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NEUROTICISM AND INDICATORS OF DAILY HEALTH: A LIFESPAN DEVELOPMENTAL APPROACH

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ABSTRACT

The current study examined associations between neuroticism and indicators of daily physical health, namely measures of self-reported physical health symptoms and cortisol at waking. Also of interest was whether the associations were moderated by age. Participants included 907 individuals from the National Study of Daily Experiences II (NSDE), an 8-day daily diary telephone study with cortisol assessed on study days 2-5. Age of the participants ranged from 33 to 84. Multilevel modeling was used to analyze the data.

Persons with higher scores on neuroticism were more likely to report at least one physical health symptom on a given day. Higher scores on neuroticism were also related to a higher number and severity of symptoms on symptom days. In addition, individuals with higher scores on neuroticism were more variable in number of symptoms but less variable in symptom severity. These associations were not moderated by age. In regards to cortisol at waking, individuals with higher scores on neuroticism had higher levels of and more within-person variation, suggesting a link between neuroticism and hyperactivity of the HPA axis. This association between neuroticism and cortisol at waking was driven mainly by the older adults. Neuroticism may influence objective daily physical health more in old age as a result of biological vulnerability. In addition, perhaps continued high levels of neuroticism contribute to heightened physical reactivity and sensitivity due to the repeated experience of stressors. This is known as amplification or a kindling effect.

Overall, these results provide support for both the biological and psychological mechanisms proposed to underlie the association between neuroticism and health. The

findings also underscore the complex associations among neuroticism, age, daily physical health symptoms, and cortisol at waking.

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Chapter 1. Literature Review

The primary purpose of this chapter is to review the literature relevant to investigating associations between neuroticism and physical health as well as age differences in these associations. Sections include: (1) an introduction to the topic and study; (2) a review of personality and health research with a focus on neuroticism, including discussion of mechanisms linking neuroticism and health as well as the importance of a lifespan developmental perspective; (3) a discussion of neuroticism and self-reported daily physical health symptoms; (4) an examination of literature linking neuroticism and cortisol; and (5) the research questions and hypotheses for the results of the present study.

Introduction

Lifespan psychological research has long been interested in structural and functional relations between the domains of personality and health (Cattell, 1950; Eysenck, 1967). Personality has been linked to a number of "subjective" measures of health such as self-reported health and well-being as well as more "objective" indicators such as disease and mortality (for review, see Smith & Spiro, 2002). For example, previous empirical work has demonstrated that hostility is associated with a more rapid decline in pulmonary function (Jackson, Kubzansky, Cohen, Jacobs, & Wright, 2007) and is a risk factor for coronary heart disease (for review, see Miller, Smith, Turner, Guijarro, & Hallet, 1996). Interestingly, evidence also links childhood conscientiousness to survival across the lifespan (Friedman et al., 1995). Similarly, studies suggest that high levels of neuroticism (e.g., Wilson, Mendes de Leon, Bienas, Evans, & Bennett, 2004) as well as increases over time (Mroczek & Spiro, 2007) are associated with a greater risk of mortality.

Although there is a rich history of investigation of the links between neuroticism and health, the majority of studies have focused on chronic conditions and disease. Furthermore, this literature has paid little attention to the role of aging in these processes. The current study will expand upon previous ideas by exploring the associations between neuroticism and daily indicators of health, daily physical health symptoms and salivary cortisol at waking, from a lifespan developmental perspective, incorporating examination of the potential moderating effects of age.

Personality and Health

Personality. There are several major models of personality and personality structure according to trait theory; just a brief overview of some of the major work is provided here. Employing a multivariate approach, Cattell found there are sixteen primary factors and five secondary factors of personality, leading to the development of the 16PF Personality Questionnaire (for a review of Cattell's work, see Dreger, 1972). Influenced by this work as well as that of others, theorists such as Goldberg (International Personality Item Pool) and Costa and McCrae (NEO) proposed five dimensions of personality ("Big Five"): extraversion, neuroticism, agreeableness, conscientiousness, and openness to experience (e.g., Costa & McCrae, 1985a, 1992; Goldberg, 1990). In addition, Eysenck posited that personality is comprised of three traits: extraversion, neuroticism, and psychoticism (Eysenck & Eysenck, 1985).

Of the major personality dimensions, neuroticism has consistently been linked to health outcomes, both conceptually and empirically. One definition of neuroticism is the tendency to experience negative emotions and to typically be more reactive to stressful situations (Costa &

McCrae, 1987). In the context of the present study, neuroticism was selected as an exemplar personality characteristic to be examined in its relation to health variables.

Health. Health can be considered a pluralistic or multidimensional and hierarchical construct so that a multi-component definition appears to be most appropriate and informative (Spiro, 2007). Health is pluralistic in that it is comprised of multiple aspects such as subjective well-being, health-related behaviors, and disease. Health is also multidimensional, it is possible that an individual has good health in some domains, yet his or her health is poor in other areas (Spiro, 2007). In regards to hierarchy, health can be described by levels or layers as well as by a temporal axis. Specifically, health represents a daily, yearly, and lifetime phenomenon (Verbrugge, 1986). Given this, research on health can be informed not only by overall assessments of physical health, but also by examining health in a daily context. Such an all-too-rare complementary perspective can comprise self-reports of daily physical symptoms as well as more objective indicators (e.g., cortisol), which are assessed in this study.

Potential Mechanisms Underlying the Association between Neuroticism and Health. There is considerable debate regarding the various mechanisms that may underlie the links between neuroticism and health; both psychological and biological explanations have been proposed. Proponents of a psychological position suggest that, for example, neuroticism may reflect a tendency towards over-reporting of self-reported illnesses as a function of memory and recall bias (Schwarz & Sudman, 1994). Similarly, others argue that neuroticism is related to illness behaviors rather than disease (Costa & McCrae, 1987).

In regards to biological positions, neuroticism has and continues to be conceptualized as a psychophysiological trait (Eysenck & Eysenck, 1985; Zuckerman, 1995). Eysenck (1967) provided support for a biological basis of personality and argued that there are autonomic and

central nervous system correlates of dimensions of personality. Experimental work suggests high emotional reactivity, related to the construct of neuroticism, is characterized by arousal and sensitivity at both the behavioral and physiological level (Eysenck, 1967). Similarly, recent studies have indicated that high levels of neuroticism are associated with larger variability in constructs such as negative affect (Eid & Diener, 1999) as well as weakened circadian rhythmicity in body temperature (Murray, Allen, Trinder, & Burgess, 2002).

Importance of a Lifespan Developmental Perspective in Personality and Health Research. Researchers have argued that utilizing a lifespan developmental perspective can contribute to personality and health research. Influenced by the principles of the lifespan perspective (Baltes, 1987; Baltes, Lindenberger, & Staudinger, 2006), Smith and Spiro (2002) suggests that personality should be considered in context. Different contexts such as work, family, and even health may be more influential at some points in the lifespan than others. For example, compared to younger adults, older individuals report fewer overload stressors but more network stressors (e.g., challenges facing their friends and relatives) (Almeida & Horn, 2004). Younger adults, in contrast, are more focused on balancing work, family, and other responsibilities.

In a seminal overview article of the status of personality-health research, Smith and Spiro (2002) presented guidelines and future directions for personality and health research, some of which contributed to the motivation for the current study. It was argued to (1) precisely define and identify the health measures of interest, (2) focus on particular personality traits and processes, (3) examine moderation of effects by age or life stage, and (4) seek out potential mechanisms. The current study will address these suggestions by (1) examining indicators of daily health (physical health symptoms and cortisol), (2) concentrating on neuroticism, (3)

investigating moderating effects of age, and (4) considering both psychological and biological explanations for the link between neuroticism and health. This will shed some light on the complex association between personality and health as well as on age differences herein.

Neuroticism and Self-reported Daily Physical Health Symptoms

Daily Physical Health Symptoms. Daily physical health symptoms are an integral part of an individual's health experiences during adulthood (e.g., Larsen & Kasimatis, 1991). Verbrugge (1986), for example, suggests health is like an iceberg in that it is comprised of distinct layers. Diseases and injuries are often the focus of health-related research and as such, are represented by the top of the iceberg, which is exposed and visible above the water. Daily physical symptoms are beneath, making up the large bottom layer of the iceberg, which is not evident to the eye at first glance. Although physical health symptoms comprise the majority of ill health experiences, little is known about the prevalence of and functional implications associated with daily health (Larsen & Kasimatis, 1991; Merrill & Verbrugge, 1999; Verbrugge, 1986). Initial evidence from large-scale U.S. national samples suggests that health symptoms impact daily life and well-being, specifically affect (Charles & Almeida, 2006). Similarly, consideration of physical health symptoms is crucial because they prompt people to consult physicians and are used by them to determine medical diagnoses (Stone, 2000; Verbrugge, 1986).

According to Pennebaker (1982), physical symptoms are defined as the perception, feeling, or belief about the state of one's body. Physical health symptoms can be measured in a variety of ways including count and severity. Diary and ecological momentary assessment studies afford the opportunity for investigation of the proportion of days or occasions with one or more symptoms as well as variability in symptom reports.

Neuroticism and Self-reported Health. Health reports are complex in nature and are influenced by a number of factors. The extant literature suggests that it is important to consider individual difference characteristics, including neuroticism, when examining self-reported measures of health such as perceived global health and chronic physical conditions (e.g., Cleary, Zaborski, & Ayanian, 2004; Costa & McCrae, 1980, 1985b; Ebert, Tucker, & Roth, 2002; Kirmayer, Robbins, & Paris, 1994; Neeleman, Bijl, & Ormel, 2004). Little is known, however, regarding the relation between neuroticism and daily physical symptoms.

Initial evidence suggests that personality not only relates to global subjective assessments of health but to daily reports as well. Specifically, a recent study utilized ecological momentary assessment to investigate personality, mood states, and daily health by asking college students to complete a mood and symptom report 3 times a day for 8 consecutive weeks (Larsen, 2007). Neuroticism was found to be strongly correlated with reports of symptoms, particularly distress- and gastrointestinal-related symptoms. These initial findings support further investigation of the association between personality and daily health. They also indicate that recall bias may not be the sole mechanism underlying neuroticism-health links, given that its influence is reduced with frequent data collection.

In fact, there is a growing interest in the study of personality and everyday experiences and examining how personality as a dynamic process unfolds daily (Tennen, Affleck, & Armeli, 2005). Much of the related literature has focused on reactions to everyday events and stressors and this can and has begun to be extended to health-related daily processes. The majority of researchers emphasize personality as a predictor of the onset of illness, employing a unidirectional perspective (Larsen, 2007). However, through the application of a more dynamic

and daily view of health, new questions can be asked and addressed about a more bidirectional association of personality and health.

Potential Age Differences in the Association between Neuroticism and Daily Physical Health Symptoms. There is evidence to suggest that neuroticism shows mean-level decline in later phases of adulthood and old age (e.g., Mroczek & Spiro, 2003). Research related to daily physical health symptoms, however, has revealed conflicting evidence about whether the experience of daily health changes with age (Horn-Mallers, Almeida, & Neupert, 2005; Verbrugge, 1986). Recent evidence suggests that young and middle-aged women report more frequent physical symptoms than older women (Horn-Mallers et al., 2005). Earlier studies have found that symptom rates are similar across age for women (Verbrugge, 1986). In contrast, men were characterized by a curvilinear pattern, with the fewest symptoms in midlife and a significant increase at older ages (Verbrugge, 1986). It appears that basic questions about the daily health of adults remain unanswered and this necessitates clarification.

