $[0.01, 0.18]$). Increases in nervousness lead to greater smoking ($B = 0.69$ $[0.28, 1.11]$) and less sleep ($B = -0.08$ $[-0.13, -0.02]$); increases in depression lead to more smoking ($B = 0.75$ $[0.33, 1.16]$). Greater anger predicted more exercise ($B = 0.07$ $[0.01, 0.14]$). See Table 2.14 for full results.

Menstrual symptoms (shown in Table 2.15) strengthened the relationship between neuroticism and nervousness ($B = 0.08$ $[0.02, 0.14]$) and anger ($B = 0.08$ $[0.01, 0.14]$). In this model, only depression was predictive of smoking ($B = 0.75$ $[0.33, 1.16]$).

Hot flashes interacted with neuroticism to predict all three emotions (see Table 2.16). Specifically, increases in hot flashes strengthened the relationship between neuroticism and nervousness ($B = 0.13$ $[0.03, 0.23]$), depression ($B = 0.19$ $[0.09, 0.30]$), and anger ($B = 0.23$

Coef		*Emotions as outcomes*	
	Nervous	Depressed	Angry
Neur	0.177 [0.150, 0.205]*	0.177 [0.149, 0.202]*	0.177 [0.149, 0.205]*
Dizziness	0.006 [-0.210, 0.245]	0.122 [-0.083, 0.338]	-0.123 [-0.341, 0.089]
Dizziness x Neur	0.064 [-0.024, 0.143]	0.000 [-0.082, 0.082]	0.097 [0.014, 0.183]*
		Emotions as predictors	
	Nervous	Depressed	Angry
Cigarettes	0.687 [0.280, 1.114]*	0.747 [0.326, 1.162]*	-0.298 [-0.670, 0.093]
Drinks	0.029 [-0.088, 0.160]	-0.074 [-0.235, 0.095]	0.080 [-0.038, 0.199]
Sleep	-0.077 [-0.131, -0.022]*	-0.019 [-0.069, 0.039]	0.010 [-0.037, 0.057]
Vigorous Exercise	-0.056 [-0.119, 0.012]	0.017 [-0.053, 0.078]	0.074 [0.010, 0.140]*

$^{*}p < .05$

Table 2.14: Predicting emotions and behaviors from neuroticism and dizziness symptoms (Model 4)

Coef		*Emotions as outcomes*	
	Nervous	Depressed	Angry
Neur	0.214 [0.169, 0.262]*	0.242 [0.195, 0.289]*	0.238 [0.189, 0.286]*
Menstrual	-0.164 [-0.313, -0.003]*	0.037 [-0.137, 0.196]	-0.135 [-0.294, 0.017]
Menstrual x Neur	0.079 [0.020, 0.141]*	0.003 [-0.059, 0.066]	0.08 [0.014, 0.138]*
		Emotions as predictors	
	Nervous	Depressed	Angry
Cigarettes	1.169 [-1.367, 3.43]	1.771 [0.741, 2.827]*	-1.437 [-2.401, -0.472]*
Drinks	-0.023 [-0.142, 0.091]	-0.130 [-0.264, 0.008]	0.051 [-0.064, 0.152]
Sleep	-0.026 [-0.128, 0.076]	-0.065 [-0.195, 0.074]	-0.084 [-0.18, 0.008]
Vigorous Exercise	-0.041 [-0.132, 0.047]	-0.021 [-0.113, 0.07]	0.071 [-0.008, 0.150]

$^{*}p < .05$; Only women were included in these analyses. Menstrual = menstrual symptoms

Table 2.15: Predicting emotions and behaviors from neuroticism and menstural symptoms (Model 4)

$[0.12, 0.34]$). Similar to previous models, increases in nervousness lead to greater smoking ($B = 0.59$ $[0.09, 1.05]$) and less sleep ($B = -0.09$ $[-0.17, -0.01]$); increases in depression lead to more smoking ($B = 0.82$ $[0.35, 1.33]$). Hot flashes had an indirect effect on reducing smoking ($est = -0.71$ $[-1.74, -0.12]$). The interaction of neuroticism and hot flashes had an indirect effect on increasing smoking ($est = 0.32$ $[0.06, 0.72]$).

		Emotions as outcomes	
Coef	Nervous	Depressed	Angry
Neur	0.211 [0.171, 0.250]*	0.223 [0.187, 0.259]*	0.206 [0.170, 0.242]*
Hot Flashes	-0.250 [-0.503, 0.024]	-0.363 [-0.623, -0.106]*	-0.419 [-0.671, -0.147]*
Hot Flashes x Neur	0.131 [0.026, 0.234]*	0.192 [0.09, 0.3]*	0.234 [0.124, 0.336]*
		Emotions as predictors	
	Nervous	Depressed	Angry
Cigarettes	0.588 [0.089, 1.054]*	0.825 [0.346, 1.33]*	-0.271 [-0.733, 0.181]
Drinks	-0.070 [-0.165, 0.022]	-0.061 [-0.161, 0.043]	0.052 [-0.032, 0.138]
Sleep	-0.089 [-0.172, -0.008]*	-0.040 [-0.158, 0.078]	-0.046 [-0.126, 0.031]
Vigorous Exercise	-0.031 [-0.109, 0.041]	0.025 [-0.057, 0.104]	0.060 [-0.014, 0.137]

$^*p < .05$; Only women were included in these analyses.

Table 2.16: Predicting emotions and behaviors from neuroticism and hot flash symptoms (Model 4)

The interaction between neuroticism and other symptoms was predictive of all emotions, such that other symptoms strengthened the relationship between neuroticism and nervousness ($B = 0.10$ $[0.03, 0.16]$), depression ($B = 0.08$ $[0.00, 0.14]$), and anger ($B = 0.10$ $[0.03, 0.16]$). Once again, greater nervousness predicted more smoking ($B = 0.70$ $[0.31, 1.10]$). Greater depression predicted more smoking ($B = 0.74$ $[0.31, 1.13]$). Greater anger predicted more exercise ($B = 0.07$ $[0.01, 0.14]$). For full results, see Table 2.17. The interaction of neuroticism and other symptoms had an indirect effect on increasing smoking ($est = 0.21$ $[0.02, 0.42]$).

Finally, the composite of all symptoms interacted with neuroticism to predict all emotions (Table 2.18). Again, as hypothesized, experiencing greater symptoms strengthened the relationship between neuroticism and nervousness ($B = 0.21$ $[0.12, 0.30]$),

Coef	Nervous	*Emotions as outcomes* Depressed	Angry
Neur	0.184 [0.156, 0.212]∗	0.183 [0.153, 0.209]∗	0.186 [0.157, 0.213]∗
Other Symptoms	-0.094 [-0.249, 0.079]	-0.083 [-0.252, 0.09]	-0.110 [-0.278, 0.048]
Other Symptoms x Neur	0.099 [0.028, 0.165]∗	0.076 [0.003, 0.145]∗	0.096 [0.031, 0.165]∗
	Nervous	*Emotions as predictors* Depressed	Angry
Cigarettes	0.696 [0.307, 1.105]∗	0.742 [0.306, 1.130]∗	-0.276 [-0.674, 0.085]
Drinks	0.038 [-0.097, 0.163]	-0.071 [-0.232, 0.084]	0.07 [-0.044, 0.192]
Sleep	-0.061 [-0.127, 0.003]	-0.019 [-0.114, 0.07]	-0.006 [-0.066, 0.049]
Vigorous Exercise	-0.057 [-0.120, 0.011]	0.014 [-0.058, 0.082]	0.072 [0.013, 0.135]∗

$^{*}p < .05$

Table 2.17: Predicting emotions and behaviors from neuroticism and other symptoms (Model 4)

depression ($B = 0.11$ $[0.03, 0.20]$), and anger ($B = 0.26$ $[0.18, 0.34]$). Again, counter to the hypotheses, smoking was positively associated with increases in nervousness ($B = 0.68$ $[0.28, 1.08]$) and depression ($B = 0.71$ $[0.32, 1.13]$). Nervousness predicted less exercise ($B = -0.06$ $[-0.13, 0.30]$).

Coef	Nervous	*Emotions as outcomes* Depressed	Angry
Neur	0.182 [0.154, 0.210]∗	0.183 [0.155, 0.212]∗	0.181 [0.155, 0.209]∗
All Symptoms	-0.235 [-0.45, -0.031]∗	0.085 [-0.115, 0.298]	-0.311 [-0.504, -0.105]∗
All Symptoms x Neur	0.21 [0.120, 0.302]∗	0.114 [0.029, 0.202]∗	0.258 [0.176, 0.342]∗
	Nervous	*Emotions as predictors* Depressed	Angry
Cigarettes	0.680 [0.275, 1.085]∗	0.714 [0.32, 1.126]∗	-0.314 [-0.68, 0.086]
Drinks	0.033 [-0.100, 0.171]	-0.075 [-0.234, 0.09]	0.09 [-0.028, 0.203]
Sleep	-0.059 [-0.129, 0.004]	-0.025 [-0.128, 0.073]	-0.007 [-0.066, 0.054]
Vigorous Exercise	-0.062 [-0.126, -0.001]∗	-0.003 [-0.069, 0.062]	0.06 [-0.001, 0.118]

$^{*}p < .05$

Table 2.18: Predicting emotions and behaviors from neuroticism and all symptoms (Model 4)

The results of model 4 using the all symptoms composite is shown in Figure 2.6. Only significant pathways are shown. As you can see, neuroticism predicted greater anxiety, depression and nervousness. These pathways are significantly moderated by situation. However, only nervousness and depression predict smoking, in the direction of more unhealthy behavior, and no emotion predicts any of the other behaviors. As a reminder, the pathways from neuroticism, situation and their interaction are estimated in model 2. Neuroticism did not predict any of the behaviors, nor did the interaction of all symptoms with neuroticism.

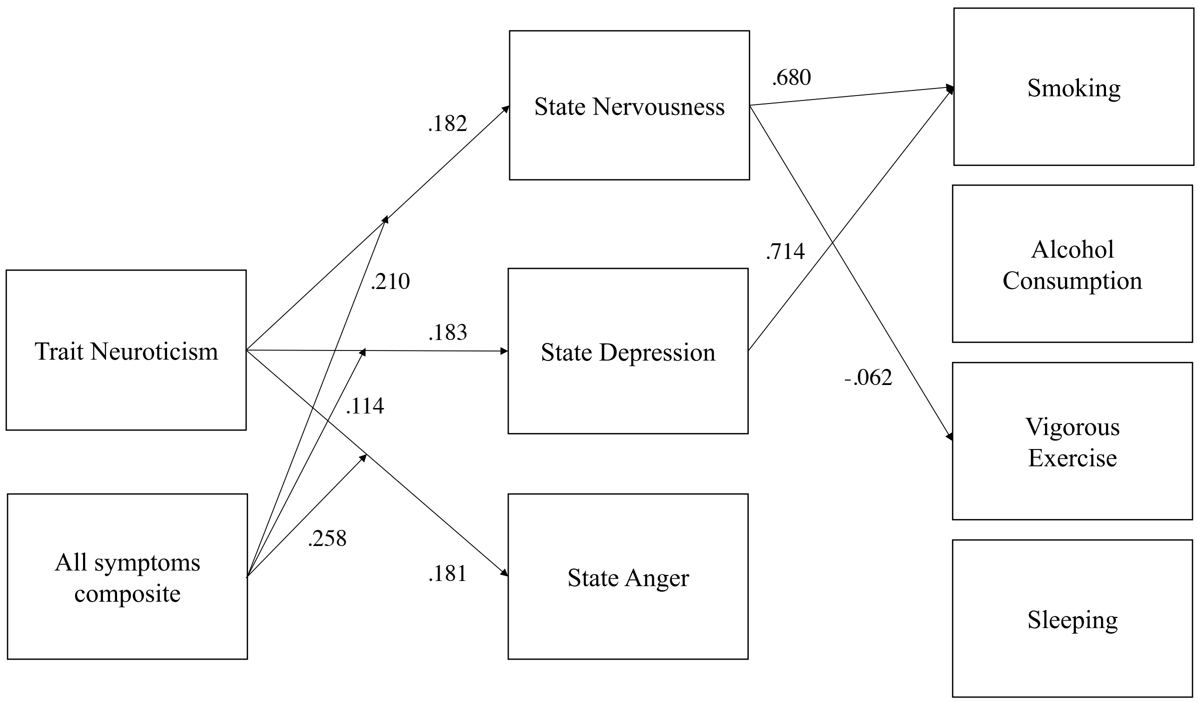


Figure 2.6: The results of model 4 using all symptoms as the situation.