One position argues that researchers should examine neuroticism as a potential moderator of the association between subjective and objective health because age, in and of itself, may not be the source of exaggerated somatic concerns (Costa & McCrae, 1985b). Health complaints in older adults could reflect changing health status and increased biological vulnerabilities (decline), and their self-reported health may be less susceptible to personal dispositions and characteristics such as neuroticism. Other work proposes that there are age differences concerning the experience and perceived significance of physical symptoms and conditions (George, 2001). Older adults are more likely than their younger counterparts to disregard or overlook mild symptoms despite their increased vulnerability to disease (Prohaska, Leventhal, Leventhal, & Keller, 1985); this points to the possibility that daily subjective health may be

relatively more detached from objective health in older adults than in younger adults. In sum, what is not well understood is if and how the association between neuroticism and self-reported health, particularly daily symptoms, varies across age. It is conceivable that neuroticism is less strongly related to self-reported daily health, particularly perceived symptom severity in old age.

Neuroticism and Cortisol

Cortisol. Cortisol is a critical hormone that impacts functioning and is one objective indicator of health that is not easily susceptible to reporting biases. This hormone is a biological marker of activity of the hypothalamic-pituitary-adrenal (HPA) axis (Dickerson & Kemeny, 2004). Corticotrophin releasing hormone (CRH) initiates activation of the HPA axis. CRH stimulates the anterior portion of the pituitary gland to release adrenocorticotropin hormone (ACTH), which then prompts the adrenal cortex to secrete cortisol into the bloodstream (Dickerson & Kemeny, 2004; Kemeny, 2003). The HPA axis plays an important role in promoting normal physiological functions and influences many biological systems. One function of cortisol is related to metabolism; the hormone mobilizes energy by increasing blood glucose levels, which provides fuel for the body. Cortisol can also influence functioning of the immune system by inhibiting proteins involved in regulating inflammation (Dickerson & Kemeny, 2004).

Chronic HPA axis activation (prolonged elevated cortisol levels) has been associated with disease as well as cognitive and affective processes. This includes, for example, development and progression of chronic illnesses such as diabetes and damage to hippocampal neurons involved in memory (Dickerson & Kemeny, 2004). Current theories and work also suggest declines in cortisol and poor cortisol signaling may be harmful as well, contributing to

poor health outcomes and conditions such as chronic fatigue syndrome (Miller, Chen, & Zhou, 2007).

Many studies measure cortisol responses in laboratory-controlled settings following acute stressors (for review, see Dickerson & Kemeny, 2004). In contrast, measurement of cortisol in natural day-to-day environments is less common, which is a strength of the present study.

Neuroticism and Cortisol. An emerging area of research is the role of personality, specifically neuroticism, in the functioning of the hypothalamic-pituitary-adrenal axis. To date, empirical evidence is equivocal regarding this topic; the findings of some studies suggest a link between neuroticism and hyperactivity of the HPA axis (Portella, Harmer, Flint, Cowen, & Goodwin, 2005; Vedhara, Tuin stra, Miles, Sanderman, & Ranchor, 2006; Zobel et al., 2004), whereas other researchers have demonstrated that neuroticism is associated with hypoactivity (McCleery & Goodwin, 2001; Oswald, Zandi, Nestadt, Potash, Kalaydijian, & Wand, 2006; Phillips, Carroll, Burns, & Drayson, 2005). In addition, other work has revealed there is no relation between this personality trait and the diurnal rhythm or responsiveness of cortisol (Schommer, Kudielka, Hellhammer, & Kirschbaum, 1999).

More specifically, a first set of recent studies suggests that neuroticism is positively associated with altered adrenocortical regulation, specifically increased HPA axis activity (hyperactivity) (Portella et al., 2005; Vedhara et al., 2006; Zobel et al., 2004). In particular, high neuroticism has been linked to enhanced early morning salivary cortisol in a sample of healthy adults as well as a higher early morning peak among newly diagnosed breast cancer patients (Portella et al., 2005; Vedhara et al., 2006). Furthermore, other results revealed that high scores on neuroticism are related to higher cortisol levels following a challenge (combined dexamethasone/corticotrophin-releasing hormone – Dex/CRH test) in a laboratory controlled

setting (Zobel et al., 2004). Combined, this series of studies suggests that higher neuroticism may be associated with hyperactivity of the HPA axis, as indexed by higher cortisol concentrations in response to a challenge as well as enhanced levels and a higher peak in the morning.

A second set of empirical work indicates that neuroticism relates to hypoactivity rather than hyperactivity of the HPA axis (McCleery & Goodwin, 2001; Oswald et al., 2006; Phillips et al., 2005). For example, one study of young, healthy adults demonstrated that higher neuroticism is related to blunted, rather than elevated, cortisol responses to laboratory psychological stress tests (Oswald et al., 2006). Similarly, McCleery and Goodwin (2001) found that in college students, individuals with low neuroticism scores show a significantly greater cortisol response to the combined dexamethasone-CRH test than their high-neuroticism counterparts. Another study focusing on vaccination revealed that high scores on neuroticism are associated with poorer antibody response and blunted cortisol reactivity (Phillips et al., 2005). This body of literature highlights the possibility that neuroticism is related to HPA axis hypoactivity, at least following some type of controlled stressor or test; this is in direct contrast to the first set of studies discussed.

To further murky the waters and add to the confusion, others have argued that there is no or limited evidence for a close relation between personality traits, including neuroticism, and the rhythm of cortisol or cortisol responses as a result of single exposure to a psychosocial stressor (Schommer et al., 1999).

There is obviously considerable debate regarding the association between neuroticism and functioning of the HPA axis; the literature does not provide a clear picture at this point. It is important to note that all studies mentioned utilized small samples of varying ages and

characteristics (e.g., differing levels of health). Furthermore, measurement and modeling of cortisol differed (e.g., free cortisol concentrations vs. cortisol responses to a stressor). Given the age range and large sample size of the second wave of the National Study of Daily Experiences, we are in a unique position to shed light on this area and help resolve this conundrum by examining, specifically, if neuroticism is associated with cortisol at waking, which is of focus given previous research linking this measure of cortisol with neuroticism.

Potential Age Differences in the Association between Neuroticism and Cortisol. As previously mentioned, studies suggest neuroticism decreases with age (e.g., Mroczek & Spiro, 2003). In regards to the HPA axis, animal research points to cortisol dysregulation as critical to the aging process (Sapolsky, Krey, & McEwen, 1986). There has been limited investigation of salivary cortisol in older adults, but it appears the HPA axis may change with age. Although, the research is not clear on this matter; results of past studies are equivocal regarding how profiles of cortisol are different for older individuals, compared to their younger counterparts (see review by Ice, Katz-Stein, Himes, & Kane, 2004).

Few researchers have investigated the association between neuroticism and age as it relates to cortisol. It may well be possible that the explicit consideration of age may help to resolve the above conundrum. Specifically, the association between neuroticism and cortisol at waking may differ as a function of age. In young adults, perhaps being high in neuroticism is associated with hyperactivity or high levels of cortisol at waking. In older adults, scoring high on neuroticism, in contrast, may be related to lack of adaptation by the HPA axis and/or inadequate cortisol response due to accumulation of damaging effects on the HPA axis, which can be considered two forms of allostatic load (for a review of allostatic load, see McEwen & Seeman, 1999); this could result in hypoactivity, characterized by low levels of cortisol at

waking. Allostatic load refers to the accumulation of negative effects and wear and tear the body experiences as a result of repeated adaptation to a variety of environmental and psychosocial challenges (McEwen & Seeman, 1999).

Conclusion

Research regarding the relation between neuroticism and self-reported health would greatly benefit from the consideration of daily physical symptoms, which are an important aspect of health not often acknowledged. As discussed, some research has also linked neuroticism to cortisol and functioning of the HPA axis; although the results are mixed. Furthermore, there is limited empirical work investigating age differences in the associations between neuroticism and these subjective and objective indicators of health, particularly at the daily level. Following from a lifespan developmental perspective, it is possible that these associations differ as a function of age. The present study seeks to contribute to the literature by addressing these issues in a national sample with participants covering the entire adult age range.

Research Questions and Hypotheses

There are two major objectives of this study; Table 1 shows the research questions and hypotheses. The first objective is to investigate associations between the personality trait neuroticism and aspects of daily self-reported health as well as the potential moderating effects of age. Consistent with a multidimensional view of health, daily physical health is conceptualized in a number of different ways, ranging from the probability of endorsing at least one symptom on a given day, the mean number and severity of symptoms on symptom days, to the variability in number and severity of symptoms. It is expected that neuroticism will be associated with a greater likelihood of reporting at least one physical health symptom on a given day as well as a higher number and severity of symptoms on symptom days. Further, it is

anticipated that neuroticism will be related to higher within-person variation in number of symptoms but not necessarily for symptom severity, potentially due to appraisals (consistently high perceived severity). In addition, age may moderate these associations; the relation between neuroticism and dimensions of daily health may be weaker for older adults.

The second objective is to examine associations (and age differences in these associations) between neuroticism and a more biological, objective indicator and marker of health, cortisol at waking. The hypothesis is that neuroticism will be associated with high levels of cortisol at waking, but the association may depend on age; high scores on neuroticism will be associated with hyperactivity of the HPA axis for young adults, but hypoactivity among older individuals, reflecting allostatic load (wear and tear [burnout] over time).

Chapter 2. Methods

This chapter describes the research methods employed in the present study. Description of the procedures, including daily saliva collection and cortisol assaying, as well as participants, measures, and plan of analysis comprise this chapter.

Procedures

Present analyses utilized data from the second wave of the National Study of Daily Experiences (NSDE II), a sub-study of the National Survey of Midlife in the United States (MIDUS II, telephone-mail survey conducted in 2004-2006). NSDE II provided follow-up on the daily diary study included in the first MIDUS investigation by repeating the 8-day telephone interview protocol. In addition, there were multiple salivary cortisol assessments on study days 2-5 (4 occasions on 4 days); Figure 1 provides an overview of the daily diary and salivary home collection. The general purpose of the MIDUS was to investigate health and well-being in midlife. Refer to Brim, Ryff, and Kessler (2004) and Almeida (2005) for thorough accounts of the MIDUS and NSDE procedures, respectively.

Data collection for the current sample of NSDE II respondents occurred in 2005-2007 with separate flights of interviews of approximately 25 participants, each one representing an 8-day sequence of interviews. The day of the week interview flights was initiated was staggered in order to control for the possible confounding between day of study and day of week. One week prior to contact, participants were sent a recruitment letter explaining the study and when they would be called as well as a $25 check. A number of response and retention strategies were utilized such as providing respondents with a toll free 800 number that they could call to arrange and change appointments.

Respondents completed brief telephone interviews about their daily experiences on each of 8 consecutive evenings. During the final interview, participants also answered several questions about their previous week. The initial and final interviews were about 15-20 minutes in duration; the other six interviews lasted approximately 10-15 minutes. Information obtained during the daily interview included time use, physical symptoms, psychological distress, work productivity, and daily stressors. The daily interview was CATI (Computer Aided Telephone Interview) programmed which enabled use of skip patterns and open-ended probe questions as well as allowed interviewers to keypunch data during the interview. Interviews were conducted by the Pennsylvania State University Survey Research Center (SRC).

Daily Saliva Collection and Cortisol Assaying. Respondents were mailed a Home Saliva Collection Kit one week prior to the initial phone call as part of the recruitment process. Saliva was obtained using salivette collection devices (Sarstedt). Included in the kit were detailed instructions as well as 16 numbered and color-coded salivettes, each one contained a small absorbent wad that was approximately ¾ of an inch in length. To minimize the influence of factors that may compromise the samples (see Kirschbaum, Read, & Hellhammer, 1992), directions sent to participants stated that collection was to occur at least 1 hour after consumption of a major meal. In addition, participants were instructed to restrict intake of dairy products 20 minutes prior to collection of each sample. Prescription and over-the-counter medications taken during the collection period were recorded as well as the history of any endocrine-related disorders. The sample's pH was checked and corrected if outside the acceptable range (pH 4-9) prior to immunoassaying for cortisol.

On saliva collection days (study days 2-5 of the 8-day sequence), participants produced four saliva samples (at waking, 30 minutes after waking, before lunch, and at bed time). The

specific time each sample was provided was obtained from a paper-pencil log that was part of the collection kit and if missing, was substituted with information from the nightly telephone interviews.

Participants used a pre-addressed, paid courier package for the return mailing of the salivettes. The salivettes were shipped to the MIDUS Biological Core at the University of Wisconsin, where they were stored in an ultracold freezer at -60 °C. For analysis, the salivettes were thawed and centrifuged at 3,000 rpm for 5 minutes yielding a clear fluid with low viscosity. Concentration of cortisol was measured using a commercially available luminescence immunoassay (IBL, Hamburg, Germany) with intra-assay and inter-assay coefficients of variations below 5%, based on previous studies (Dressendörfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992; Polk, Cohen, Doyle, Skoner, & Kirschbaum, 2005).

Participants

Of the 1,992 MIDUS II respondents contacted, 1,265 agreed to participate, yielding a response rate of 63%. Respondents generally completed the majority of the daily interviews: 72% of the participants completed all eight interviews (7+ interviews: 90%). The result was a total of 9,536 days out of a possible 10,120 (or 94%). Of the 1,265 individuals, there were 800 random digit dialed respondents (RDD), 233 twins, 176 siblings, and 56 city oversamples. Ninety percent of the respondents (1,143) provided saliva samples, which have been assayed for cortisol. 17,464 out of a possible 18,288 samples (or 96%) were usable, with the remainder being either missing or with inadequate volume to detect cortisol (532; ~3%) or out of range potentially due to improper collection (292; < 2%).

For the present study, the sample was limited to unrelated individuals by selecting one member of each family in order to remove further confounding nesting occurring within families.

Furthermore, respondents were selected who provided complete and valid data on the demographic and predictor variables of interest (gender, education, age, number of chronic health conditions, self-rated health, average wakeup time, and neuroticism) as well as had at least one valid value for cortisol at waking across the study days. In order to attempt to control for saliva collection noncompliance, days were dropped from the cortisol at waking analyses when a participant woke up after noon, was awake for more than 20 or less than 12 hours, lunch cortisol was 10 nmol/1 higher than cortisol collected 30 minutes after waking, and/or the second collection was taken more than 1 hour after the sample at waking. This resulted in a final sample of 907 individuals with 6,895 daily telephone interviews out of a possible 7,256 (or 95%) and 3,185 waking cortisol samples out of a possible 3,628 (907 X 4 days; or 88%).

Table 2 provides demographic and background characteristics of the sample. The participants ranged from 33 to 84 years of age (M = 58, SD = 12). Approximately 55% of the respondents were female. In regards to marital status, 73% were married at the time of the study, 13% were separated or divorced, 8% were widowed, and 6% were never married. Furthermore, 90% had at least one child. In regards to educational status, approximately 31% reported they had graduated from high school or less. The remainder had some college (23%), obtained either an associate's or bachelor's degree (28%), or had at least some graduate level training (18%). Ninety-three percent (93%) of the sample described themselves as Caucasian, 3% African American, and 4% as other. Respondents, on average, reported 2.51 chronic conditions with a standard deviation of 2.41. In regards to self-rated physical health, 18% indicated they were in excellent health, 41% very good, 30% good, 8% fair, and 3% poor. Overall, the sample was rather representative of the U.S. population, although most of the respondents were Caucasian and fairly well-educated.

Measures

Neuroticism. As part of the MIDUS II self-administered questionnaire, personality traits were measured by asking participants how much each of 31 self-descriptive adjectives described them. Response options included: *a lot* (1), *some* (2), *a little* (3), and *not at all* (4). Neuroticism was assessed by four items (e.g., *moody*). The adjectives for the personality scales were selected from existing trait lists and inventories (Bem, 1981; Goldberg, 1992; John, 1990; & Trapnell & Wiggins, 1990); some additional items were also generated to increase reliabilities of certain scales. The neuroticism scale was constructed by calculating the mean across the set of items for cases that had valid values for at least half of the scale items. The items, except *calm*, were reverse-coded such that higher scores reflected higher standings in each dimension. Coefficient alpha for the neuroticism scale was approximately.75 in the current sample (n = 907); the average score on neuroticism was 1.99 with a standard deviation of .62. Detailed descriptions of the personality scales created for the MIDUS, including scale construction, scoring, and measurement properties can be found in Lachman & Weaver (1997).

The personality scales have been used in a number of studies that have demonstrated their construct validity. For example, the neuroticism scale is negatively associated with subjective physical health and global well-being (Staudinger, Fleeson, & Baltes, 1999).

Daily physical health symptoms. Daily physical symptoms were measured in the NSDE II using an adapted version of Larsen and Kasimatis' (1991) physical symptom checklist. Participants were asked every study day whether they experienced each of 27 symptoms (headache, backache, muscle soreness, fatigue, joint pain, muscle weakness, cough, sore throat, fever, chills, other cold/flu symptoms, allergies, nauseas, diarrhea, constipation, poor appetite, other stomach problems, dizziness, hot flashes/flushes, chest pain, shortness of breath/difficulty

breathing, menstrual-related symptoms, skin-related problems, eye-related problems, ear-related problems, teeth-related problems, and any other physical symptoms). For the present study, two symptoms were dropped (hot flashes/flushes and menstrual-related symptoms) because they were mainly applicable to women respondents. For each symptom experienced, participants were asked to rate the severity of the symptom on a 10-point Likert-scale (1 = *very mild*, 10 = very *severe*).

From these responses, three variables were created: *any symptoms*, *number of symptoms*, and *symptom severity*. *Any symptoms* was a binary variable, indicating whether the respondent reported having one or more symptoms on that day. Symptoms were reported on 64% of the study days. On each symptom day, *number of symptoms* was calculated by summing affirmative responses from the 25-item symptom list (M = 2.62, SD = 1.99). This distribution of this count variable was non-normal (skewness = 2.01, kurtosis = 6.10). Future analyses will use multilevel poisson regression to account for this distribution. *Symptom severity* was determined by computing the mean of the symptom severity ratings on each symptom day (M = 3.58, SD = 1.75).

Daily Cortisol at Waking. Following from previous studies (e.g., Adam, Hawkley, Kudielka, & Cacioppo, 2006) cortisol values were transformed due to positive skew in the data. One was added and then the natural log was taken; the resulting mean waking cortisol across the 4 days of saliva collection was 2.69 with a standard deviation of .57. On average, participants woke up and provided their first sample at approximately 6:45 A.M. (SD = 1 hour 15 minutes).

Data Analysis

Given the nested structure of the data, multilevel models were used to account for the repeated measurements nested within individuals (Snijders & Bosker, 1999). In addition, this

approach treats incomplete data as missing at random (Little & Rubin, 1987); participants with fewer interview days were given less weight in the analyses. All models were fit to the data using SAS (Littell, Miliken, Stoup, & Wolfinger, 1996).

Daily Physical Health Symptoms. To address the research objectives of the present study, three sets of three multilevel models were used to examine the unique association of neuroticism with each of the daily health variables of interest (any symptoms, number of symptoms, and symptom severity) as well as how age moderates these associations. Model 1 examined the association of neuroticism with the daily physical health symptom variables controlling for gender, education, and age as well as interview day effects. The extant literature suggests these demographic characteristics are related to physical health (e.g., Cleary et al., 2004, Marmot, 2004). Number of chronic conditions and self-rated health were entered in Model 2 to investigate the relation between neuroticism and daily symptoms, above indicators of global health (Cleary et al., 2004). Finally, Model 3 included the neuroticism by age interaction term to test if the association was moderated by age. Linear multilevel regression was used to model number of symptoms and symptom severity, while logistic multilevel modeling was necessary to model the dichotomous variable, any symptoms. Neuroticism, age, education, number of chronic conditions, and self-rated health were standardized prior to analysis.

To examine the association between neuroticism and daily physical health symptoms, Model 1 was parameterized as:

Level 1: $Y_{it} = \beta_{0i} + \beta_{1i}(day_{it}) + \beta_{2i}(day_{it}*day_{it}) + e_{it}$

Level 2: $\beta_{0i} = \delta_{00} + \delta_{01}(gender_i) + \delta_{02}(education_i) + \delta_{03}(age_i) + \delta_{04}(neuroticism_i) + u_{0i}$

$\beta_{1i} = \delta_{10} + u_{1i}$

$\beta_{2i} = \delta_{20} + u_{2i}$

Where, at Level 1, Y_{it} is the score on the variable of interest (any, number, or severity of symptoms) for person *i* at time (day) *t*, is a function of an individual's intercept (average), β_{0i}, and residual error, e_{it}, controlling for linear (β_{1i}) and quadratic (β_{2i}) effects of day of study. At Level 2, β_{0i} is a function of the between-persons intercept, δ_{00}, the between-persons effects of gender, δ_{01}, education, δ_{02}, age, δ_{03}, neuroticism, δ_{04}, and a between-persons error term, u_{0i}. In Model 2, number of chronic conditions and self-rated health were added to Level 2. Finally, the neuroticism by age interaction term was included at Level 2 in Model 3.

In addition, linear multilevel models can be used to examine individual differences in within-person variation (Hoffman, 2007). Substantively significant heterogeneity in residual error can occur at Level 1, which may be modeled as a function of predictor variables (Raudenbush & Bryk, 2002). The residual errors were allowed to vary across individuals, σ_i^2, in order to test whether the within-person variation in number and severity of daily physical health symptoms was associated with neuroticism and/or age (included in Models 1 and 2):

$$\text{Level 1 residual: } \sigma_i^2 = \alpha_0(\exp(\alpha_1\,(\text{neuroticism}) + \alpha_2\,(\text{age}))$$

The interaction between neuroticism and age was aged to the Level 1 residual equation at Model 3. The exponential function was utilized to limit the influence of the mean and normalize the variance in order to employ a linear prediction model.

Daily Cortisol at Waking. The same analysis procedure (hierarchical linear multilevel modeling) was followed for cortisol at waking as described for number and severity of daily physical health symptoms, except that average wakeup time was also included (beginning at Model 1) as covariate. In addition, linear and quadratic fixed effects of day of study were not significant and excluded from these models.

Chapter 3. Results

The results are provided in two main sections. The first section reports analyses examining associations between neuroticism and measures of daily physical health symptoms, including three main outcomes: (1) any symptoms (endorsing at least one physical health symptom on a given day) as well as (2) number and (3) severity on symptom days. The second section investigates the association between neuroticism and cortisol at waking.

Daily Physical Health Symptoms

Any Symptoms. The results from the hierarchical multilevel logistic regression analyses modeling any daily physical health symptoms are given in Table 3. Model 1 examined the association of neuroticism with reporting at least one symptom, controlling for demographic characteristics (gender, education, and age) and interview day effects. Number of chronic conditions and self-rated health were entered in Model 2 to investigate the relation between neuroticism and any daily symptoms, above indicators of global health. Finally, Model 3 included the neuroticism by age interaction term to test if the association was moderated by age.