Overall, the first half of the model was confirmed. In all cases, neuroticism predicted greater nervousness, depression and anger when individuals experienced average levels of symptoms. Increased symptoms tended to strengthen the relationship between neuroticism and emotion. However, the second half of the model – the relationship from those increased emotions to behavior – was not as hypothesized. Specifically, increases in anxiety, depression and anger tended to lead to increases in smoking, not decreases. In some cases, greater nervousness lead to less sleep. To conclude, while the hypothesized pathways from neuroticism and situation to emotion were supported, the link between emotion and behavior was not. It does not appear that this model accounts for different effects of neuroticism on health behaviors, nor does it explain the pathways through which neuroticism may influence health.

However, it is possible this model accounts for the effects of neuroticism in other domains. What follows is a test of all four models, with a focus on model 4, in the educational domain. It is possible that the effects of neuroticism and emotion on educational behaviors may differ, for several reasons. First, adults have fairly well-established health behaviors, whereas students, especially first-semester freshmen, may be more focused on changing behaviors. Second, it is likely that not all adults value their health or make their health a major goal. Students at a prestigious university almost uniformly value success in educational settings, as this is one of the criteria by which they are admitted to the school. For these reasons, we may find that the effects of neuroticism and emotion on educational behaviors, such as studying or skipping class, may be larger and therefore easier to detect.

3. Study 2: Academic Behaviors

3.1 Study 2 Methods

3.1.1 Participants

Participants were freshman students taking a seminar in psychology either in 2015 or 2016. As part of this course, students completed a weekly survey which included questions about their recent emotions, academic behaviors and performance in the classroom. Students were asked if their data could be used for research puposes. Of the 296 students in the course, 222 provided consent and completed the personality questionnaire. These 222 students are included in these analyses. These students completed between 6 and 14 weekly reports, for a total of 2,870 reports.

3.1.2 Measures

Neuroticism

Approximately mid-way through the semester, students completed the NEO-FFI (Costa Jr. and McCrae, 1992), a 60-item measure of personality. This included 12 items assessing neuroticism including items like "I feel inferior to others," and "I rarely feel lonely or blue." Students rated these items on a scale from 1 (*Strongly disagree*) to 5 (*Strongly Agree*). Responses were averaged to create a single trait scale for each participant ($M = 3.04$, $SD = 0.70$). This scale showed good reliability in this sample ($\alpha = 0.86$).

Neuroticism was grand-mean centered for the analyses, allowing for easier interpretation of results.

Situation: Academic feedback

Each week, students were asked to think about the most significant exam or assignment they had received back (i.e., for which they had found out the grade they had received) that week. There were a total of 1,158 of grades received. *Whether or not a student received feedback* is one way that situations will be operationalized. Students were asked to report what kind of assignment was returned. Students reported that 29.58 % of the grades were on midterm exams, 10.28 % of the grades were on essays, 2.54 % were on quizzes, and 2.16 % were on assignments, such as lab reports and homeworks. The rest were unreported.

Students were asked to report *the grade they received*, which is the second way that siutations will be operationalized. Some students provided a letter grade, some provided a percentage and some provided a fraction of the number of points the received over the total. The numeric grade was transformed to be the percentage correct multipled by 100. Both the letter grade and the numeric grade will be used in the analyses. In addition, some students provided details regrading curving grades, when relevant. Finally, students were asked to report how they *felt about their grade* on a scale from 1 (*very negative*) to 5 (*very positive*; $M = 3.39$, $SD = 1.52$). This will be the third way situations will be operaionalized.

To measure these grades on the same scale, each student was assigned both a numeric grade and a letter grade. If they did not directly report a numeric grade, they were assigned the value of the smallest percentage needed to receive that grade. For example, if a student reported receiving a B on an assignment, they were assigned the numeric grade 83. (Figure 3.2 shows the distribution of these grades.) If a student reported receiving an F, they were given a 50%, so as not to skew the distribution of grades unnecessarily. If a

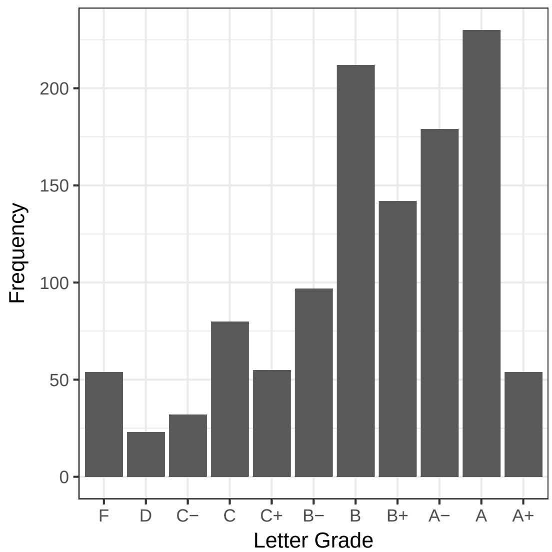


Figure 3.1: Distribution of letter grades

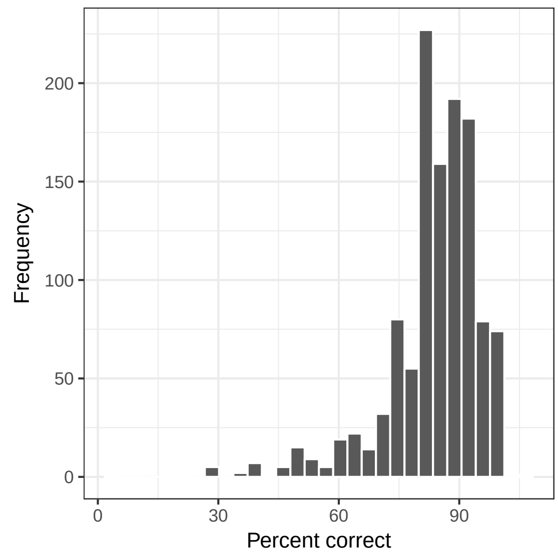


Figure 3.2: Distribution of numeric grades

student indicated that the grade was curved and provided both their percentage and their letter grade, the letter grade was used to assign their numeric grade. For example, if a student reported that they received 66% on an exam, but after the curve was awarded a C+, their numeric grade was assigned as 77%.

Some students ($n = 117$) either reported no grade or reported that they were uncomfortable providing their grade. The latter students are of great value to the study, as the goal is to examine behavior after receiving a poor grade. Instead of removing these reports, grades for these students were estimated by taking the average numeric grade reported for students receiving feedback on the same assignment (e.g. exam or paper) and feeling the same way about their grade (i.e., 1-5). Appendix C includes specific details on the values assigned as numeric and letter grades in various situations.

The given numeric grade variable was centered at 85 for ease of interpreation. This value was chosen to represent an "average" grade in the sense of what average performance in a class might be. (This is instead of choosing the average of the sample, which is likely very high, or within-person centering, which would remove the natural comparison students make between their grade and benchmarks of success set by themselves, their parents,

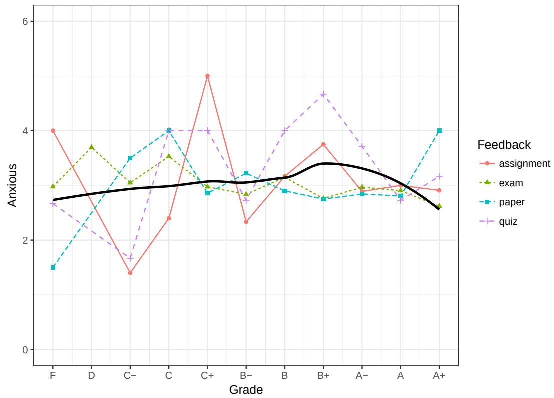


Figure 3.3: Relationship between numeric grade and anxiety

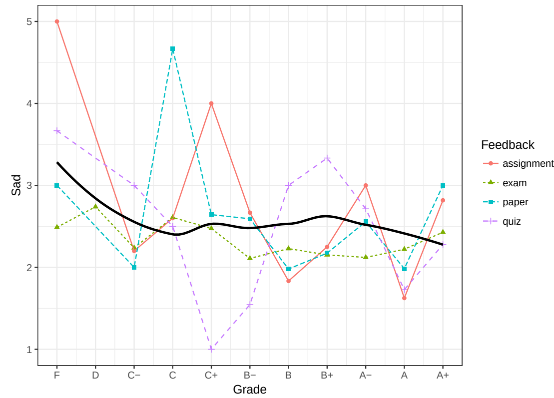


Figure 3.4: Relationship between numeric grade and sadness

professors and friends.) Simple two-level hierarchical models (week nested within student) were run to examine the relationship between letter grade and emotion, with no covariates. These models demonstrated evidence of both linear and quadratic effects (see Figures 3.3 and 3.4). Quadratic effects of number grade were tested in all the models; however, the coefficient estimates for the squared terms and their interactions were too small[1] and so were excluded from this thesis for brevity.

Emotion

Each week, students completed a survey which included questions about their moods and activities of the past week. For these analyses, two items assessing emotion will be used. The first item asked students to indicate how much of the time in the past week they had felt *anxious* on a scale from 0 (*Not at all*) to 6 (*Very much*; $M = 2.97$, $SD = 1.69$). The second item asked students to indicate how much of the time they had felt *sad*, on the same scale ($M = 2.34$, $SD = 1.56$). There were no items that assessed anger in this data set. Emotions will be grand-mean centered for the analyses described here.

[1] Less than .005

Behavior: Academic behaviors

Each week, students were asked about the extent to which they engaged in a number of academic behaviors. Students reported the average number of hours each day they spent *studying* for class (including reading assigments, homework, preparing for exams, writing papers, and working on course-related projects; $M = 3.98$, $SD = 2.23$) . Students also reported the number of hours they spent on *social media* ($M = 1.88$, $SD = 1.30$). Students reported how many times in the past week they *skipped a class* ($M = 0.73$, $SD = 1.25$) and the number of times they *visited a professor* outside of class ($M = 0.46$, $SD = 0.81$).

Prediction time frames

The use of academic behaviors in conjuction with feedback on academic work provided some unique challenges. First, the use of weeks as the time frame makes it difficult to assess causality. Are students studying because they are sad or, as a friend interpreted my results, are they sad because they are studying? While true causality cannot be established with these data, problems of concurrency can be eliminated by using emotion and feedback in one week to predict behavior in the next. This was done in the majority of the analyses.

Second, students are expected to change their behavior partly in response to feedback (otherwise, this study would not exist), but these changes may only be seen in certain circumstances. More specifically, I expect students who receive poor grades to study more *but only as they approach another exam or assignment*. Consequently, when analyzing the relationship between specific feedback (i.e., letter grade, numeric grade or perception of grade) and hours of studying, I predicted studying behavior not in the following week, but in the next week in which a student had an assignment, exam or paper. This does limit power - it is likely that some students will have one fewer time point available for analyses - but provides a more realistic test of the hypotheses.

3.1.3 Analyses

Prediction of emotion

A three-level hierarchical linear modeling will be used to test the theoretical model. Level one will be the prediction of a rating from the emotion category (see Equation 3.1). One dummy code will be incorporated to indicate which emotion is the outcome. This coefficients will represent the average differences in ratings of nervousness (anxiety), and sadness. Next, emotion will be nested within weeks (Level 2). At this level, the emotion coefficients will be predicted by the academic feedback variable. Only the intercept (i.e., the mean rating of anxiety) will be allowed to vary across days (see Equation 3.2). Academic feedback will be examined in two different ways. First, a binary variable representing whether the student received feedback at all will be used to predict emotion. Second, the continuous numeric variable of the percentage of points their earned on the assignment (obtained from the direct report when possible or from the minimum grade needed if the letter grade was reported). The effects of these two variables will be modeled separately. Weeks will be nested within person (Level 3). At this level, neuroticism will be used to predict all coefficients: intercepts, mean levels of anxiety, the difference between anxiety and sadness and the interaction between each of the emotions and feedback. All coefficients will be allowed to vary at this level (see Equation 3.5).

Level 1: Emotion level

$$Rating_{ijk} = \pi_{0jk} + \pi_{1jk}(IsSad_{ijk}) + e_{ijk} \tag{3.1}$$

Level 2: Week level

$$\pi_{0jk} = \beta_{00k} + \beta_{01k}(AcademicFeedback_{jk}) + r_{0jk}$$
$$\pi_{1jk} = \beta_{10k} + \beta_{11k}(AcademicFeedback_{jk})$$

(3.2)

Level 3: Person level

$$\beta_{00k} = \gamma_{000} + \gamma_{001}(Neuroticism_k) + \mu_{00k}$$
$$\beta_{01k} = \gamma_{010} + \gamma_{011}(Neuroticism_k) + \mu_{01k}$$
$$\beta_{10k} = \gamma_{100} + \gamma_{101}(Neuroticism_k)$$
$$\beta_{11k} = \gamma_{110} + \gamma_{111}(Neuroticism_k)$$

(3.3)

This model will be run twice, once with each of the emotions as the reference group, to estimate the pathways from neuroticism and situation to each of the emotions.

Additional models will be run predicting each of the four academic behaviors. These will be two-level models, with week nested within participant. An example of the hours spent studying model is described below.

Level 1: Week level

$$Studying_{jk} = \beta_{0k} + \beta_{1k}(AcademicFeedback_{jk}) + r_{jk}$$

(3.4)

Level 2: Person level

$$\beta_{0k} = \gamma_{000} + \gamma_{001}(Neuroticism_k) + \mu_{0k}$$
$$\beta_{1k} = \gamma_{100} + \gamma_{101}(Neuroticism_k) + \mu_{1k}$$
(3.5)

The same procedure described in Study 1 will be used here to estimate the paths from emotion to academic behavior. Using the models to predict emotion and behavior, predicted scores for each person will be calculated using the fixed effects coefficients of these models. These predictions will be subtracted from observed scores to generate residuals, which will be used in the model predicting behavior from emotion. In other words, the residuals of the emotion variables will constitute the independent variables and the residuals of behavior will be the dependent variables. This model is described in equations 2.12 and 2.13.

Level 1: Week Level

$$Behavior_{ij} = \beta_{0j} + \beta_{1j}(Anxious_{ij}) + \beta_{2j}(Sad_{ij}) + e_{ij}$$
(3.6)

Level 2: Person Level

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$
$$\beta_{1j} = \gamma_{10} + \mu_{1j}$$
$$\beta_{2j} = \gamma_{20} + \mu_{2j}$$
(3.7)

This entire model estimate procedure will be used to estimate the models with each of the situations or academic feedback variables (whether or not feedback was received and the numeric grade) leading to each of the academic behaviors (hours studying, on social media, times visited the professor and times skipped class) through the emotions, resulting in a total of 8 models.

3.1.4 Hypotheses

It is hypothesized that individuals high in neuroticism will experience higher levels of each emotion overall. That is, the mean level of anxiety and sadness should increase as participants increase in trait neuroticism. Receiving feedback and receiving poorer grades are both expected to increase experiences of anxiety and decrease experiences of sadness. Finally, greater anxiety in the face of feedback is hypothesized to increase participation in adaptive behaviors (studying and visiting the professor) and decrease participation in maladaptive behaviors (using social media and skipping class). Greater levels of sadness are hypothesized to have the opposite effect on academic behaviors.

3.2 Study 2 Results

As in Study 1, correlations were calculated using different values based on the variable type. For correlations between two person-level variables and correlations between two week-level variables, the raw scores were used, with pairwise deletion. For correlations between one person-level variable and one week-level variable, the correlation was between the raw person-level score and the student's average of the week-level variable. All correlations can be found in Table 3.1.

Neuroticism was positively associated with feeling more anxious ($r = 0.58$) and feeling more sad ($r = 0.59$). Neuroticism was associated with receiving worse grades (measured by percent correct; $r = -0.09$) and feeling worse about grades ($r = -0.13$). This was despite the positive association between neuroticism and studying more hours ($r = 0.08$) and possibly related to the associations between neuroticism and spending more time on social media ($r = 0.12$), skipping class more often ($r = 0.08$) and visiting professors outside of class less often ($r = -0.14$).

Feeling anxious was associated with feeling worse about grades ($r = -0.08$) but not receiving worse grades ($r = -0.05$). Anxiety in one week was associated with studying more the following week ($r = 0.07$) but not with hours on social media ($r = 0.03$), skipping class ($r = -0.01$) or visiting the professor ($r = 0.03$).

Feeling sad was associated with receiving a poor grade ($r = -0.08$) and feeling poorly about grades ($r = -0.11$). Feeling sad one week was associated with spending more time on social media ($r = 0.05$) and skipping class ($r = 0.06$) the following week but was unrelated to positive academic behaviors, studying ($r = 0.02$) and speaking to professors ($r = -0.02$).

	1	2	3	4	5	6	7	8	9	10	11
1. Gender	1.00*										
2. Neuroticism	0.28*	1.00*									
3. Anxious	0.25*	0.58*	1.00*								
4. Sad	0.21*	0.59*	0.52*	1.00*							
5. Received feedback	0.04	-0.05	0.02	0.00	1.00*						
6. Numeric Grade	0.04	-0.09	-0.05	-0.08*		1.00*					
7. Feel about grade	0.09	-0.13	-0.08*	-0.11*	0.06*	0.68*	1.00*				
8. Hours studying	0.17*	0.08	0.07*	0.02	0.05*	-0.03	-0.05	1.00*			
9. Hours social media	0.13	0.12	0.03	0.05*	-0.04	-0.04	-0.06	0.00	1.00*		
10. Number times skip class	-0.13	0.08	-0.01	0.06*	0.07*	-0.13*	-0.08*	-0.04*	0.07*	1.00*	
11. Number times visited professor	-0.13	-0.14*	0.03	-0.02	0.12*	0.03	-0.03	0.14*	-0.09*	-0.03	1.00*

$^{*}p < .05$

Table 3.1: Correlations between study variables

3.2.1 Model 1: Neuroticism predicting behavior

The first model tested the effect of neuroticism on behavior, controlling for gender.[2] This effect was estimated using multilevel models with weeks nested within person. Neuroticism was grand-mean centered; as a result, intercepts can be interpreted as sample-level means. Intercepts were allowed to vary across participant, and so the neuroticism coefficient can be interpreted as the extent to which neuroticism increases or decreases a participant's average level of the behavior compared to the sample average. Bootstrapping with 1,000 iterations was used to estimate the 95% confidence intervals. Full results can be found in Table 3.2.

	Academic Behaviors			
	Hours studying	Hours on social media	Number times skipped class	Number times visit professor
	(1)	(2)	(3)	(4)
Intercept	3.06*	1.39*	1.30*	0.67*
	(2.01,4.02)	(0.71,2.08)	(0.84,1.78)	(0.35,1.02)
Neuroticism	0.12	0.12	0.15	-0.10
	(-0.25,0.50)	(-0.12,0.35)	(-0.02,0.32)	(-0.22,0.02)
Gender	0.59*	0.27	-0.33*	-0.12
	(0.07,1.18)	(-0.11,0.65)	(-0.59,-0.08)	(-0.32,0.06)
Students	211	211	211	211
Observations	2,432	2,433	2,403	2,398

Note: $^*p < .05$

Table 3.2: Predicting academic behaviors from trait neuroticism (Model 1)

Neuroticism was a weak predictor of academic behaviors. Neuroticism did not predict the number of hours students spent studying ($B = 0.12$, 95% CI = $[-0.25, 0.50]$), the number of hours spent on social media ($B = 0.12$, $[-0.12, 0.35]$), visiting a professor outside of class ($B = -0.10$, $[-0.22, 0.02]$) or the number of times students skipped class ($B = 0.15$, $[-0.02, 0.32]$).

[2] As a reminder, the sample consists of freshman undergraduates, meaning there was little variability in age. Consequently, I did not control for age in this study.

3.2.2 Models 2 and 3: The interaction of neuroticism or emotion and situation in predicting behavior

Next, models two and three were estimated. In model two, situation (i.e., academic feedback) was introduced as a covariate and the interaction between situation and neuroticism was included. In model three, weekly emotions – anxiety and sadness – and situation were main effects and the interactions of situation with each of the emotions were included. All models controlled for gender.

For the first set of models, academic feedback was a binary variable representing whether feedback was received that week or not (see Table 3.3 for results). All behaviors were assessed the following week. Feedback did not interact with neuroticism to predict hours studied ($B = -0.01$, $[-0.11, 0.08]$), hours on social media ($B = -0.01$, $[-0.11, 0.08]$), skipping class ($B = -0.04$, $[-0.16, 0.09]$), or visiting the professor ($B = -0.03$, $[-0.12, 0.05]$). Feedback did not interact with feeling anxious or sad to predict any academic behaviors.

Next, letter grade was used to operationalize academic feedback. As a reminder, dummy codes representing grades B, C, D and E/F were used. In the tables presented, the intercept is renamed "Grade A" for clarity. In addition, while letter grade in one week was used to predict time spent on social media, skipping class and visiting the professor the following week, hours spent studying was predicted in the next week which included a test or exam. Full results can be found in Table 3.4. Letter grade did not interact with neuroticism to predict any of the academic behaviors and did not interact with anxiety or sadness, with one exception. The relationship between anxiety and visiting a professor was negative for students who received a C but positive for students who received an A. This interaction is depicted in Figure 3.5.

Numeric grade was also used to operationalize academic feedback. Again, hours spent studying was predicted in the next week which included a test or exam. Full results can be found in Table 3.5. Numeric grade did not interact with neuroticism, anxiety or sadness to

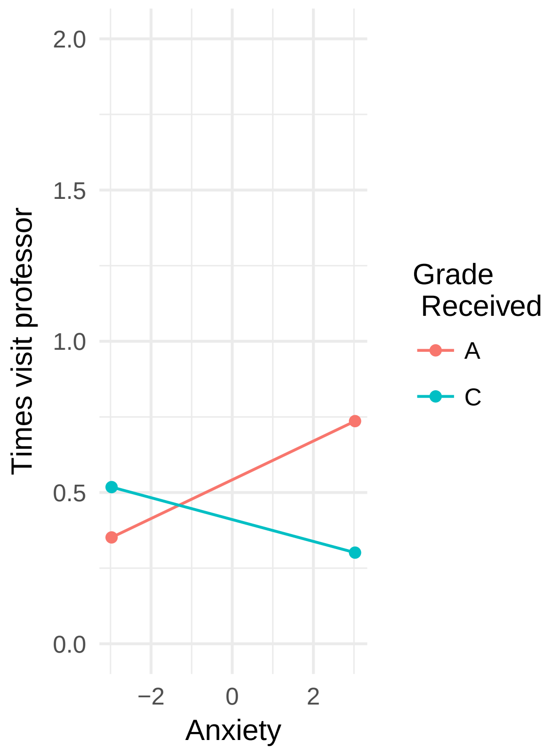


Figure 3.5: Relationship between anxiety, letter grade and visiting professors in model 3.

predict behavior.

Finally, student perception of the grade was used to predict academic behavior. Students' feelings about their grade did not interact with neuroticism, anxiety or sadness to predict behavior. Results can be found in Table 3.6.