In Model 1, the odds of reporting a symptom decreased across study day. The rate of change, however, was not constant; there was deceleration. Figure 2 represents the linear and quadratic effects of day of study, showing the largest decline was between the first and second day of study. Women were more likely than men to report any symptoms; education and age, however, were not associated with the likelihood of endorsing a symptom. Neuroticism was found to be a predictor of any symptoms, persons one standard deviation above the mean in neuroticism were 78% more likely to have at least one physical health symptom on a given day[1]. The intercept (2.00), given in the note of Table 3, represents the log-odds of endorsing any symptoms for a man of average age, education, and neuroticism on the first day of the study.

Also included in the note is the random effect for the intercept, which indicates that the intercept varied significantly across persons.

Model 2 demonstrates that those with more chronic conditions were more likely to endorse a symptom as well as those with poorer self-rated health. Neuroticism remained a significant predictor, although the effect was reduced compared to the prior model. The interaction between neuroticism and age was not significant (Model 3), suggesting that the association between this aspect of personality and reporting at least one daily physical health symptom was consistent across age.

Number and Severity of Symptoms. Tables 4 and 5 show the results from the multilevel linear regression analyses modeling the number and severity of daily physical health symptoms on symptom days (n = 4,380). Three models were estimated for both of these daily symptom variables as described above for the dichotomous outcome, any symptoms, with the addition of testing the effect of age and neuroticism (Models 1 and 2) as well as their interaction (Model 3) on the residual variance.

The intercepts, as shown in Tables 4 and 5 for Model 1, represent the predicted number (2.63) and severity (3.34 on a scale from 1 to 10) of symptoms on symptom days for a man of average age, education, and neuroticism on the first day of the study. The linear effect of day of study was significant and negative for number of daily physical health symptoms and severity, indicating a decrease across study days. The quadratic effect of day of study was significant and positive for both of the health outcomes, suggesting that the decline in reporting symptoms was stronger in the beginning of the study (similar to Figure 2 for any symptoms). Women reported a higher number of symptoms and those they reported were perceived as more severe. Higher levels of education were not related to reporting more symptoms, but were associated with less

severe symptom ratings. Age was not associated with severity; however, older adults reported a higher number of symptoms. Higher scores on neuroticism were related to a higher number of symptoms and higher severity[2] (see Figure 3).

In addition to level, neuroticism was investigated as a predictor of day-to-day variation in number and severity of symptoms. Higher levels of neuroticism were associated with less within-person variance in symptom severity, but more within-person variance in number of daily physical health symptoms (see neuroticism effects on residual variance in the bottom portion of Tables 4 and 5). There was no effect of age on either of the residual variances, meaning that within-person variation in the number and severity of symptoms did not differ as a function of age. The random effects for the intercepts were significant, indicating that the intercepts varied significantly across persons. In addition, the random effects of day and day*day were significant; there were individual differences in the rate of change in number and severity of daily physical health symptoms across the study days.

Model 2 in Tables 4 and 5 shows that a higher number of chronic conditions and poorer self-rated health were associated with more symptoms and higher perceived severity. Neuroticism remained a significant predictor for both outcomes when controlling for these indices of global health, although the effect was reduced (partially mediated) compared to the prior models. The fixed effects and effects on the residual variance of the interaction between neuroticism and age were not significant, suggesting that the associations are constant across the lifespan (Model 3 in Tables 4 and 5).

Cortisol at Waking

Multilevel linear models were also used to examine the association of neuroticism with salivary cortisol at waking. Model 1 examined the association of neuroticism with cortisol,

controlling for demographic and personal characteristics (gender, education, age, and average wakeup time). Number of chronic conditions and self-rated health were entered in Model 2 to investigate the relation between neuroticism and cortisol, above global health. Model 3 included the neuroticism by age interaction term to determine if the association was moderated by age. Simultaneously, the effects of age and neuroticism (Models 1 and 2) as well as their interaction (Model 3) on the residual variance were also tested.

The results are presented in Table 6. The intercept (2.74) represents predicted cortisol at waking (+1, natural log) for a man of average education, age, wakeup time, and neuroticism. Women had lower cortisol values at waking, compared to men. In addition, greater education and being older were associated with higher levels of cortisol at waking. Average wakeup time was not related to waking cortisol values. Neuroticism was not associated with cortisol in Model 1, but after including number of chronic conditions and self-rated health (Model 2), higher scores on neuroticism were associated with higher cortisol at waking. A higher number of chronic conditions and poorer self-rated health were associated with lower levels of waking cortisol. As evident in Model 3, the neuroticism by age interaction term was significant, indicating that the effect of neuroticism is not constant across the lifespan[3]. Figure 4 shows that the effect of neuroticism on waking cortisol was mainly driven by the older adults. Older adults with high scores on neuroticism had the highest values of cortisol at waking.

Across the three models (see bottom portion of the table – random effects), there was an effect of age on the residual variance such that increasing age was associated with less within-person variation in cortisol at waking. In contrast, higher scores on neuroticism were associated with more within-person variation (greater day-to-day fluctuations in cortisol at waking). The age by neuroticism effect on the residual variance was not significant.

Chapter 4. Discussion

This discussion chapter consists of three major sections. First, the main findings of the present study are summarized and embedded in previous research and existing literature. Second, the limitations of the current investigation into the relation between neuroticism and daily physical health across the lifespan are considered. Finally, implications for future research in the area of personality and health are outlined.

Summary of Main Findings and Their Relation to Previous Research

Personality, particularly neuroticism, has been linked to a number of global subjective and objective indicators of health. Despite the attention paid to this topic, little research has explored associations between neuroticism and aspects of daily physical health as well as the role of aging in these processes, which strengthens this field of inquiry.

The central objective of the present study was to examine associations between neuroticism and daily health in adulthood as well as moderating effects of age. Daily health was assessed using subjective and objective indicators, namely measures of daily physical health symptoms and cortisol at waking, respectively. Table 7 summarizes the specific questions, hypotheses, and findings.

Neuroticism and Self-reported Daily Physical Health Symptoms. The first set of questions was aimed at investigating the link between the personality trait neuroticism and aspects of self-reported daily physical health symptoms: any symptoms (reporting at least one on a given day) as well as number and severity of symptoms on symptom days. Analyses were also conducted to examine neuroticism as a predictor of within-person variation in number and severity of symptoms. Further, moderating effects of age were tested to determine if the associations were constant across the lifespan.

As expected, persons with higher scores on neuroticism were more likely to report at least one physical health symptom on a given day. Higher scores on neuroticism were also related to a higher number and severity of symptoms on symptom days. The effect of neuroticism remained after controlling for two global indicators of health, self-rated health and number of chronic conditions, indicating that this aspect of personality is a unique predictor of several measures of self-reported daily health, which is consistent with previous research in this area (e.g., Larsen, 2007). This is a critical because daily symptoms are an important component of health, influencing well-being as well as triggering visits to the doctor (Charles & Almeida, 2006; Stone, 2000; Verbrugge, 1986). Furthermore, initial follow-up analyses using NSDE II support these points and suggest daily physical health symptoms are also associated with increased daily cutbacks at work. Prevention and intervention efforts directed at promoting and improving health may be strengthened by incorporating components to reduce neuroticism and increase skills for coping with stress. Also, understanding how personal dispositions are related to symptom reports may assist physicians in treating their patients.

In addition to level, neuroticism was also associated with within-person variation in number and severity of symptoms. Individuals with higher scores on neuroticism were more variable in number of symptoms but less variable in symptom severity. As discussed, past theoretical and empirical work suggests large variability in multiple constructs is characteristic of neuroticism (Eid & Diener, 1999; Eysenck, 1967; Murray et al., 2002). As anticipated, the findings of the present study suggest neuroticism is differentially associated with within-person variation in various daily physical health outcomes. This may be due to level of subjectivity; reporting severity involves an additional level of appraisal and is a more cognitively complex process than responding yes or no to experiencing a list of symptoms. A bias or responding

tendency likely emerges when neurotic individuals provide ratings of perceived severity; neuroticism may be characterized by heightened sensitivity to triggers signifying different symptoms but constancy in subjective experiences. The mechanisms underlying the links between neuroticism and self-reported physical health (at least in regards to symptoms) appear to involve both psychological and biological explanations. For example, individuals with high scores on neuroticism may be psychologically consistent, but biologically variable.

Contrary to expectations, age was not found to be a moderator of the associations between neuroticism and aspects of daily physical health symptoms. This indicates that neuroticism is a risk factor for poor daily health, of equal significance across the lifespan. In the present study, however, age was included as a continuous variable; it is conceivable that one or more of the associations are nonlinear in nature. Different patterns may exist in very old age as compared to younger adulthood, specifically.

Neuroticism and Cortisol at Waking. The second set of questions examined the association between neuroticism and cortisol at waking, as a marker of functioning of the HPA axis. Cortisol at waking is a rather objective, endogenous marker of health and is likely the least susceptible of the four daily saliva measurements in the NSDE II (at waking, 30 minutes after waking, before lunch, and at bed) to compliance concerns such as eating before or not collecting the sample at the appropriate time. Research indicates the cortisol response to waking is not significantly influenced by factors such as exercise, drinking alcohol before bed, and smoking status (Pruessner et al., 1997). As with daily physical health symptoms, analyses were also performed to investigate neuroticism as a predictor of within-person variation in cortisol at waking; in addition, moderating effects of age on the level and variability were of interest.

Individuals with higher scores on neuroticism had higher levels of and more within-person variation in cortisol at waking, this is consistent with studies suggesting a link between neuroticism and hyperactivity of the HPA axis (Portella et al., 2005; Vedhara et al., 2006; & Zobel et al., 2004). These findings provide support for biological positions offered to explain the association between neuroticism and health.

Interestingly, the effect of neuroticism on cortisol at waking emerged after controlling for global indicators of health; number of chronic conditions and self-rated physical health suppressed the association between neuroticism and cortisol. Poorer ratings of self-rated health and a higher number of chronic conditions were associated with lower levels of waking cortisol, reflecting hypoactivity of the hypothalamic-pituitary-adrenal axis, which has been shown to characterize particularly unhealthy individuals such as those with breast cancer (Touitou, Bogdan, Benavides, & Auzebi, 1996). Perhaps controlling for these health indices removed cortisol hypoactivity among individuals of extremely poor health with high scores on neuroticism (outliers), which previously cancelled out the hyperactivity effect. Chronic activation of the HPA axis, marked by lengthy enhanced levels of cortisol, has also been linked to a number of diseases such as diabetes and impaired memory (for review, see Dickerson & Kemeny, 2004). There is evidence for nonlinearity in the association between cortisol and health (Sapolsky et al., 1986). Both hypoactivity and hyperactivity of the HPA axis appear to negatively impact health, but differing consequences may result as function of the type of abnormal pattern of cortisol.

Age did moderate the association between neuroticism and cortisol at waking but not as expected. There was a stronger association between neuroticism and cortisol at waking for older as compared to younger adults. In other words, older individuals with higher scores on

neuroticism had the highest levels of waking cortisol. Neuroticism may influence objective daily health more in old age due to biological vulnerability. Older adults experience overall declines in health; they suffer from more chronic and terminal illnesses and have a higher risk of mortality (Verbrugge, 1986), which may increase susceptibility to the negative health effects of neuroticism. In addition, perhaps high levels of neuroticism over time contribute to heightened physical reactivity and sensitivity due to the repeated experience of stressors, for example. This represents amplification or a kindling effect; continued exposure to a stimulus produces sensitization as a result of change and realignment of neural networks (see Mroczek & Almeida, 2004).