	Dependent variable:							
	Hours Studying		Hours on Social Media		Number of Times Skip Class		Number of Times Visit Professor	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.02		0.11		0.17		−0.09	
	(−0.37, 0.37)		(−0.13, 0.34)		(−0.003, 0.34)		(−0.21, 0.02)	
Feedback	0.10	0.10	−0.04	−0.04	0.19*	0.19*	0.13*	0.13*
	(−0.03, 0.23)	(−0.04, 0.23)	(−0.11, 0.03)	(−0.10, 0.03)	(0.10, 0.27)	(0.10, 0.27)	(0.07, 0.19)	(0.07, 0.19)
Neuroticism x Feedback	0.22*		−0.01		−0.04		−0.03	
	(0.01, 0.41)		(−0.11, 0.08)		(−0.16, 0.09)		(−0.12, 0.05)	
Anxious		−0.02		−0.01		0.003		0.02
		(−0.09, 0.06)		(−0.05, 0.02)		(−0.04, 0.05)		(−0.01, 0.05)
Sad		0.08*		−0.02		0.02		−0.01
		(0.003, 0.16)		(−0.05, 0.02)		(−0.03, 0.06)		(−0.04, 0.02)
Anxious x Feedback		0.03		0.01		−0.01		0.01
		(−0.07, 0.13)		(−0.03, 0.05)		(−0.07, 0.04)		(−0.03, 0.05)
Sad x Feedback		−0.03		0.02		0.01		−0.03
		(−0.13, 0.07)		(−0.02, 0.07)		(−0.05, 0.08)		(−0.07, 0.01)
Students	211	211	211	211	211	211	211	211
Observations	2,432	2,419	2,433	2,420	2,403	2,390	2,398	2,385

Note: $^{*}p < .05$

Table 3.3: Predicting academic behaviors from neuroticism and emotions by receiving feedback (Models 2 and 3)

	Dependent variable:							
	Hours Studying		Hours on Social Media		Number of Times Skip Class		Number of Times Visit Professor	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Grade A	2.22*	2.67*	1.40*	1.34*	1.72*	1.62*	0.80*	0.89*
	(0.75, 3.63)	(1.67, 3.80)	(0.73, 2.10)	(0.68, 2.02)	(1.17, 2.27)	(1.07, 2.13)	(0.39, 1.25)	(0.49, 1.31)
Grade B vs A	0.86	0.10	−0.02	−0.02	0.08	0.07	0.01	0.02
	(−0.11, 1.91)	(−0.13, 0.32)	(−0.11, 0.09)	(−0.11, 0.08)	(−0.08, 0.24)	(−0.07, 0.22)	(−0.10, 0.11)	(−0.08, 0.13)
Grade C vs A	−0.58	0.15	0.08	0.08	0.21	0.20	−0.12	−0.13
	(−1.95, 0.89)	(−0.17, 0.48)	(−0.06, 0.22)	(−0.05, 0.22)	(−0.01, 0.40)	(−0.01, 0.41)	(−0.27, 0.03)	(−0.27, 0.02)
Grade D/F vs A	1.29	0.57*	0.07	0.08	0.15	0.11	−0.04	0.03
	(−0.78, 3.44)	(0.01, 1.07)	(−0.12, 0.26)	(−0.11, 0.29)	(−0.15, 0.43)	(−0.18, 0.41)	(−0.23, 0.13)	(−0.19, 0.22)
Neuroticism	0.19		0.12		0.15		−0.07	
	(−0.27, 0.59)		(−0.14, 0.37)		(−0.09, 0.37)		(−0.23, 0.11)	
Neur x Grade B	−0.24		0.001		0.02		−0.13	
	(−0.58, 0.07)		(−0.15, 0.15)		(−0.21, 0.25)		(−0.29, 0.03)	
Neur x Grade C	0.25		−0.09		0.06		−0.07	
	(−0.23, 0.71)		(−0.30, 0.11)		(−0.23, 0.40)		(−0.28, 0.12)	
Neur x Grade D/F	−0.25		−0.11		0.08		0.12	
	(−0.93, 0.40)		(−0.39, 0.18)		(−0.34, 0.48)		(−0.16, 0.38)	
Anxious		0.04		0.005		−0.04		0.08*
		(−0.08, 0.16)		(−0.05, 0.06)		(−0.12, 0.05)		(0.02, 0.13)
Sad		0.03		0.03		0.07		−0.08*
		(−0.10, 0.16)		(−0.03, 0.08)		(−0.02, 0.16)		(−0.14, −0.02)
Anxious x Grade B		−0.03		−0.001		0.05		−0.08*
		(−0.17, 0.12)		(−0.07, 0.06)		(−0.04, 0.16)		(−0.14, −0.01)
Anxious x Grade C		−0.001		−0.05		0.07		−0.12*
		(−0.22, 0.21)		(−0.14, 0.04)		(−0.07, 0.21)		(−0.21, −0.02)
Anxious x Grade D/F		0.05		−0.03		0.004		−0.02
		(−0.26, 0.37)		(−0.15, 0.09)		(−0.17, 0.18)		(−0.14, 0.09)
Sad x Grade B		−0.09		−0.03		−0.09		0.08*
		(−0.25, 0.07)		(−0.09, 0.05)		(−0.20, 0.02)		(0.01, 0.16)
Sad x Grade C		−0.03		0.02		−0.06		0.09
		(−0.24, 0.19)		(−0.07, 0.11)		(−0.20, 0.09)		(−0.02, 0.18)
Sad x Grade D/F		−0.23		−0.08		0.10		−0.05
		(−0.53, 0.05)		(−0.21, 0.05)		(−0.10, 0.30)		(−0.17, 0.08)
Students	201	201	203	203	203	203	203	203
Observations	948	943	1,024	1,019	1,023	1,018	1,026	1,021
Note:								$^{*}p < .05$

Table 3.4: Predicting academic behaviors from neuroticism and emotions by letter grade (Models 2 and 3)

	Dependent variable:							
	Hours Studying		Hours on Social Media		Number of Times Skip Class		Number of Times Visit Professor	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	0.06 (−0.33, 0.48)		0.12 (−0.12, 0.36)		0.17 (−0.01, 0.36)		−0.12 (−0.26, 0.03)	
Numeric	−0.02 (−0.07, 0.02)	−0.01 (−0.02, 0.004)	−0.002 (−0.01, 0.003)	−0.002 (−0.01, 0.003)	−0.01 (−0.01, 0.001)	−0.01 (−0.01, 0.001)	0.002 (−0.002, 0.01)	0.002 (−0.002, 0.01)
Neuroticism x Numeric	0.01 (−0.01, 0.02)		0.003 (−0.003, 0.01)		−0.003 (−0.01, 0.01)		0.0004 (−0.005, 0.01)	
Anxious		0.01 (−0.06, 0.09)		−0.01 (−0.04, 0.03)		−0.01 (−0.06, 0.04)		0.02 (−0.01, 0.06)
Sad		−0.02 (−0.10, 0.06)		0.02 (−0.01, 0.06)		0.02 (−0.03, 0.08)		−0.04 (−0.07, 0.001)
Anxious x Numeric		0.001 (−0.01, 0.01)		0.001 (−0.002, 0.003)		−0.002 (−0.01, 0.002)		0.001 (−0.001, 0.004)
Sad x Numeric		0.005 (−0.001, 0.01)		−0.0002 (−0.003, 0.003)		0.0002 (−0.004, 0.004)		0.0003 (−0.002, 0.003)
Students	201	201	203	203	203	203	203	203
Observations	969	964	1,049	1,044	1,047	1,042	1,050	1,045
Note:								$^*p < .05$; Numeric = Numeric grade

Table 3.5: Predicting academic behaviors from neuroticism and emotions by numeric grade (Models 2 and 3)

	Dependent variable:							
	Hours Studying		Hours on Social Media		Number of Times Skip Class		Number of Times Visit Professor	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
Neuroticism	−0.01		0.11		0.16		−0.12	
	(−0.55, 0.51)		(−0.13, 0.34)		(−0.01, 0.33)		(−0.25, 0.03)	
Feel about Grade	−0.14	−0.06	−0.02	−0.02	−0.02	−0.02	0.003	0.002
	(−0.43, 0.17)	(−0.13, 0.01)	(−0.05, 0.01)	(−0.05, 0.01)	(−0.06, 0.02)	(−0.07, 0.02)	(−0.03, 0.03)	(−0.03, 0.03)
Neuroticism x Feel about Grade	0.02		0.01		−0.04		0.02	
	(−0.08, 0.12)		(−0.04, 0.06)		(−0.10, 0.03)		(−0.03, 0.06)	
Anxious		−0.05		−0.01		−0.02		0.02
		(−0.24, 0.14)		(−0.04, 0.03)		(−0.07, 0.03)		(−0.02, 0.05)
Sad		−0.11		0.03		0.04		−0.03
		(−0.28, 0.09)		(−0.01, 0.06)		(−0.01, 0.10)		(−0.07, 0.0005)
Anxious x Feel about Grade		0.01		0.01		0.003		0.01
		(−0.03, 0.06)		(−0.01, 0.03)		(−0.03, 0.03)		(−0.01, 0.03)
Sad x Feel about Grade		0.03		−0.004		−0.003		−0.02
		(−0.02, 0.08)		(−0.02, 0.02)		(−0.03, 0.03)		(−0.04, 0.003)
Students	204	204	210	210	209	209	209	209
Observations	1,045	1,040	1,167	1,159	1,164	1,156	1,167	1,159

Note: $^{*}p < .05$

Table 3.6: Predicting academic behaviors from neuroticism and emotions by perception of grade (Models 2 and 3)

3.2.3 Model 4: The integration of neuroticism, situation and emotion to predict behavior

Finally, the proposed model (shown in Figure 1.3) was tested. For each form of academic feedback, the interaction of neuroticism and that form of feedback was used to predict emotion and separately used to predict behavior. The residuals of the emotion model were then used to predict the residuals of the behavior model, allowing for the estimation of the mediation pathway. Bootstrapping with 1,000 samples was used to estimate the coefficients and their confidence intervals. Neuroticism was grand-mean centered, allowing for easier interpretation.

Direct and indirect effects of neuroticism, feedback and their interaction were also estimated. The same bootstrapping procedure that was used in Study 1 to estimate direct and indirect effects was used here. First, I ran a model with the interaction of neuroticism and feedback predicting behavior. These pathways were extracted as 'total effects.' Then, using the same sampled data set, I ran a model with neuroticism, symptom and their interaction as predictors, and with the addition of the three emotion variables as predictors. The pathways for neuroticism, feedback and their interaction was extracted from this model as the 'direct effects.' To estimate indirect effects, direct effects were subtracted from total effects. This bootstrapping procedure was run with 1,000 iterations. Median values for direct, total and indirect effects were used as final estimates, and the percentile method was used to extract confidence intervals. All models control for gender. Results for neuroticism were largely consistent – there were no indirect effects of neuroticism on behavior through emotion, no were there any indirect effects of feedback or the interaction of feedback and neuroticism. There were some direct effects - neuroticism had a significant direct effect on most behaviors in most models. Other effects were sparse and will not be discussed in this chapter. Interested reviewers can see all the results in Appendix D.

The results for the model using feedback – a binary variable representing whether a student received feedback that week or not – is presented in Table 3.7 and displayed graphically in Figure 3.6. When students did not receive feedback, neuroticism was a significant predictor of anxiety ($B = 0.84$ $[0.66, 1.02]$) and sadness ($B = 0.69$ $[0.49, 0.88]$). However, feedback and neuroticism did not interact to predict anxiety ($B = 0.15$ $[-0.03, 0.32]$) or sadness ($B = 0.16$ $[-0.01, 0.33]$), which would have been expected had students high in neuroticism reacted more strongly to events. Students who felt more anxious visited the professor outside of class more ($B = 0.03$ $[0.01, 0.05]$). Students who felt more sad also visited the professor outside of class more ($B = 0.07$ $[0.01, 0.13]$) and studied more the following week ($B = 0.06$ $[0.01, 0.13]$).

	Emotions as outcomes	
Coef	Anxious	Sad
Neur	0.835 [0.657, 1.022]∗	0.692 [0.494, 0.877]∗
Received feedback	0.070 [-0.053, 0.192]	-0.010 [-0.136, 0.105]
Received feedback x Neur	0.152 [-0.026, 0.325]	0.163 [-0.009, 0.328]
	Emotions as predictors	
	Anxious	Sad
Hours studying	-0.006 [-0.065, 0.045]	0.065 [0.010, 0.128]∗
Hours on social media	-0.007 [-0.033, 0.019]	-0.008 [-0.036, 0.018]
Number times skipped class	-0.004 [-0.040, 0.030]	0.022 [-0.013, 0.061]
Number of times visit professor	0.027 [0.007, 0.047]∗	-0.028 [-0.05, -0.007]∗

$^{*}p < .05$

Table 3.7: Predicting emotions and behaviors from neuroticism and Feedback (Model 4)

The results for the letter grade model are shown in Table 3.8. When students received A's, neuroticism significantly predicted greater anxiety ($B = 1.05$ $[0.78, 1.29]$) and greater sadness ($B = 0.82$ $[0.55, 1.08]$). At average levels of neuroticism, students who received C grades were more anxious ($B = 0.33$ $[0.08, 0.61]$) and sadder than students who received A grades ($B = 0.32$ $[0.04, 0.58]$) and students who received D grades were also sadder than students who received A grades ($B = 0.46$ $[0.10, 0.83]$). Grades did not interact with neuroticism to predict emotion. Moreover, emotion did not predict any of the academic behaviors.

The results for the numeric grade model are shown in Table 3.9. Numeric grade was

Coef	*Emotions as outcomes* Anxious	Sad
Grade A	-0.361 [-0.961, 0.181]	-0.401 [-0.968, 0.176]
Grade B vs A	0.152 [-0.033, 0.341]	0.011 [-0.175, 0.216]
Grade C vs A	0.332 [0.080, 0.607]∗	0.315 [0.041, 0.576]∗
Grade D/F vs A	0.268 [-0.075, 0.614]	0.459 [0.101, 0.831]∗
Neur	1.050 [0.784, 1.294]∗	0.823 [0.552, 1.084]∗
Grade B x Neur	-0.134 [-0.423, 0.173]	0.001 [-0.285, 0.290]
Neur x Grade C	-0.324 [-0.701, 0.045]	-0.011 [-0.397, 0.365]
Neur x Grade DF	0.040 [-0.519, 0.545]	-0.292 [-0.815, 0.211]
	Emotions as predictors	
	Anxious	Sad
Hours studying	0.030 [-0.047, 0.109]	-0.034 [-0.118, 0.05]
Hours on social media	0.022 [-0.044, 0.091]	0.002 [-0.07, 0.084]
Number times skipped class	-0.018 [-0.091, 0.057]	0.026 [-0.031, 0.082]
Number of times visit professor	0.018 [-0.016, 0.053]	-0.032 [-0.093, 0.036]

$^{*}p < .05$

Table 3.8: Predicting emotions and behaviors from neuroticism and Feedback (Model 4)

centered at 85, which may be considered an “average” score on an exam or essay (in the sense of professor expectations, not actual class performance). When students received average grades, neuroticism significantly predicted greater anxiety ($B = 0.96$ $[0.75, 1.17]$) and greater sadness ($B = 0.82$ $[0.60, 1.03]$). At average levels of neuroticism, better grades predicted less anxiety ($B = -0.01$ $[-0.02, 0.00]$) and less sadness ($B = -0.01$ $[-0.02, 0.00]$). However, the interaction between grade and neuroticism did not predict emotion, and emotions did not predict academic behaviors,

Finally, the results for the “feelings about grade” model are shown in Table 3.10. Feelings are grand-mean centered. When students felt average about their grades, neuroticism significantly predicted greater anxiety ($B = 1.00$ $[0.79, 1.18]$) and greater sadness ($B = 0.85$ $[0.65, 1.06]$). In addition, as students felt more positively about their grades, they felt less anxiety ($B = -0.08$ $[-0.13, -0.02]$) and less sadness ($B = -0.09$ $[-0.15, -0.04]$). The interaction of feelings and neuroticism did not predict emotion; emotions did not predict academic behaviors.

Coef	*Emotions as outcomes* Anxious	Sad
Neur	0.962 [0.752, 1.171]∗	0.82 [0.601, 1.035]∗
Numeric Grade	-0.009 [-0.016, -0.001]∗	-0.012 [-0.019, -0.005]∗
Numeric Grade x Neur	0.003 [-0.007, 0.013]	0.005 [-0.005, 0.015]
	Emotions as predictors	
	Anxious	Sad
Hours studying	0.023 [-0.059, 0.100]	-0.039 [-0.121, 0.045]
Hours on social media	0.021 [-0.050, 0.084]	0.008 [-0.068, 0.085]
Number times skipped class	-0.015 [-0.089, 0.060]	0.017 [-0.046, 0.078]
Number of times visit professor	0.021 [-0.013, 0.055]	-0.038 [-0.105, 0.027]

$^{*}p < .05$

Table 3.9: Predicting emotions and behaviors from neuroticism and numeric grade (Model 4)

Coef	*Emotions as outcomes* Anxious	Sad
Neur	0.996 [0.794, 1.177]∗	0.847 [0.650, 1.060]∗
Feel about grade	-0.075 [-0.132, -0.018]∗	-0.092 [-0.151, -0.038]∗
Feel about grade x Neur	0.052 [-0.035, 0.133]	0.028 [-0.058, 0.109]
	Emotions as predictors	
	Anxious	Sad
Hours studying	-0.016 [-0.094, 0.071]	-0.013 [-0.092, 0.071]
Hours on social media	0.013 [-0.054, 0.078]	0.054 [-0.02, 0.131]
Number times skipped class	-0.031 [-0.103, 0.042]	0.035 [-0.022, 0.096]
Number of times visit professor	0.017 [-0.023, 0.057]	-0.034 [-0.076, 0.011]

$^{*}p < .05$

Table 3.10: Predicting emotions and behaviors from neuroticism and perception of grade (Model 4)

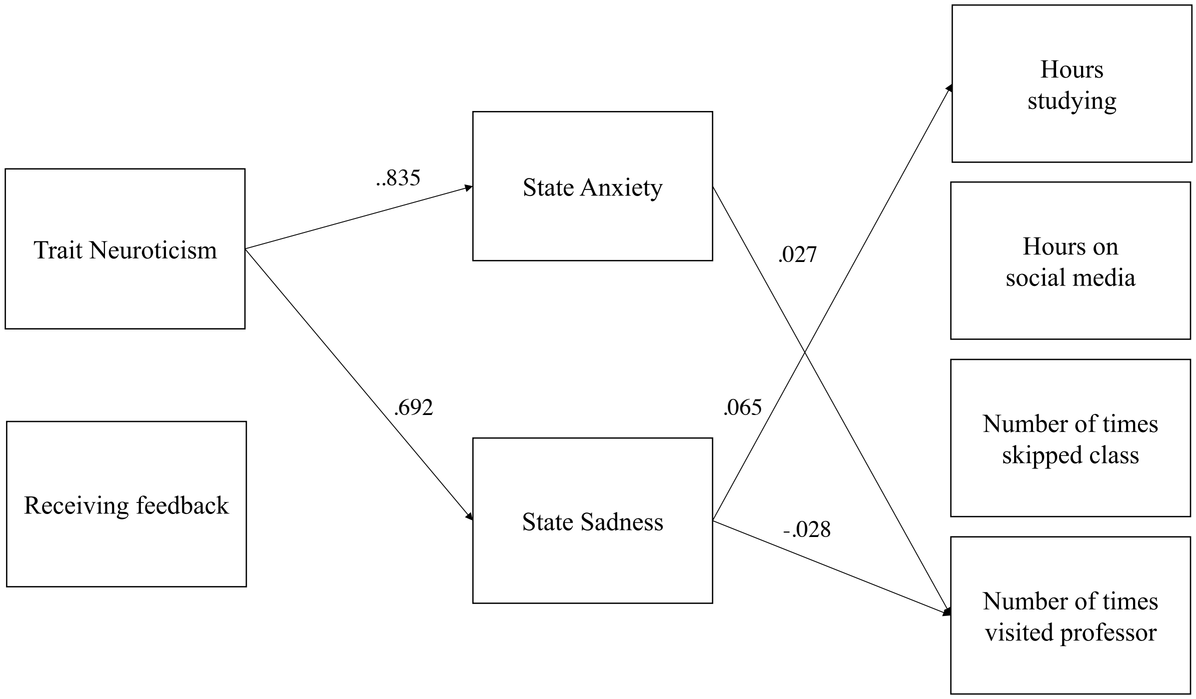


Figure 3.6: The results of model 4 using all symptoms as the situation.

Overall, there was little evidence that neuroticism predicted academic behaviors or interacted with academic feedback to predict academic behaviors. Furthermore, academic feedback did not interact with week-level emotions to predict behavior. Finally, there was little support for the proposed theoretical model (Figure 1.3). Specficially, situation did not moderate the effect of neuroticism when situation was operationalized as numeric grade, letter grade or perception of grade. In these models, week-level emotions did not predict behaviors. However, when situation was operationalized as receiving any feedback, feedback predicted emotion and emotion predicted hours studying and visiting the professor. This suggests that any kind of feedback - positive or negative - can elicit anxiety or sadness and in turn influence behavior.

4. Discussion

Overall, these studies lend little support for the proposed theory of healthy neuroticism. The primary model of interest – the interaction of neuroticism and situation on behavior is mediated by increases in anxiety and decreases in depression and anger - was not supported. Specifically, in the education domain, only the model which used receiving feedback as the situation and studying as the outcome yielded estimates consistent with the hypotheses. In the health domain, not only did none of the models yield coefficients in support of the hypotheses, but several models provided counter support, as increases in nervousness predicted less healthy behavior, not more healthy.

Additional analyses (models 2 and 3) yielded little support for other proposed manifestations of healthy neuroticism. It does not appear that situation moderates the effect of neuroticism on behavior, nor does it moderate the specific negative emotions that are under the broader umbrella of neuroticism. And without the moderation, neuroticism and the specific emotions had null or negligible effects on behavior, which itself suggests that current focus on the maladaptiveness of neuroticism as a trait may be exaggerated.

4.1 Issues muddying the water

These analyses suggest that not only might the theory of healthy neuroticism be unfounded, but the whole assumption that neuroticism results in worse behaviors and outcomes may be overblown. Lest we throw the signal out with the noise, we must consider the limitations of the current studies and the degree to which they can mask real results.

First, there is the issue of measurement of neuroticism in the health study. The scale used, the MIDI personality scales (Lachman and Weaver, 1997), are included in a number of large panel studies and have been used to successfully investigate the relationship between traits and health outcomes many times (e.g., Goodwin and Friedman, 2006; Mroczek and Almeida, 2004; Turiano et al., 2013, 2012; Weston et al., 2015; Weston and Jackson, 2014). However, many acknowledge that this scale is limited. With only four items, the specificity of the scale is restricted, as is the range of possible trait scores. The items used - "worrying," "nervous," "calm (R)," and "moody"' - capture a sense of anxiety but not depression or anger, let alone other negative emotions or general emotional instability (Goldberg, 1993). And while this rough measure may be sufficient to estimate broad outcomes, like mortality, disease onset and even patterns of behavior, it does seem insufficient to predict behaviors at such a level of specificity as the day. This alone may have hindered the ability to capture the relationship between neuroticism and daily health behaviors.

Second, not only was the measurement of neuroticism in the health study too coarse, but the time frame used to measure emotion was too broad. As a reminder, the health study asked participants to report their emotion over the last 24 hours, while the education study asked for emotion over the past week. Both of these methods are retrospective and ask participants to aggregate emotion over a period of time. Retrospective reports of emotion can be clouded by memory biases or defensive mechanisms (Barrett, 1997). Moreover, aggregating across multiple instances of emotion can obscure more fine-grained emotions (Levenson, 2014). Emotion researchers are more prone to debate the merits of assessing emotion by the second versus the millisecond (Mauss et al., 2005) rather than by the day or week. In the present studies, it is impossible to tell whether the emotions assessed are in response to the situations experienced, as we cannot know how long after the event a participant experienced an emotion, or even whether participants experienced the emotion after the situation. Similarly, it is impossible to know in most of these models whether the emotion preceded the behavior (let alone caused it). Future research should consider the use of more frequent assessments of emotion. Even better, health researchers should seek opportunities to measure emotional responses to specific events. Patients with chronic and serious illnesses often seek psychological counseling in addition to medical treatments. During counseling, patients already report their emotions to diagnoses, treatment options, changes in health, etc., throughout the process of addressing health concerns. Those patients willing to share their experience with researchers can provide real-world data on how health situations can influence emotion and behavior.