Overall, these findings for neuroticism and cortisol show that neuroticism is associated not only with daily self-reported health but objective indicators as well. Psychological positions (e.g., recall bias and reporting tendencies), therefore, do not solely explain the association between neuroticism and health. The results provide further support for prevention and intervention efforts aimed at reducing neuroticism and improving strategies for coping with stress. It appears that the effects of neuroticism on the HPA axis are particularly pronounced later in life, pointing to the need for targeting at-risk older adults.

Limitations of the Present Study

It is critical to note the potential limitations of the present study, which constrain inferences and conclusions drawn. Two major issues necessitate particular consideration: (1) restrictions imposed by study design and resulting sample characteristics, and (2) concerns regarding the methods and analysis strategies selected.

Restrictions Imposed by Study Design and Resulting Sample Characteristics. Although the present study utilized a national sample, the participants tended to be Caucasian and well-

educated, indicating higher socioeconomic status. These sample characteristics limit generalizability to other ethnic groups and less-educated individuals.

In addition, the current investigation was cross-sectional in nature, utilizing only the second waves of the Midlife in the United States: A National Study of Health and Well-being (MIDUS) and the National Study of Daily Experiences (NSDE). Therefore, cohort effects are possible; respondents who survive to older age may differ in important ways from those who do not, as well as younger respondents, with regards to the variables of interest: neuroticism, daily physical health symptoms, and cortisol at waking. Generational differences due to historical events, for example, may be partially responsible for the findings. Without a cross-sequential design (multigenerational longitudinal data), cohort and aging effects cannot be disentangled. Longitudinal data may also assist in determining the direction of effects; here neuroticism was the presumed predictor, but poor health may also serve to increase neuroticism as a result of health-related anxieties and worry.

Another potential limitation is the measurement of the personality trait neuroticism. This aspect of personality was measured using a very short (4-item) scale, but the reliability and construct validity were reasonable and adequate (see Measures in Methods Section).

Finally, although home saliva collection is a particular strength of the present study, there were a number of challenges related to participant compliance. Cortisol levels can be biased if the collection procedures are not properly followed, for example, if participants eat or drink prior to taking a sample. Although the present study attempted to address these issues by statistically controlling for potential confounds such as time of collection, other sources of noncompliance are possible, which may be related to the variables of interest. It might be of benefit to further

investigate how neuroticism and daily health are associated with compliance and adherence to protocol.

Concerns Regarding the Methods and Analysis Strategies Selected. In addition to possible nonlinear effects of age as mentioned previously, another issue involves analysis of daily physical health symptoms in the present study. All of the symptoms included in the checklist were grouped together; no distinctions were made according to type or severity, etc. Perhaps the association between neuroticism and daily physical health symptoms was carried by a subset of symptoms, which may or may not be the same across age. Previous work suggests that the most common daily symptoms reported by younger adults are those linked to respiratory problems, while older adults often report pain-related symptoms (Verbrugge, 1986).

In sum, this study was constrained and restricted by certain characteristics of the sample as well as the methods and analysis strategies chosen. Interpretation of the results is contingent upon these several limitations.

Future Directions

The outlook for research in the field of personality and daily health in adulthood is promising. The current study points to several future directions and topics worthy of further consideration. First, this area may profit from examination of combinations of traits as well as changes in personality over time. Second, knowledge about this topic can be enhanced by considering the diurnal rhythm of cortisol, as an objective indicator of daily physical health, in addition to waking cortisol. Finally, incorporating stressor exposure and reactivity may assist in clarifying the mechanisms and processes underlying the associations between personality, specifically neuroticism, and aspects of daily physical health.

The present study focused on one of the "Big Five" personality traits, neuroticism. The findings of this thesis are consistent with previous work demonstrating higher scores on neuroticism are associated with poorer health. In contrast, other dimensions included in this five factor model of personality such as conscientiousness have been linked to behaviors that promote better health and limit risk factors (for review see Bogg & Roberts, 2004). Similarly, extraversion predicts a number of health outcomes; a recent study suggests high extraversion is protective of death (Shipley, Weiss, Der, Taylor, & Deary, 2007). Examining individuals' personality profiles or types (combined and interactive effect of traits) likely provides a more holistic and comprehensive view of how personality influences health and well-being. For example, conscientiousness or extraversion may buffer the negative effects of neuroticism on health.

In addition, the first and second waves of MIDUS can be combined in future analyses to investigate approximately 10-year stability and change in personality and its influence on subjective and objective indicators of daily health. Initial, related work using MIDUS has focused on several non-daily health indices (i.e., self-reported physical health, blood pressure at last physician visit, and amount of days cut back at work in the past 30 days due to physical reasons (Mroczek, Turiano, Pitzer, Karlamangla, Singer, & Ryff, in review). Increases in agreeableness, conscientiousness, extraversion, and openness were associated with higher health ratings, while increases in neuroticism were associated with worse self-reported physical health. In addition, increases in openness and conscientiousness and decreases in neuroticism were related to fewer work cutback days. Lower blood pressure was associated with increases in conscientiousness and decreases in neuroticism. These findings highlight that both trait level and change are predictive of health outcomes.

In regards to cortisol, the present study focused solely on levels at waking. Investigation of diurnal cortisol, however, affords a view into individuals' chronobiology (Keenan, Licinio, & Veldhuis, 2001). Levels of cortisol typically peak in the morning shortly after awakening (30-40 minutes post-awakening) then gradually decline throughout the rest of the day (Kirschbaum & Hellhammer, 1989; Pruessner et al., 1997). Abnormal diurnal patterns of cortisol (e.g., high levels or hyperactivity vs. low levels or hypoactivity), produced by the failure of the hypothalamic-pituitary-adrenal axis to deactivate in the evening or activate in the morning, may have potentially serious physiological consequences and negatively impact physical health (Sapolsky et al., 1986). Therefore, it would be interesting and informative to investigate how neuroticism is related to the diurnal rhythm of cortisol. Although older adults with higher scores on neuroticism had the highest levels of cortisol at waking in the present study, they may not demonstrate the typical rise and decline. Perhaps the diurnal rhythm of cortisol is high and flat in young adults with high scores on neuroticism (hyperactivity), but flat and low (hypoactivity) in older adults scoring high on neuroticism due to wear and tear on the body over time (allostatic load) given the accumulation of damaging effects on the HPA axis.

As previously mentioned, one definition of neuroticism is the tendency to be more reactive to stressful situations (Costa & McCrae, 1987). On average, individuals are more likely to report having physical health symptoms on days they experience stressors than on stressor-free days; stressors perceived as severe particularly impact well-being (Almeida, Wethington, & Kessler, 2002). Further, the extant literature suggests that exposure to acute stressors can increase levels of cortisol for a short period of time (Kemeny, 2003). Chronic exposure and adaptation to daily stressors may have a biological cost (allostatic load) as evidenced, for example, by abnormal diurnal patterns of cortisol, which reflect dysregulation of the

hypothalamic-pituitary-adrenal axis (Almeida, 2005; Kemeny, 2003; McEwen, 1998). Previous work suggests individuals high in neuroticism are more emotionally reactive to daily stress (Mroczek & Almeida, 2004). These individuals may also be characterized by enhanced physical reactivity as measured by self-reported daily physical health symptoms and cortisol, for example.

The present study explored some key questions related to personality and health in adulthood, focusing on indicators of daily health, which have received limited attention despite their significance. In addition to the tentative conclusions to be drawn from this study, the results highlight the complex associations among neuroticism, age, daily physical health symptoms, and cortisol at waking. Additional insights can be gained from continued investigation in this area with particular attention paid to explanations for the personality-health link.

References

Adam, E. K., Hawkley, L. C., Kudielka, B. M., & Cacioppo, J. T. (2006). Day-to-day dynamics of experience-cortisol associations in a population-based sample of older adults. *Proceedings of the National Academy of Sciences, 103*, 17058-17063.

Almeida, D. M. (2005). Resilience and vulnerability to daily stressors assessed via diary methods. *Current Directions in Psychological Science, 14*, 64-68.

Almeida, D. M., & Horn, M. C. (2004). Is daily life more stressful during middle adulthood? In O. G. Brim, C. D. Ryff, & R. C. Kessler (Eds.), *How healthy are we? A national study of well-being at midlife* (pp. 425-451). Chicago: The University of Chicago Press.

Almeida, D. M., Wethington, E., & Kessler, R. C. (2002). The Daily Inventory of Stressful Events: An interview-based approach for measuring daily stressors. *Assessment, 9*, 41-55.

Baltes, P. B. (1987). Theoretical propositions of life-span developmental psychology: on the dynamics between growth and decline. *Developmental Psychology, 23*, 611-626.

Baltes, P. B., Lindenberger, U., & Staudinger, U. M. (2006). Lifespan theory in developmental psychology. In R. M. Learner (Ed.), *Handbook of child psychology*, (6th ed., pp. 569-664). New York: Wiley.

Bem, S. L. (1981). *Bem Sex-Role Inventory Manual*. Palo Alto, CA: Consulting Psychologists Press.

Bogg, T; & Roberts, B. W. (2004). Conscientiousness and health behaviors: A meta-analysis. *Psychological Bulletin, 130*, 887-919.

Brim, O. G., Ryff, C. D., & Kessler, R. C. (2004). The MIDUS National Survey: An overview. In O. G. Brim, C. D. Ryff, & R. C. Kessler (Eds.), *How healthy are we? A national study of well-being at midlife* (pp. 1-36). Chicago: University of Chicago Press.

Cattell, R. B. (1950). *Personality: A systematic theoretical and factual study*. New York: McGraw-Hill.

Charles, S. T., & Almeida, D. M. (2006). Daily reports of symptoms and negative affect: Not all symptoms are the same. *Psychology and Health, 21*, 1-17.

Cleary, P. D., Zaborski, L., & Ayanian, J. Z. (2004). Sex differences in health over the course of midlife. In O. G. Brim, C. D. Ryff, & R. C. Kessler (Eds.), *How healthy are we? A national study of well-being at midlife* (pp. 37-63). Chicago: University of Chicago Press.

Costa, P. T., & McCrae, R. R. (1980). Somatic complaints in males as a function of age and neuroticism: A longitudinal analysis. *Journal of Behavioral Medicine, 3*, 245-257.

Costa, P. T., & McCrae, R. R. (1985a). *The NEO personality inventory manual*. Odessa, FL: Psychological Assessment Resources, Inc.

Costa, P. T., & McCrae, R. R. (1985b). Hypochondrias, neuroticism, and aging: When are somatic complaints unfounded? *American Psychologist, 40*, 19-28.

Costa, P. T., & McCrae, R. R. (1987). Neuroticism, somatic complaints and illness: Is the bark worse than the bite? *Journal of Personality, 55*, 299-316.

Costa, P. T., & McCrae, R. R. (1992). *NEO PI-R professional manual*. Odessa, FL: Psychological Assessment Resources.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin, 130*, 355-391.

Dreger, R. M. (Ed.) (1972). *Multivariate personality research: Contributions to the understanding of personality in honor of Raymond B. Cattell*. Baton Rouge, LA: Claitor's Publishing Division.

Dressendörfer, R. A., Kirschbaum, C., Rohde, W., Stahl, F., & Strasburger, C. J. (1992). Synthesis of a cortisol-biotin conjugate and evaluation as tracer in an immunoassay for salivary cortisol measurement. *Journal of Steroid Biochemistry and Molecular Biology, 43*, 683-692.

Ebert, S. A., Tucker, D. C., & Roth, D. L., (2002). Psychological resistance factors as predictors of general health status and physical symptom reporting. *Psychology, Health, and Medicine, 7*, 363-375.