This brings us to the third measurement issue that may obscure our ability to see relationships between neuroticism and adaptive behaviors: situations. As mentioned above, there is no doubt that serious health situations, like being diagnosed with cancer, elicit strong negative behaviors in patients, and similarly, there is no doubt that patients will change their behavior in response to such a situation. Can the same be said for health symptoms, like a stomach ache or dizziness? It seems unlikely. The health situations chosen in the current study may not have been strong enough to elicit a behavioral response, especially for some of the behaviors chosen. For example, a regular smoker is not going to skip cigarettes for a day because of a back ache. If these results are any indication, that person will smoke more, perhaps as a distraction or a comfort. These minor or daily health situations may not be strong enough to elicit new behaviors. In that vein, a recent study on predictors of daily behavior found that while personality and situation both predicted behavior, they did so independently (Sherman et al., 2015). Specifically, personality traits and situational characteristics, as measured by the DIAMONDS model (Rauthmann et al., 2014), predict state expressions (i.e., the extent to which a participant's momentary behavior, feelings or thoughts were pertaining to one of ten personality constructs). But the extent to which a trait was related to state expressions did not depend on the situation at hand. While the daily behavior study did not measure specific health situations, the symptoms used in the current study may be the type of daily situation described by the DIAMONDS model. That is, while health symptoms may directly impact behavior, they do not do so through changing the existing relationship between trait neuroticism and health behaviors.

4.2 Implications for personality and health

As described above, there were certainly methodological choices made which may have prevented us from finding the expected results. However, let's assume for a moment that these choices did not, in fact, inhibit the study. Certainly between the use of large (in the case of the health study) and sufficient (in the case of the education study) sample sizes, each with many repeated measures, there is enough power to overcome some problems of low reliability or broadness in our measures. If these results are to be believed,[1] then the implication for personality and health researchers is clear: pay less attention to neuroticism.

Think back to the initial problem which precipitated the need for a theory of healthy neuroticism. The association between neuroticism and health, especially mortality, appeared to jump around from large panel study to large panel study. In some cases, neuroticism predicted greater mortality, but in some cases, predicted greater longevity. Results were often taken at face value, because the sample sizes were substantial enough to warrant that these studies be taken seriously. But even large studies are subject to chance, especially when the true population results are small. The current study, along with a long literature of neuroticism and health, suggest that the effect of neuroticism on health is likely extremely small, and sample variation has resulted in some positive, some negative and some null results. Rather than being of "public health significance" (Lahey, 2009), neuroticism may just be a nuisance.

The drive to fit neuroticism into a literature of health is (reasonably) founded on the relationship of neuroticism to stress and the knowledge that chronic stress has severe

[1] Personally, I believe them.

implications for physical health (Cohen and Wills, 1985). If neuroticism is related to experiencing chronic stress (which it is), and chronic stress is related to worse health (which it is), then there's every reason to predict neuroticism is related to worse health. However, the mathematics get in the way. The link from neuroticism to health in this chain is composed of two parts: the neuroticism to stress part and the stress to health part. That link from neuroticism to health is calculated by multiplying each pathway along the chain together. Assume for a moment that the link between stress and health is large, perhaps as large as $r = -.50$.[2] Neuroticism is the *tendency* to experience stress, which is not the same as experiencing chronic stress. So the path from neuroticism to chronic stress is expected to be tiny. Significant, but tiny, perhaps no larger than $r = .10$. Meaning the pathway personality and health researchers search for - the link from neuroticism to mortality, or disease onset, or behavior - is even smaller. Given our generous hypothetical estimates, the direct correlation from neuroticism to health is $r = -.05$. And remember, this is our population effect, which means sample estimates will bounce around this number... much like they do in the literature. Which brings us back to the point above. It seems almost certain that neuroticism has a negative relationship to health. It's just not a large enough relationship to reliably detect. This is especially problematic given that other personality traits are more directly related to health, like conscientiousness or extraversion. These relationships are easier for us to identify, and thus to change or intervene on. If the goal is to improve health, either by encouraging new behaviors or identifying at-risk patients in health care settings, our time will be more efficiently spent turning away from neuroticism and turning towards other traits.

[2] While this relationship is consistently found in the literature, the effect size depends substantially on the measurement of stress and of health (Cohen and Wills, 1985). Consequently, it is difficult to find a specific number to put here.

4.3 Future directions for neuroticism and health

I should clarify: I do not mean to say neuroticism is not worth studying in relation to health. Instead, it seems likely that current conceptions of neuroticism are inefficient. Measuring neuroticism at the trait level and expecting those estimates to be associated with behavior or narrow health outcomes is unreasonable, especially given the specific mechanisms by which we expect neuroticism to impact health. Certainly many would advocate for the use of facets or even items of neuroticism as predictors (e.g., Vainik et al., 2015). But there are other narrow personality constructs which merit consideration.

One such construct is body vigilance, sometimes called body awareness. There has yet to be a consistent definition of body vigilance among researchers, although we may think of this construct as containing several parts: proprioception the perceptions of joint angles and muscle tension;, 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). The concept of body vigilance has been woven into the theory of healthy neuroticism from its very beginning. 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 mine). The term "vigilance" then appears in a number writings about healthy neuroticism (e.g., Hampson, 2012; Hill and Roberts, 2016; Mroczek et al., 2009; Murray and Booth, 2015; Smith et al., 2004; Weston and Jackson, 2014). But vigilance is never measured by personality researchers.

Which is not to say that measures of vigilance do not exist. In fact, the first challenge of neuroticism researchers who wish to measure vigilance will be deciding the best (set of) measure(s) to use. One review found twelve self-report measures of body vigilance (Mehling et al., 2009). Importantly, body vigilance appears to be associated with the major constructs 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 SRH and cross-sectional illness (Hansell and Sherman, 1991). Another measure interacted with physical impairment in hemodialysis patients to predict medication adherence (Christensen et al., 1996). Vigilance is related to higher trait anxiety (Schmidt and Lerew, 1997) and even trait neuroticism (Lombardo et al., 2007). In fact the relationship between neuroticism and pain vigilance, a specific kind of body vigilance, is mediated by pain catastrophizing and fear of movement (Goubert et al., 2004) in a sample of patients with non-specific chronic or recurrent back pain. This suggests that neuroticism may be related to general body vigilance through general anxiety or fear, which maps perfectly onto our conception of healthy neuroticism. This would also further explain why it may be difficult to identify relationships between neuroticism and health: perhaps only vigilance, a specific component of anxiety, a specific component of neuroticism, is associated with these health outcomes. Future research should include the improvement of measurement of body vigilance and the subsequent inclusion of this construct in studies of neuroticism and health.

In addition to examining specific facets or constructs, we should also continue to examine state level emotions and their relationship to neuroticism. Recent advances in experience sampling methodology have allowed for frequent and specific measurements of moods and emotions that were not possible a decade ago. Even more recently, new ways to think about these momentary assessments have generated better ways to evaluate differences in emotion. Theories of the "dynamics of affect" posit that individuals can be characterized by not only their average levels of affect, but how their affect states vary and change over time. These dynamics include affective variability, instability, inertia and reactivity (Ong and Ram, 2016). Variability is the degree to which changes in affect deviate from a person's average. Instability is the probability that a person's affective state will change from one moment to another and the extent to which they change. Inertia is the degree to which a person's affective state endures across time (which is similar to instability but without the level of emotion and with an attempt to capture a length of time). Finally, reactivity is the magnitude of an emotional response to external events. Combined, these dynamics can identify, for individuals, whether their affect is stable and resistant to outside forces, or fragile and susceptible to external influences. Already, these dynamics are being used in the psychopathology literature, as they are related to depression, borderline personality disorder and psychopathy (Wichers et al., 2015). There is some evidence that negative affect dynamics are associated with neuroticism (Jacobs et al., 2011; Mroczek and Almeida, 2004). But these dynamics are rarely used in health research, with a few notable exceptions. Positive affect variability has a curvilinear relationship with cortisol, suggesting that positive affect can be both too variable and too stable (Human et al., 2015). And positive affect reactivity is associated with greater mortality (Mroczek et al., 2015). Future research on neuroticism and health should consider the degree to which neuroticism is related to the dynamics of positive and negative affect, and whether those dynamics predict health outcomes and behaviors.

Finally, while the interaction of conscientiousness and neuroticism has not been a consistent predictor of adaptive outcomes, we should continue to look at the combination of these traits (and the combination of others). Specifically, I think there is fruitful ground in applying some of the ideas of this dissertation to the interaction of traits. For example, how might combinations of traits predict emotions or behaviors? How might a combination of traits predict a response to a situation? A conscientious neurotic might respond with more anxiety when facing a health situation, because neuroticism predicts reactivity, or less anxiety, because conscientiousness predicts less reactivity. These traits could result in a wash, an average amount of anxiety. Or might lead a person to have stronger reactions only when it is adaptive to do so.

4.4 Conclusion

Neuroticism may be the most fascinating of the personality traits. From the earliest days of trait psychology, we have measured and analyzed and scrutinized neuroticism and its consequences for our well-being, our relationships, our jobs and our health. We have found damning evidence that our worst fears should be our own anxieties. Conversely, we have also learned that our paranoia – or vigilance – is not only justified but will save us in the end. These confusing and opposing results seem to have lead us farther down the rabbit hole of neuroticism, as we struggle to find an answer. Is my neuroticism killing me? Or is it making me healthy? This dissertation, for all its lofty intentions, has not solved this question.

However, if we are to continue this mad search for neurotic truth, we know a few places not to look. We know that somatic symptoms, while they make us feel anxious or angry, do not motivate us to change our behavior. Nor do they trigger different effects of neuroticism. We also know that some measurements of affect are better than others, and perhaps we need to be more creative when it comes to defining, measuring and summarizing emotions. And we know that despite all our talk of vigilance, we haven't noticed how much we've left that construct out.

As for this health researcher, she will broaden her scope. Extraversion, for example, is more predictive of mortality than neuroticism, but examined less. And traits outside of the Big Five, especially more narrow traits or scales empirically created, can be both more predictive of outcomes and more explanatory of mechanisms. Which is not to say she, this researcher, will give up on neuroticism. It is fascinating. And the thought that it might not be so bad helps her sleep at night.

A. Packages Used

This document was produced using R version 3.3.2. In addition to R and the base packages, the following packages were used.

Name	Version
boot	1.3-18
car	2.1-3
dplyr	0.5.0
ggplot2	2.2.0
gridExtra	2.2.1
knitr	1.15.1
lme4	1.1-12
Matrix	1.2-7.1
psych	1.6.9
stargazer	5.2
tidyr	0.6.0
xtable	1.8-2

Table A.1: R packages used

B. Estimates of direct and indirect effects in Study 1

Direct and indirect effects were estimated using a bootstrapping procedure. For each iteration of the bootstrap, model 2 (in which neuroticism interacted with symptom to estimate behavior) was run to estimate the total effect of neuroticism, symptom and their interaction. Next, the three emotions were added to the model, and the estimates for neuroticism, symptom and interaction were used as the direct effects. Indirect effects were calculated by subtracting the direct effect from the total effect. Bootstrapping was run with 1,000 iterations. Presented here are four tables, one for each behavior, which shows the indirect effect, direct effect and total effect for neuroticism, symptom and interaction, with each symptom as a separate row in the table.

Symptom	Direct Effect	Neuroticism Indirect Effect	Total Effect
Head and back aches	0.37 [0.02, 0.72]*	0.21 [0.10, 0.34]*	0.59 [0.24, 0.92]*
Cold and flu	0.37 [-0.01, 0.73]	0.22 [0.10, 0.35]*	0.59 [0.24, 0.96]*
Digestive	0.36 [0.02, 0.72]*	0.22 [0.11, 0.35]*	0.58 [0.25, 0.95]*
Dizziness	0.36 [0.01, 0.72]*	0.20 [0.09, 0.32]*	0.55 [0.22, 0.95]*
Menstrual	0.45 [-0.02, 0.93]	0.20 [0.00, 0.44]	0.66 [0.20, 1.14]*
Hot Flashes	0.10 [-0.28, 0.52]	0.24 [0.06, 0.44]*	0.35 [-0.06, 0.77]
Other	0.36 [0.02, 0.72]*	0.20 [0.08, 0.32]*	0.57 [0.23, 0.91]*
All	0.37 [0.04, 0.75]*	0.21 [0.09, 0.33]*	0.58 [0.25, 0.93]*
		Symptom	
	Direct Effect	*Indirect Effect*	*Total Effect*
Head and back aches	-0.46 [-1.41, 0.53]	0.01 [-0.16, 0.18]	-0.45 [-1.40, 0.55]
Cold and flu	0.70 [-0.84, 2.40]	0.06 [-0.20, 0.37]	0.78 [-0.84, 2.45]
Digestive	-0.59 [-2.56, 1.41]	0.11 [-0.26, 0.49]	-0.47 [-2.46, 1.46]
Dizziness	1.34 [-1.76, 4.46]	-0.03 [-0.45, 0.56]	1.36 [-1.89, 4.47]
Menstrual	-0.98 [-2.70, 1.64]	0.21 [-0.17, 0.68]	-0.74 [-2.52, 1.89]
Hot Flashes	0.84 [-3.19, 4.55]	-0.71 [-1.74, -0.12]*	0.14 [-4.14, 3.42]
Other	0.16 [-3.13, 3.78]	-0.29 [-0.73, 0.11]	-0.14 [-3.41, 3.58]
All	-0.20 [-3.81, 3.79]	-0.11 [-0.67, 0.46]	-0.27 [-3.99, 3.61]
		Interaction	
	Direct Effect	*Indirect Effect*	*Total Effect*
Head and back aches	0.23 [-0.18, 0.62]	0.03 [-0.05, 0.11]	0.26 [-0.15, 0.65]
Cold and flu	-0.30 [-0.96, 0.33]	0.01 [-0.12, 0.14]	-0.29 [-0.96, 0.36]
Digestive	0.19 [-0.51, 0.87]	0.03 [-0.12, 0.20]	0.22 [-0.50, 0.93]
Dizziness	-0.42 [-1.65, 0.80]	0.11 [-0.14, 0.34]	-0.29 [-1.59, 0.89]
Menstrual	0.33 [-0.60, 0.95]	-0.06 [-0.26, 0.11]	0.25 [-0.68, 0.89]
Hot Flashes	-0.38 [-1.73, 1.15]	0.32 [0.06, 0.72]*	-0.08 [-1.35, 1.62]
Other	-0.09 [-1.73, 1.24]	0.21 [0.02, 0.42]*	0.12 [-1.50, 1.50]
All	0.17 [-1.41, 1.61]	0.23 [-0.05, 0.52]	0.39 [-1.18, 1.88]

Table B.1: Indirect estimates of neuroticism and symptom on cigarette smoking

Symptom	Direct Effect	Neuroticism Indirect Effect	Total Effect
Head and back aches	0.03 [-0.06, 0.12]	0.01 [-0.02, 0.03]	0.04 [-0.06, 0.13]
Cold and flu	0.03 [-0.06, 0.12]	0.00 [-0.02, 0.03]	0.04 [-0.06, 0.13]
Digestive	0.03 [-0.06, 0.12]	0.01 [-0.02, 0.03]	0.04 [-0.06, 0.12]
Dizziness	0.03 [-0.06, 0.12]	0.00 [-0.02, 0.02]	0.04 [-0.06, 0.12]
Menstrual	0.15 [0.06, 0.25]*	-0.02 [-0.05, 0.01]	0.13 [0.05, 0.23]*
Hot Flashes	0.18 [0.10, 0.26]*	-0.02 [-0.04, 0.01]	0.17 [0.09, 0.24]*
Other	0.03 [-0.06, 0.12]	0.00 [-0.02, 0.02]	0.04 [-0.06, 0.12]
All	0.03 [-0.06, 0.11]	0.01 [-0.02, 0.03]	0.04 [-0.05, 0.12]
		Symptom	
	Direct Effect	*Indirect Effect*	*Total Effect*
Head and back aches	0.11 [-0.11, 0.34]	-0.01 [-0.06, 0.02]	0.10 [-0.12, 0.33]
Cold and flu	-0.03 [-0.30, 0.22]	-0.02 [-0.10, 0.02]	-0.06 [-0.32, 0.18]
Digestive	0.04 [-0.29, 0.37]	-0.03 [-0.16, 0.04]	0.00 [-0.33, 0.32]
Dizziness	0.56 [-0.26, 1.49]	-0.07 [-0.36, 0.06]	0.48 [-0.35, 1.31]
Menstrual	-0.02 [-0.39, 0.35]	-0.02 [-0.15, 0.05]	-0.04 [-0.42, 0.34]
Hot Flashes	0.57 [-0.30, 1.80]	-0.05 [-0.37, 0.06]	0.49 [-0.36, 1.65]
Other	0.16 [-0.47, 0.82]	0.00 [-0.03, 0.03]	0.16 [-0.47, 0.82]
All	0.34 [-0.32, 1.00]	-0.07 [-0.41, 0.19]	0.25 [-0.40, 0.96]
		Interaction	
	Direct Effect	*Indirect Effect*	*Total Effect*
Head and back aches	-0.06 [-0.15, 0.02]	0.00 [-0.01, 0.02]	-0.06 [-0.15, 0.03]
Cold and flu	0.01 [-0.10, 0.11]	0.01 [-0.01, 0.04]	0.02 [-0.08, 0.12]
Digestive	-0.04 [-0.17, 0.09]	0.01 [-0.01, 0.06]	-0.03 [-0.16, 0.10]
Dizziness	-0.26 [-0.62, 0.07]	0.03 [-0.02, 0.13]	-0.23 [-0.57, 0.09]
Menstrual	0.00 [-0.14, 0.14]	0.00 [-0.02, 0.04]	0.01 [-0.13, 0.14]
Hot Flashes	-0.21 [-0.67, 0.11]	0.01 [-0.03, 0.10]	-0.20 [-0.62, 0.13]
Other	-0.09 [-0.35, 0.18]	0.00 [-0.02, 0.01]	-0.08 [-0.35, 0.17]
All	-0.21 [-0.51, 0.08]	0.01 [-0.10, 0.15]	-0.20 [-0.51, 0.09]

Table B.2: Indirect estimates of neuroticism and symptom on alcohol consumption

Symptom	*Direct Effect*	Neuroticism *Indirect Effect*	*Total Effect*
Head and back aches	0.01 [-0.04, 0.06]	0.00 [-0.02, 0.02]	0.01 [-0.04, 0.06]
Cold and flu	0.01 [-0.04, 0.06]	0.01 [-0.01, 0.02]	0.01 [-0.04, 0.06]
Digestive	0.01 [-0.05, 0.06]	0.00 [-0.01, 0.02]	0.01 [-0.04, 0.06]
Dizziness	0.01 [-0.04, 0.06]	0.00 [-0.01, 0.02]	0.01 [-0.04, 0.06]
Menstrual	-0.02 [-0.10, 0.06]	0.00 [-0.02, 0.02]	-0.02 [-0.10, 0.06]
Hot Flashes	0.03 [-0.04, 0.09]	0.01 [-0.01, 0.04]	0.04 [-0.03, 0.10]
Other	0.01 [-0.05, 0.07]	0.00 [-0.01, 0.02]	0.01 [-0.04, 0.06]
All	0.02 [-0.04, 0.07]	0.00 [-0.02, 0.01]	0.01 [-0.04, 0.06]
		Symptom	
	Direct Effect	*Indirect Effect*	*Total Effect*
Head and back aches	0.02 [-0.14, 0.17]	0.01 [0.00, 0.02]	0.02 [-0.13, 0.18]
Cold and flu	-0.20 [-0.50, 0.06]	0.00 [-0.01, 0.02]	-0.20 [-0.49, 0.06]
Digestive	-0.34 [-0.70, 0.00]	0.01 [-0.02, 0.05]	-0.33 [-0.69, 0.02]
Dizziness	-0.07 [-0.62, 0.54]	0.00 [-0.04, 0.05]	-0.06 [-0.61, 0.53]
Menstrual	0.09 [-0.23, 0.40]	0.00 [-0.03, 0.02]	0.09 [-0.22, 0.39]
Hot Flashes	0.10 [-0.60, 0.79]	-0.05 [-0.14, 0.01]	0.05 [-0.68, 0.75]
Other	0.30 [-0.18, 0.74]	0.00 [-0.02, 0.02]	0.30 [-0.17, 0.74]
All	-0.23 [-0.83, 0.38]	0.02 [-0.03, 0.09]	-0.21 [-0.79, 0.38]
		Interaction	
	Direct Effect	*Indirect Effect*	*Total Effect*
Head and back aches	0.04 [-0.03, 0.12]	0.00 [-0.01, 0.00]	0.04 [-0.03, 0.11]
Cold and flu	0.09 [-0.03, 0.23]	0.00 [-0.01, 0.01]	0.09 [-0.03, 0.24]
Digestive	0.13 [0.00, 0.28]	0.00 [-0.02, 0.01]	0.13 [-0.01, 0.27]
Dizziness	0.06 [-0.18, 0.28]	0.00 [-0.02, 0.02]	0.06 [-0.18, 0.28]
Menstrual	-0.02 [-0.14, 0.09]	0.00 [-0.01, 0.01]	-0.02 [-0.13, 0.09]
Hot Flashes	0.03 [-0.25, 0.35]	0.02 [0.00, 0.06]	0.05 [-0.22, 0.37]
Other	-0.05 [-0.24, 0.16]	0.00 [-0.01, 0.01]	-0.05 [-0.24, 0.17]
All	0.25 [-0.02, 0.53]	-0.01 [-0.04, 0.02]	0.24 [-0.02, 0.51]

Table B.3: Indirect estimates of neuroticism and symptom on vigorous exercise

Symptom	Direct Effect	Neuroticism Indirect Effect	Total Effect
Head and back aches	0.03 [-0.01, 0.08]	-0.02 [-0.03, 0.00]	0.02 [-0.03, 0.06]
Cold and flu	0.03 [-0.01, 0.08]	-0.02 [-0.03, 0.00]	0.02 [-0.02, 0.06]
Digestive	0.03 [-0.01, 0.08]	-0.01 [-0.03, 0.00]	0.02 [-0.02, 0.06]
Dizziness	0.03 [-0.01, 0.08]	-0.02 [-0.03, 0.00]∗	0.02 [-0.02, 0.06]
Menstrual	0.10 [0.01, 0.17]∗	-0.03 [-0.05, 0.00]	0.07 [0.00, 0.14]
Hot Flashes	0.04 [-0.02, 0.11]	-0.02 [-0.05, 0.00]∗	0.02 [-0.04, 0.08]
Other	0.03 [-0.01, 0.08]	-0.02 [-0.03, 0.00]∗	0.02 [-0.03, 0.06]
All	0.03 [-0.01, 0.08]	-0.02 [-0.03, 0.00]	0.02 [-0.03, 0.06]
		Symptom	
	Direct Effect	*Indirect Effect*	*Total Effect*
Head and back aches	0.04 [-0.12, 0.19]	0.01 [0.00, 0.05]	0.05 [-0.11, 0.21]
Cold and flu	0.10 [-0.11, 0.33]	0.02 [0.00, 0.09]	0.13 [-0.09, 0.37]
Digestive	0.18 [-0.18, 0.59]	0.04 [-0.01, 0.19]	0.23 [-0.16, 0.65]
Dizziness	0.44 [-0.10, 1.04]	0.05 [-0.01, 0.32]	0.52 [-0.09, 1.18]
Menstrual	0.12 [-0.26, 0.50]	0.01 [-0.03, 0.05]	0.13 [-0.24, 0.51]
Hot Flashes	-0.04 [-0.56, 0.54]	0.03 [-0.02, 0.10]	-0.01 [-0.54, 0.57]
Other	0.25 [-0.09, 0.59]	0.01 [-0.01, 0.03]	0.25 [-0.09, 0.59]
All	0.42 [-0.22, 1.04]	0.08 [-0.02, 0.37]	0.52 [-0.17, 1.14]
		Interaction	
	Direct Effect	*Indirect Effect*	*Total Effect*
Head and back aches	-0.01 [-0.08, 0.05]	0.00 [-0.02, 0.00]	-0.02 [-0.08, 0.05]
Cold and flu	-0.04 [-0.14, 0.05]	-0.01 [-0.03, 0.00]∗	-0.05 [-0.15, 0.04]
Digestive	-0.07 [-0.23, 0.07]	-0.02 [-0.07, 0.00]	-0.09 [-0.26, 0.06]
Dizziness	-0.17 [-0.41, 0.05]	-0.02 [-0.12, 0.00]∗	-0.21 [-0.46, 0.04]
Menstrual	-0.04 [-0.19, 0.11]	-0.01 [-0.03, 0.01]	-0.04 [-0.19, 0.10]
Hot Flashes	0.05 [-0.22, 0.29]	-0.01 [-0.05, 0.01]	0.03 [-0.23, 0.28]
Other	-0.08 [-0.23, 0.06]	-0.01 [-0.02, 0.00]	-0.09 [-0.24, 0.05]
All	-0.16 [-0.41, 0.09]	-0.04 [-0.14, 0.00]	-0.21 [-0.46, 0.07]

Table B.4: Indirect estimates of neuroticism and symptom on hours of sleep

C. Assigning letter and numeric grades in Study 2

In study 2, the education study, students were asked each week if they had received feedback on an assignment, test, paper, etc. If they responded yes, they were asked to report the grade they have received. This was an open-ended question and students provided a range of answers. Most common were fractions, percentages and letter grades. In order to include all feedback reports in each of the models, each report needed a letter and a numeric grade. First, all numeric grades were transformed to be the percent correct x 100. (E.g., an 88 indicates that a student received 88% of the total points possible.) From there, missing information was filled in through a series of rules.