Eid, M., & Diener, E. (1999). Intraindividual variability in affect: Reliability, validity, and personality correlates. *Journal of Personality and Social Psychology, 76*, 662-676.

Eysenck, H. J. (1967). *The biological basis of personality*. Springfield, IL: Charles C. Thomas.

Eysenck, H. J., & Eysenck, M. W. (1985). *Personality and individual differences: A natural science approach.* New York: Plenum.

Friedman, H. S., Tucker, J. S., Schwartz, J. E., Tomlinson-Keasey, C., Martin, L. R., Wingard, D. L., & Criqui, M. H. (1995). Psychosocial and behavioral predictors of longevity: The aging and death of the "Termites". *American Psychologist, 50*, 69-78.

George, L. K. (2001). The social psychology of health. In R. H. Binstock & L. K. George (Eds.), *Handbook of Aging and the Social Sciences* (5th ed., pp. 217-237). San Diego, CA: Academic Press.

Goldberg, L. R. (1990). An alternative "description of personality": The big-five factor structure. *Journal of Personality and Social Psychology, 59*, 1216-1229.

Goldberg, L. R. (1992). The development of markers for the Big-Five factor structure. *Psychological Assessment, 4*, 26-42.

Hoffman, L. (2007). Multilevel models for examining individuals differences in within-person variation and covariation over time. *Multivariate Behavioral Research, 42*, 609-629.

Horn-Mallers, M., Almeida, D. M., & Neupert, S. D. (2005). Women's daily physical health symptoms and stressful experiences across adulthood. *Psychology and Health, 20*, 389-403.

Ice, G. H., Katz-Stein, A., Himes, J., & Kane, R. L. (2004). Diurnal cycles of salivary cortisol in older adults. *Psychoendocrinology, 29*, 355-370.

Jackson, B., Kubzansky, L. D., Cohen, S., Jacobs, D. R., Jr., & Wright, R. J. (2007). Does harboring hostility hurt? Associations between hostility and pulmonary function in the Coronary Artery Risk Development in (Young) Adults (CARDIA) Study. *Health Psychology, 26,* 333-340.

John, O. P. (1990). The "Big Five" factor taxonomy: Dimensions of personality in the natural language and in questionnaires. In L. A. Pervin (Ed.), *Handbook of personality theory and research*, (pp. 66-100). New York: Guilford.

Keenan, D. M., Licinio, J., & Veldhuis, J. D. (2001). A feedback-controlled ensemble model of the stress-responsive hypothalamo-pituitary-adrenal axis. *Proceedings of the National Academy of Sciences, 98*, 4028-4033.

Kemeny, M. E. (2003). The psychobiology of stress. *Current Directions in Psychological Science, 12*, 124-129.

Kirmayer, L. J., Robbins, J. M., & Paris, J. (1994). Somatoform disorders: Personality and the social matrix of somatic distress. *Journal of Abnormal Psychology, 103*, 125-136.

Kirschbaum, C., & Hellhammer, D. H. (1989). Salivary cortisol in psychobiological research: An overview. *Neuropsychobiology, 22*, 150-169.

Kirschbaum, C., Read, G. F., & Helhammer, D. H. (1992). *Assessment of hormones and drugs in saliva in biobehavioral research*. Seattle, WA: Hogrefe & Huber.

Lachman, M. E., & Weaver, S. L. (1997). *The Midlife Development Inventory (MIDI) personality scales: Scale construction and scoring* (Technical Report). Waltham, MA: Brandeis University, Department of Psychology.

Larsen, R. J. (2007). Personality, mood states, and daily health. In A. A. Stone, S. Shiffman, A. A. Atienza, & L. Nebeling (Eds.), *The science of real-time data capture: Self-reports in health research* (pp. 251-267). New York: Oxford University Press, Inc.

Larsen, R. J., & Kasimatis, M. (1991). Day-to-day physical symptoms: Individual differences in the occurrence, duration, and emotional concomitants of minor daily illnesses. *Journal of Personality, 59*, 388-423.

Little, R. C., Milliken, G. A., Stroup, W. W., & Wolfinger, R. D. (1996). *SAS system for mixed models*. Cary, NC: SAS Institute.

Little, R. C., & Rubin, D. B. (1987). *Statistical analysis with missing data*. New York: John Wiley.

Marmot, M. (2004), *The status syndrome: How social standing affects our health and longevity*. New York: Holt.

McCleery, J. M., & Goodwin, G. M. (2001). High and low neuroticism predict different cortisol responses to the combined dexamethasone-CRH test. *Biological Psychiatry, 49*, 410-415.

McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine, 338*, 171-179.

McEwen, B. S., & Seeman, T. E. (1999). *Allostatic load and allostasis*. John D. and Catherine T. MacArthur Research Network on Socioeconomic Status and Health.

Miller, G. E., Chin, E., & Zhou, E. S. (2007). If it goes up, must it come down? Chronic stress and the hypothalamic-pituitary-adrenocortical axis in humans. *Psychological Bulletin, 133*, 25-45.

Miller, T. Q., Smith, T. W., Turner, C. W., Guijarro, M. L., & Hallet, A. J. (1996). A meta-analytic review of research on hostility and physical health. *Psychological Bulletin, 119*, 322-348.

Merrill, S. S., & Verbrugge, L . M. (1999). Health and disease in midlife. In S. L. Willis & J. D. Reid (Eds.), *Life in the middle: Psychological and social development in middle age* (pp. 77-103). San Diego: Academic Press.

Mroczek, D. K., & Almeida, D. M. (2004). The effect of daily stress, personality, and age on daily negative affect. *Journal of Personality, 72*, 355-378.

Mroczek, D. K., & Spiro, A. III. (2003). Modeling intraindividual change in personality traits: Findings from the Normative Aging Study. *Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, 58*, 153-165.

Mroczek, D. K., & Sprio, A. III. (2007). Personality change influences mortality in older men. *Psychological Science, 18*, 371-376.

Mroczek, D. K., Turiano, N., Pitzer, L., Karlamangla, A., Singer, B., & Ryff, C. D. (in review). *Journal of Personality and Social Psychology.*

Murray, G., Allen, N. B., Trinder, J., & Burgess, H. (2002). Is weakened circadian rhythmicity a characteristic of neuroticism? *Journal of Affective Disorders, 72*, 281-289.

Neeleman, J., Bijl, R., & Ormel, J. (2004). Neuroticism, a central link between somatic and psychiatric morbidity: path analysis of prospective data. *Psychological Medicine, 34*, 521-531.

Oswald, L. M., Zandi, P., Nestadt, G., Potash, J. B., Kalaydijian, A. E., & Wand, G. S. (2006). Relationship between cortisol responses to stress and personality. *Neuropsychopharmacology, 31*, 1583-1591.

Pennebaker, J. (1982). *The psychology of physical symptoms*. New York: Oxford University Press.

Phillips, A. C., Carroll, D., Burns, V. E., & Drayson, M. (2005). Neuroticism, cortisol reactivity, and antibody response to vaccination. *Psychophysiology, 42*, 232-238.

Polk, D. E., Cohen, S., Doyle, W. J., Skoner, D. P., & Kirschbaum, C. (2005). State and trait affect as predictors of salivary cortisol in healthy adults. *Psychoneuroendocrinology, 30*, 261-272.

Portella, M. J., Harmer, C. J., Flint, J., Cowen, P., & Goodwin, G. M. (2005). Enhanced early morning salivary cortisol in neuroticism. *American Journal of Psychiatry, 162*, 807-809.

Prohaska, T. B., Leventhal, E. A., Leventhal, H., & Keller, M. L. (1985). Health practices and illness cognition in young, middle-aged, and elderly adults. *Journal of Gerontology, 40*, 569-578.

Pruessner, J. C., Wolf, O. T., Hellhammer, D. H., Buske-Kirschbaum, A., von Auer, K., Jobst, S., Kaspers, F., & Kirschbaum, C. (1997). Free cortisol levels after awakening: A reliable biological marker for the assessment of adrenocortical activity. *Life Sciences, 61*, 2539-2549.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, California: Sage Publications, Inc.

Sapolsky, R. M., Krey, L. C., & McEwen, B. S. (1986). The neuroendocrinology of stress and aging: The glucocorticoid cascade hypothesis. *Endocrinology Review, 7*, 284-301.

Schommer, N. C., Kudielka, B. M., Hellhammer, D. H., & Kirschbaum, C. (1999). No evidence for a close relationship between personality traits and circadian cortisol rhythm or a single cortisol stress response. *Psychological Reports, 84*, 840-842.

Schwarz, N., & Sudman, S. (1994). *Autobiographical memory and the validity of retrospective reports.* New York: Springer-Verlag.

Shipley, B. A.; Weiss, A., Der, G., Taylor, M. D., & Dreary, I. J. (2007). Neuroticism, extraversion, and mortality in the UK Health and Lifestyle Survey: A 21-year prospective cohort study. *Psychosomatic Medicine, 69*, 923-931.

Smith, T. W., & Spiro, A. III. (2002). Personality, health, and aging: prolegomenon for the next generation. *Journal of Research in Personality, 36*, 363-394.

Snijders, T. & Bosker, R. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. London: SAGE Publications Ltd.

Spiro, A. III., (2007). The relevance of a lifespan developmental approach to health. In C. M. Aldwin, C. L. Park, & A. Spiro III (Eds.), *Handbook of health psychology and aging* (pp. 75-93). New York: The Guildford Press.

Staudinger, U. M., Fleeson, W. & Baltes, P. B. (1999). Predictors of subjective physical health and global well-being: Similarity and differences between the United States and Germany. *Journal of Personality and Social Psychology, 76*, 305-319.

Stone, A. A. (2000). Self-reporting of physical symptoms. In A. A. Stone, J. S. Turkkan, C. A. Bachrach, J. B. Jobe, H. S. Kurtzman, & V. S. Cain (Eds.), *The science of self-report* (pp. 297-298). Mahwah, NJ: Lawrence Erlbaum Associates.

Tennen, H., Affleck, G., & Armeli, S. (2005). Personality and daily experience revisited. *Journal of Personality, 73*, 1465-1483.

Touitou, Y., Bogdan, A., Levi, F., Benavides, M., & Auzebi, A. (1996). Disruption of the circadian patterns of serum cortisol in breast and ovarian cancer patients: Relationship with tumour marker antigens. *British Journal of Cancer, 74*, 1248-1252.

Trapnell, P. D., & Wiggins, J. S. (1990). Extension of the Interpersonal Adjective Scales to include the Big Five dimensions of personality. *Journal of Personality and Social Psychology*, *59*, 781-790.

Vedhara, K., Tuin stra, J., Miles, J. N. V., Sanderman, R., & Ranchor, A. V. (2006). Psychosocial factors associated with indices of cortisol production in women with breast cancer and controls. *Psychoneuroendocrinology, 31*, 299-311.

Verbrugge, L. M. (1986). From sneezes to adieux: Stages of health for American men and women. *Social Science & Medicine, 22*, 1195-1212.

Wilson, R. S., Mendes de Leon, C. F., Bienas, J. L., Evans, D. A., & Bennett, D. A. (2004). Personality and mortality in old age. *Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, 59*, 110-116.

Zobel, A., Barkow, K., Schulze-Rauschenbach, S., von Widdern, O., Metten, M., Pfeiffer, U., Schnell, S., Wagner, M., & Maier, W. (2004). High neuroticism and depressive temperament are associated with dysfunctional regulation of the hypothalamic-pituitary-

adrenocortical system in healthy volunteers. *Acta Psychiatrica Scandinavica, 109*, 392-399.