Table C.1 shows the rules used to assign letter grades if a numeric grade was provided. Numeric grades were rounded down to the nearest whole number, in the case where the numeric grade included a fraction of a percent. So a numeric 79.7 would have received a C+ letter grade.

Some students provided letter grades, instead of numeric ones. In those cases, students were given the smallest possible numeric grade they could have earned to receive

Numeric Grade Provided	Letter Grade Assigned
0 - 59	F
60 - 62	D-
63 - 66	D
67 - 69	D+
70 - 72	C-
73 - 76	C
77 - 79	C+
80 - 82	B-
83 - 86	B
87 - 89	B+
90 - 92	A-
93 - 96	A
100+	A+

Table C.1: Letter grade assigned based on numeric grade provided.

that letter grade. One exception was if a student reported an F, in which case they received a 50, not a 0. Those values are provided in Table C.2.

Finally, there were instances in which a participant reported that they had received a grade but did not report what grade it was. In those cases, the numeric grade was imputed using the following procedure. First, the data were subsetted to include only occasions where students received feedback on the same type of project (Exam, Paper, Project, Homework) and had the same response on the question "How did you feel about the grade you received?". The average of these numeric grades was found and used as a proxy for the grade received by the student. This method was chosen, as it was noted that students often seemed less upset by lower grades on exams than they did about average grades on written papers. Analyses were run with and without these imputed scores, but no substantial difference was observed.

Several other rules were established, in the event of odd cases. They are as follows:

- If a participant writes in either the feedback box (i.e., indicates in the open-ended

Letter Grade Provided	Number Grade Assigned
F	50
D-	60
D	63
D+	67
C-	70
C	73
C+	77
B-	80
B	83
B+	87
A-	90
A	93
A+	100

Table C.2: Numeric grade assigned based on letter grade provided.

question that they received a grade of some kind but does not write their grade) or responds to the question "How did you feel about the grade you received?", the participant is assumed to have received feedback and their score was imputed (see above).

- If a participant indicates that grades were curved in some way, the numeric grade is based upon the letter grade they received.
- If a participant reports receiving grades for multiple assignments, each assignment consists of one observation. This meant that in some models, assignments are nested within weeks, nested within participant.
- If a participant reports multiple grades for the same project, the lowest grade is the one used in the analyses.

D. Estimates of direct and indirect effects in Study 2

Direct and indirect effects were estimated using a bootstrapping procedure. For each iteration of the bootstrap, model 2 (in which neuroticism interacted with feedback to estimate behavior) was run to estimate the total effect of neuroticism, fedback and their interaction. In the case of letter grade, the models were unable to run with multiple situations (i.e., B compared to A, C compared to A, etc.). Instead, a binary variable was created that was 0 when a student received a B- or better and 1 when they received a C+ or worse.Next, the two emotions were added to the model, and the estimates for neuroticism, feedback and interaction were used as the direct effects. Indirect effects were calculated by subtracting the direct effect from the total effect. Bootstrapping was run with 1,000 iterations. Presented here are four tables, one for each behavior, which shows the indirect effect, direct effect and total effect for neuroticism, feedback and interaction, with each symptom as a separate row in the table.

Symptom	Direct Effect	Neuroticism Indirect Effect	Total Effect
Received grade	-0.04 [-0.24, 0.15]	0.05 [-0.01, 0.10]	0.01 [-0.18, 0.19]
Letter grade	0.11 [-0.04, 0.28]	0.06 [-0.01, 0.12]	0.17 [0.02, 0.33]∗
Number grade	0.21 [0.03, 0.37]∗	0.01 [-0.08, 0.10]	0.22 [0.06, 0.38]∗
Feel about grade	0.22 [0.06, 0.38]∗	-0.01 [-0.10, 0.08]	0.21 [0.07, 0.34]∗
		Feedback	
	Direct Effect	*Indirect Effect*	*Total Effect*
Received grade	0.11 [-0.01, 0.24]	0.00 [-0.01, 0.01]	0.12 [-0.01, 0.24]
Letter grade	-0.12 [-0.27, 0.01]	0.02 [0.00, 0.03]∗	-0.11 [-0.25, 0.03]
Number grade	0.01 [0.00, 0.02]	0.00 [0.00, 0.00]	0.01 [0.00, 0.01]
Feel about grade	-0.02 [-0.09, 0.05]	0.00 [-0.01, 0.01]	-0.02 [-0.09, 0.05]
		Interaction	
	Direct Effect	*Indirect Effect*	*Total Effect*
Received grade	0.20 [-0.01, 0.47]	0.00 [-0.02, 0.02]	0.21 [-0.01, 0.47]
Letter grade	-0.07 [-0.28, 0.13]	-0.01 [-0.03, 0.01]	-0.08 [-0.29, 0.12]
Number grade	0.00 [-0.02, 0.01]	0.00 [0.00, 0.00]	0.00 [-0.01, 0.01]
Feel about grade	-0.05 [-0.16, 0.04]	0.01 [-0.01, 0.02]	-0.04 [-0.15, 0.05]

Table D.1: Indirect estimates of neuroticism and feedback on hours studying

Symptom	Direct Effect	Neuroticism Indirect Effect	Total Effect
Received grade	0.12 [0.06, 0.19]∗	-0.01 [-0.03, 0.01]	0.11 [0.05, 0.18]∗
Letter grade	0.14 [0.07, 0.21]∗	-0.02 [-0.04, 0.01]	0.13 [0.06, 0.19]∗
Number grade	0.10 [0.01, 0.18]∗	0.01 [-0.03, 0.05]	0.12 [0.03, 0.19]∗
Feel about grade	0.09 [0.02, 0.16]∗	0.02 [-0.02, 0.06]	0.11 [0.05, 0.17]∗
		Feedback	
	Direct Effect	*Indirect Effect*	*Total Effect*
Received grade	-0.04 [-0.10, 0.02]	0.00 [-0.01, 0.00]	-0.04 [-0.10, 0.02]
Letter grade	0.05 [-0.01, 0.11]	0.00 [-0.01, 0.00]	0.05 [-0.01, 0.11]
Number grade	0.00 [-0.01, 0.00]	0.00 [0.00, 0.00]	0.00 [-0.01, 0.00]
Feel about grade	-0.02 [-0.05, 0.01]	0.00 [-0.01, 0.01]	-0.02 [-0.05, 0.01]
		Interaction	
	Direct Effect	*Indirect Effect*	*Total Effect*
Received grade	0.00 [-0.09, 0.08]	0.00 [-0.01, 0.00]	-0.01 [-0.09, 0.08]
Letter grade	-0.03 [-0.11, 0.06]	0.00 [0.00, 0.01]	-0.02 [-0.10, 0.06]
Number grade	0.00 [0.00, 0.01]	0.00 [0.00, 0.00]	0.00 [0.00, 0.01]
Feel about grade	0.00 [-0.03, 0.04]	0.00 [0.00, 0.01]	0.01 [-0.03, 0.05]

Table D.2: Indirect estimates of neuroticism and feedback on hours on social media

Symptom	Neuroticism *Direct Effect*	*Indirect Effect*	*Total Effect*
Received grade	0.17 [0.07, 0.26]∗	0.01 [-0.02, 0.04]	0.18 [0.09, 0.27]∗
Letter grade	0.11 [-0.01, 0.23]	0.02 [-0.02, 0.05]	0.13 [0.02, 0.24]∗
Number grade	0.16 [0.03, 0.27]∗	0.00 [-0.05, 0.05]	0.16 [0.04, 0.27]∗
Feel about grade	0.15 [0.04, 0.28]∗	0.00 [-0.04, 0.06]	0.16 [0.05, 0.27]∗
	Feedback		
	Direct Effect	*Indirect Effect*	*Total Effect*
Received grade	0.18 [0.11, 0.26]∗	0.00 [0.00, 0.01]	0.18 [0.11, 0.26]∗
Letter grade	-0.10 [-0.19, -0.02]∗	0.00 [0.00, 0.01]	-0.10 [-0.18, -0.02]∗
Number grade	0.00 [-0.01, 0.00]	0.00 [0.00, 0.00]	0.00 [-0.01, 0.00]
Feel about grade	-0.01 [-0.06, 0.03]	0.00 [-0.01, 0.01]	-0.01 [-0.06, 0.03]
	Interaction		
	Direct Effect	*Indirect Effect*	*Total Effect*
Received grade	-0.05 [-0.18, 0.09]	0.00 [-0.01, 0.01]	-0.04 [-0.18, 0.09]
Letter grade	0.06 [-0.07, 0.19]	0.00 [-0.01, 0.01]	0.06 [-0.07, 0.18]
Number grade	0.00 [-0.01, 0.01]	0.00 [0.00, 0.00]	0.00 [-0.01, 0.01]
Feel about grade	-0.03 [-0.09, 0.03]	0.00 [0.00, 0.01]	-0.03 [-0.09, 0.03]

Table D.3: Indirect estimates of neuroticism and feedback on skipping class

Symptom	Neuroticism *Direct Effect*	*Indirect Effect*	*Total Effect*
Received grade	-0.08 [-0.15, -0.02]∗	0.00 [-0.02, 0.02]	-0.09 [-0.15, -0.03]∗
Feel about grade	-0.11 [-0.19, -0.04]∗	0.00 [-0.04, 0.03]	-0.12 [-0.19, -0.05]∗
Letter grade	-0.12 [-0.20, -0.05]∗	0.00 [-0.02, 0.03]	-0.12 [-0.19, -0.05]∗
Number grade	-0.12 [-0.19, -0.03]∗	0.00 [-0.04, 0.03]	-0.12 [-0.19, -0.04]∗
	Feedback		
	Direct Effect	*Indirect Effect*	*Total Effect*
Received grade	0.14 [0.09, 0.19]∗	0.00 [-0.01, 0.01]	0.14 [0.09, 0.19]∗
Feel about grade	0.00 [-0.03, 0.03]	0.00 [-0.01, 0.01]	0.00 [-0.03, 0.03]
Letter grade	-0.15 [-0.21, -0.10]∗	0.00 [-0.01, 0.01]	-0.15 [-0.21, -0.09]∗
Number grade	0.00 [0.00, 0.01]	0.00 [0.00, 0.00]	0.00 [0.00, 0.01]
	Interaction		
	Direct Effect	*Indirect Effect*	*Total Effect*
Received grade	-0.03 [-0.11, 0.06]	0.00 [-0.01, 0.01]	-0.02 [-0.11, 0.06]
Feel about grade	0.02 [-0.03, 0.06]	0.00 [-0.01, 0.01]	0.01 [-0.03, 0.06]
Letter grade	0.04 [-0.05, 0.12]	0.00 [-0.01, 0.01]	0.04 [-0.05, 0.12]
Number grade	0.00 [-0.01, 0.01]	0.00 [0.00, 0.00]	0.00 [-0.01, 0.01]

Table D.4: Indirect estimates of neuroticism and feedback on visiting professors

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