Zuckerman, M. (1995). Good and bad humors: Biochemical bases of personality and its disorders. *Psychological Science, 6*, 325-332.

Footnotes

[1] Models including demographic variables (gender, education, and age) explained 2% of the variation in whether a respondent reported at least one physical health symptom on a given day. Inclusion of neuroticism explained an additional 3% of the variation.

[2] Models including demographic factors (gender, education, and age) explained 2% of the random intercept variance for number of daily physical health symptoms and 7% for symptom severity, compared to the intercept only models. Inclusion of neuroticism explained an additional 4% of the individual differences in the intercept for number of symptoms and 3% for symptom severity.

[3] Models including covariates (gender, education, age, average wakeup time, number of chronic conditions, and self-rated health) explained 10% of the random intercept variance for cortisol at waking, compared to the intercept only model. Inclusion of neuroticism and the neuroticism by age interaction each explained an additional 1% of the individual differences in the intercept.

Table 1

Research Questions and Hypotheses of the Present Study

Neuroticism and Self-Reported Daily Physical Health Symptoms	
Q_{1a}	Is neuroticism associated with measures of daily physical health symptoms (any symptoms, number, severity, and variation)?
	Hypothesis: Higher scores on neuroticism will be associated with a greater likelihood of reporting at least one physical health symptom on a given day as well as a higher number and severity of symptoms on symptom days. In addition, higher scores on neuroticism will be associated with more within-person variation in number of symptoms but not symptom severity.
Q_{1b}	Does age moderate the associations between neuroticism and measures of daily physical health symptoms?
	Hypothesis: The associations between neuroticism and dimensions of daily physical health may be weaker for older adults.
Neuroticism and Cortisol at Waking	
Q_{2a}	Is neuroticism associated with cortisol at waking?
	Hypothesis: Individuals with higher scores on neuroticism will exhibit hyperactivity or high levels of cortisol at waking.
Q_{2b}	Does age moderate the association between neuroticism and cortisol at waking?
	Hypothesis: Higher scores on neuroticism will be associated with hyperactivity or high levels of waking cortisol in young adults, but hypoactivity or low levels in older adults.

Table 2

Characteristics of Participants

Demographic/Background Variable	*n*	Percentage (%)	Mean (*SD*)
Gender*			
Male	408	45.00	
Female	499	55.00	
Marital Status			
Married	658	72.62	
Separated/Divorced	121	13.36	
Widowed	71	7.84	
Never Married	56	6.18	
Children			
Yes	813	89.64	
No	94	10.36	
Education*			
High School Graduate or Less	286	31.53	
Some College	210	23.15	
Associate or Bachelor Degree	251	27.67	
Graduate Training	160	17.65	
Ethnicity			
Caucasian	844	93.26	
African-American/Black	28	3.09	
Other	33	3.65	
Self-rated Health*			
Excellent	160	17.64	
Very Good	374	41.23	
Good	270	29.77	
Fair	77	8.49	
Poor	26	2.87	
Number of Chronic Conditions*	907		2.51 (2.41)
Average Wakeup Time*	907		6:47 (1:15)
Age*	907		57.53 (12.46)
Neuroticism*	907		1.99 (.62)

Note. n = 907 individuals. One individual had missing data for marital status and two individuals had missing data for ethnicity, but these variables were not of interest in the present study and were not included in analyses. *These variables were examined in the present study. Average wakeup time was 6:47 A.M. (*SD* = 1 hour and 15 minutes).

Table 3

Parameter Estimates of Logistic Multilevel Models for Any Physical Health Symptoms

	Model 1		Model 2		Model 3	
Fixed Effects	95% CI	OR	95% CI	OR	95% CI	OR
Day of study	0.47, 0.59	0.53***	0.48, 0.59	0.53***	0.48, 0.59	0.53***
Day*day	1.04, 1.08	1.06***	1.04, 1.08	1.06***	1.04, 1.08	1.06***
Gender	1.06, 2.17	1.61**	0.96, 1.88	1.42*	0.96, 1.88	1.42**
Education	0.72, 1.02	0.87	0.83, 1.16	0.99	0.83, 1.16	0.99
Age	0.98, 1.40	1.19	0.75, 1.06	0.91	0.76, 1.06	0.91
Neuroticism	1.46, 2.09	1.78***	1.09, 1.53	1.31**	1.09, 1.54	1.32**
Number chronic conditions			1.85, 2.79	2.32***	1.84, 2.79	2.31***
Self-rated health			1.23, 1.79	1.51***	1.23, 1.80	1.51***
Neuroticism X age					0.86, 1.20	1.03
-2LL	6869.70		6742.10		6741.90	

Note. CI = confidence interval. OR = odds ratio. n = 907 individuals, 6,895 days. *$p < .05$; **$p < .01$; ***$p < .001$.
Intercept: Model 1 (2.00*), Model 2 (2.09*), Model 3 (2.10*).
Random intercept variance: Model 1 (5.11*), Model 2 (4.20*), Model 3 (4.20*).
Random linear and quadratic effects of day of study not included.

Table 4

Parameter Estimates of Linear Multilevel Models for Number of Daily Physical Health Symptoms

	Model 1		Model 2		Model 3	
Fixed Effects	*Est.*	*SE*	*Est.*	*SE*	*Est.*	*SE*
Intercept	2.63***	(.09)	2.68***	(.09)	2.68***	(.09)
Day of study	-.24***	(.03)	-.25***	(.03)	-.25***	(.03)
Day*day	.02***	(.00)	.02***	(.00)	.02***	(.00)
Gender	.28**	(.11)	.17	(.10)	.17	(.10)
Education	-.03	(.05)	.05	(.05)	.05	(.05)
Age	.11*	(.05)	-.06	(.05)	-.06	(.05)
Neuroticism	.31***	(.05)	.12*	(.05)	.12*	(.05)
Number of chronic conditions			.56***	(.05)	.56***	(.05)
Self-rated health			.22***	(.05)	.22***	(.05)
Neuroticism X age					.01	(.05)
Random Effects						
Residual variance	1.28***	(.04)	1.28***	(.04)	1.27***	(.04)
Random intercept variance	3.15***	(.39)	2.48***	(.18)	2.48***	(.18)
Random day variance	.24***	(.04)	.24***	(.04)	.24****	(.04)
Random day*day variance	.00***	(.00)	.00***	(.00)	.00***	(.00)
Age effect on residual variance	-.03	(.03)	-.03	(.03)	-.03	(03)
Neuroticism effect on residual variance	.22***	(.03)	.21***	(.03)	.21***	(.03)
Age X neuroticism effect on residual variance					-.01	(.03)
-2LL	15892.50		15725.60		15725.40	

Note. SE = standard error. n = 850 individuals, 4,380 days with at least one symptom.
*p < .05; **p < .01; ***p < .001.

Table 5

Parameter Estimates of Linear Multilevel Models for Average Severity of Daily Physical Health Symptoms

	Model 1		Model 2		Model 3	
Fixed Effects	*Est.*	*SE*	*Est.*	*SE*	*Est.*	*SE*
Intercept	3.34***	(.08)	3.32***	(.08)	3.32***	(.08)
Day of study	-.11***	(.03)	-.11***	(.03)	-.11***	(.03)
Day*day	.01***	(.00)	.01***	(.00)	.01***	(.00)
Gender	.49***	(.10)	.49***	(.10)	.49***	(.10)
Education	-.18***	(.05)	-.11*	(.05)	-.11*	(.05)
Age	.05	(.05)	-.03	(.05)	-.03	(.05)
Neuroticism	.23***	(.05)	.12*	(.05)	.12*	(.05)
Number of chronic conditions			.16**	(.05)	.16*	(.05)
Self-rated health			.32***	(.05)	.31*	(.05)
Neuroticism X age					-.00	(.05)
Random Effects						
Residual variance	1.08***	(.03)	1.08***	(.03)	1.08***	(.03)
Random intercept variance	1.85***	(.14)	1.69***	(.13)	1.68***	(.13)
Random day variance	.13***	(.03)	.13***	(.03)	.13***	(.03)
Random day*day variance	.00***	(.00)	.00***	(.00)	.00***	(.00)
Age effect on residual variance	-.00	(.03)	-.00	(.03)	-.00	(.03)
Neuroticism effect on residual variance	-.09**	(.03)	-.09***	(.03)	-.09***	(.03)
Age X neuroticism effect on residual variance					-.01	(.03)
-2LL	14989.30		14923.30		14923.00	

Note. SE = standard error. n = 850 individuals, 4,380 days with at least one symptom.
*p < .05; **p < .01; ***p < .001.

Table 6

Parameter Estimates of Linear Multilevel Models for Cortisol at Waking (nmol/l + 1, ln)

	Model 1		Model 2		Model 3	
Fixed Effects	*Est.*	*SE*	*Est.*	*SE*	*Est.*	*SE*
Intercept	2.74***	(.02)	2.74***	(.02)	2.75***	(.02)
Gender	-.09**	(.03)	-.09**	(.03)	-.09**	(.03)
Education	.06***	(.01)	.05**	(.01)	.05**	(.01)
Age	.04*	(.01)	.06***	(.02)	.06***	(.02)
Wakeup time	-.03	(.02)	-.02	(.02)	-.02	(.02)
Neuroticism	.01	(.02)	.03*	(.02)	.04*	(.02)
Number of chronic conditions			-.04*	(.02)	-.04*	(.02)
Self-rated health			-.05**	(.02)	-.05**	(.02)
Neuroticism X age					.03*	(.01)
Random Effects						
Residual variance	.19***	(.01)	.19***	(.01)	.19***	(.01)
Random intercept variance	.13***	(.01)	.13***	(.01)	.12***	(.01)
Age effect on residual variance	-.06*	(.03)	-.06*	(.03)	-.06*	(.03)
Neuroticism effect on residual variance	.11***	(.03)	.11***	(.03)	.10**	(.03)
Age X neuroticism effect on residual variance					-.02	(.03)
-2LL	4873.1		4847.0		4842.6	

Note. SE = standard error. n = 907 individuals, 3,185 days. Linear and quadratic fixed effects for day of study were not significant and excluded from these models.
*$p < .05$; **$p < .01$; ***$p < .001$.

Table 7

Review of Research Questions, Hypotheses, and Main Findings

Research Questions and Hypotheses		Supported by Results?
Neuroticism and Self-Reported Daily Physical Health Symptoms		
Q_{1a}	Is neuroticism associated with measures of daily physical health symptoms (any symptoms, number, severity, and variation)?	Yes
	Hypothesis: Higher scores on neuroticism will be associated with a greater likelihood of reporting at least one physical health symptom on a given day as well as a higher number and severity of symptoms on symptom days. In addition, higher scores on neuroticism will be associated with more within-person variation in number of symptoms but not symptom severity.	Yes
Q_{1b}	Does age moderate the associations between neuroticism and measures of daily physical health symptoms?	No
	Hypothesis: The associations between neuroticism and dimensions of daily physical health may be weaker for older adults.	
Neuroticism and Cortisol at Waking		
Q_{2a}	Is neuroticism associated with cortisol at waking?	Yes
	Hypothesis: Individuals with higher scores on neuroticism will exhibit hyperactivity or high levels of cortisol at waking.	Yes
Q_{2b}	Does age moderate the association between neuroticism and cortisol at waking?	Yes
	Hypothesis: Higher scores on neuroticism will be associated with hyperactivity or high levels of waking cortisol in young adults, but hypoactivity or low levels in older adults.	No

Figure 1

National Study of Daily Experiences (NSDE II) Overview

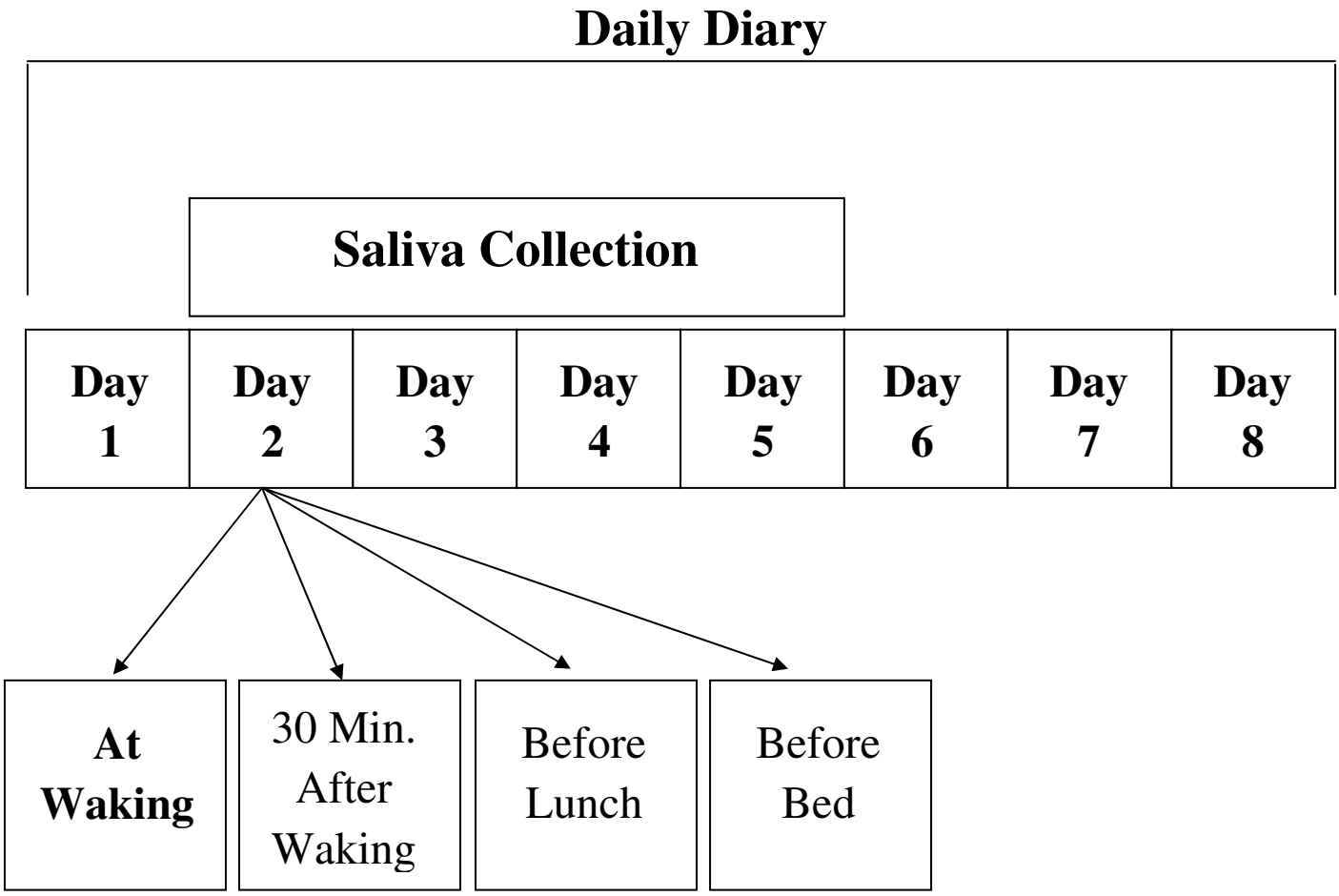
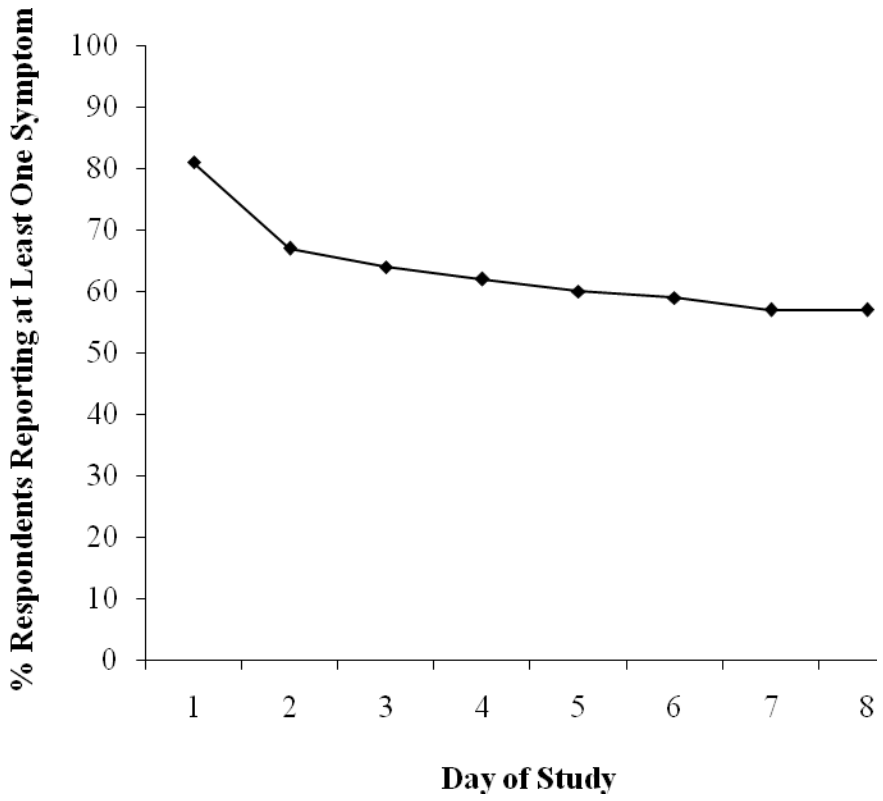


Figure 2

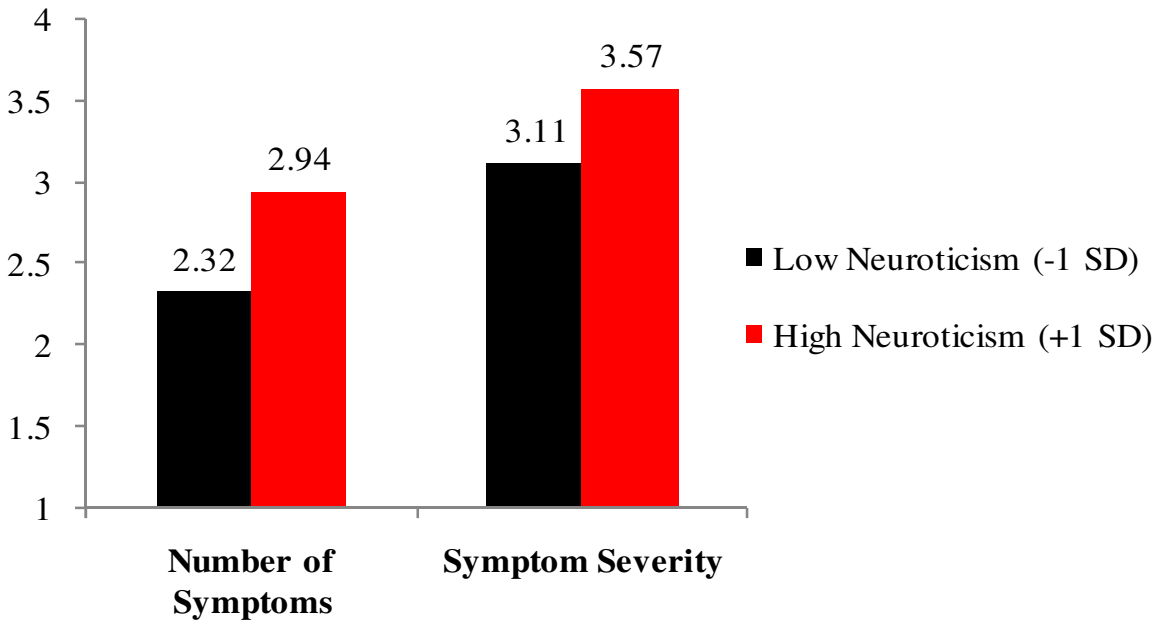
Percentage of Respondents Reporting at Least One Physical Health Symptom as a Function of Day of Study.



Note. Representation of linear and quadratic effects of day of study.

Figure 3

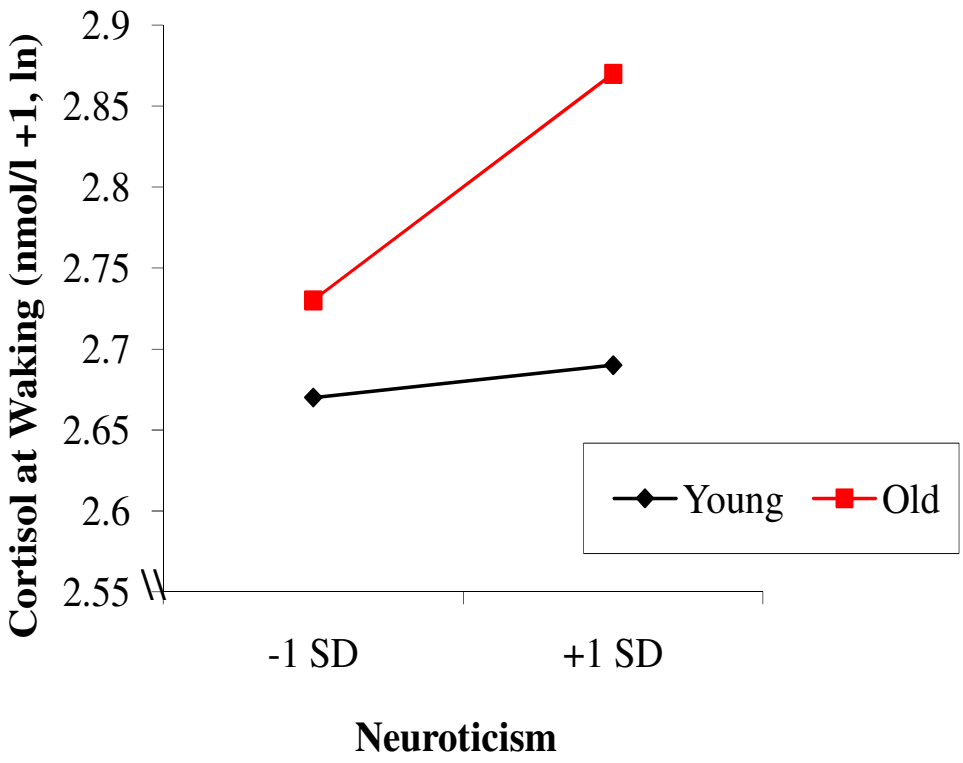
Predicted Number and Severity of Daily Physical Health Symptoms on Symptom Days as a Function of Neuroticism



Note. Controlling for linear and quadratic effects of day of study, gender, education, and age. Possible values for number of daily physical health symptoms on symptom days ranged from 1 to 25 and severity was measured on a 10-point Likert-scale (1 = very mild, 10 = very severe).

Figure 4

Cortisol at Waking (nmol/l +1, ln) as a Function of Neuroticism, Age, and their Interaction.



Note. Controlling for gender, education, average wakeup time, number of chronic conditions, and self-rated health. Young refers to one standard deviation below the mean age and old refers to one standard deviation above.