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BEHAVIORAL, PERSONALITY, AND HORMONAL CORRELATES OF TYPES AND DIMENSIONS OF PHYSICAL HEALTH SYMPTOMS IN DAILY LIFE

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ABSTRACT

Daily physical health symptoms are an integral part of health during adulthood, however, much remains to be explored regarding these experiences. Although different types and dimensions may be important, few studies have simultaneously examined these aspects of symptom reports and at the daily level. The goal of this dissertation was to examine multiple dimensions (e.g., frequency, severity) and types of physical symptoms in daily life as well as behavioral, personality, and hormonal correlates using a national sample of adults.

The first aim of Paper 1 was to provide a descriptive account of daily physical health symptom experiences. Symptom types were compared, and age and gender differences were also examined. The second aim was to examine how levels of and fluctuations in various aspects of daily physical symptoms are associated with daily work cutback, an index of symptom-related impairment. Both between- and within- person associations and the role of age as a moderator were examined using logistic multilevel modeling. In general, the results provided evidence for multidimensionality. In addition, women generally reported worse daily physical health compared to men. Fewer age differences emerged, though older adults experienced bodily pain more frequently. Finally, symptom experiences were linked to the odds of reporting any work cutback, particularly for adults in midlife in some instances.

Paper 2 examined how neuroticism was associated with daily physical health symptom occurrence as well as level of and fluctuation in symptom severity by symptom type. The second aim was to investigate how neuroticism and physical symptom experiences were associated with and combined to predict parameters of diurnal cortisol, specifically the cortisol awakening response (CAR) and daily decline. Results from logistic and linear multilevel models demonstrated that neuroticism was primarily associated with bodily pain and fatigue symptoms as well as a less steep (CAR) and more day-to-day variation in the afternoon/evening cortisol decline. In addition, specific types and dimensions of symptom experiences were associated with a flatter daily cortisol decline as well as interacted with neuroticism to influence diurnal cortisol. Collectively, these results have implications for assessment of daily physical health symptoms in survey research and medical settings. In addition, neuroticism is a risk factor for poor daily physical health and physiological dysregulation with intervention applications.

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Introduction

My research interests are primarily focused on aspects of daily physical health across the adult lifespan such as self-reported physical symptoms, for example. Therefore, the overarching purpose of this dissertation was to characterize multiple types and dimensions of daily physical health symptoms as well as examine specific behavioral, personality, and hormonal correlates. The aims of Paper 1 and Paper 2 are provided below following a brief definition of daily physical health symptoms. More elaborated justification for these studies as well as their fit and contribution to the existing literature are provided in the respective introduction sections.

Daily Physical Health Symptoms

Physical health symptoms represent a variety of bodily sensations and involve perceptions, feelings, and beliefs about one's physical state and condition (Kroenke, 2003; Pennebaker, 1982). The majority of research to date on physical health symptoms has employed a global approach in regards to timescale and content with a dependence on composite checklists assessing occurrence and single reports of symptoms. Assessing physical health symptoms multiple times and at the daily level, however, provides a more complete understanding of these experiences and their implications for everyday life (Larsen, 2007; Larsen & Kasimatis, 1991). Physical health is a state as well as a dynamic and complex process that varies as a function of time (e.g., days) (Spiro, 2007; Verbrugge, 1986). In addition, Kroenke (2001) argued that severity and temporal characteristics such as frequency represent distinct dimensions of symptom reporting. Several studies have also demonstrated that symptoms form particular groups or clusters (e.g., pain, gastrointestinal, upper respiratory, distress, fatigue) (Larsen, 2007; Rosmalen, Neeleman, Gans, & de Jonge, 2007). Few studies, however, have simultaneously examined several dimensions as well as various types of daily physical health symptoms.

Paper 1 Aims

The first aim of Paper 1 was to provide a descriptive account of daily physical health symptom items and types (i.e., cold/flu, gastrointestinal, bodily pain, fatigue, allergy, and "other" symptoms as well as a composite category), including their prevalence and frequency as well as average and maximum severity. The types of symptoms were compared, and age and gender differences were also examined in order to further characterize symptom experiences.

The second aim of Paper 1 was to demonstrate the importance and relevance of these symptoms in everyday life across the adult lifespan by examining how levels of and fluctuations in these various aspects of daily physical health symptoms are associated with daily cutback in work activities as an indicator of symptom-related impairment. Both between- and within-person associations were examined. Analyses also assessed whether age moderated these associations.

Paper 2 Aims

Paper 2 further examined daily physical health symptom types and dimensions with a focus on the role of neuroticism as an important individual difference factor in symptom reporting and linked across levels of health (i.e., consideration of the biomarker cortisol). The first aim was to examine how neuroticism was associated with daily occurrence as well as level of and fluctuation in symptom severity separately by symptom type. The second aim was to investigate how both neuroticism and physical symptom experiences (i.e., frequency and average severity for the various types) were associated with parameters of diurnal cortisol, specifically the cortisol awakening response and afternoon/evening decline. In addition, interactive effects between neuroticism and physical symptom experiences on diurnal cortisol were tested.

Both studies utilized data from the National Study of Daily Experiences (NSDE II, Project 2), which is the eight-day dairy portion of the second wave of the Midlife in the United States national study of health and well-being. Saliva samples were collected four times a day by participants on the second to fifth days of the study. Respondents ranged in age from approximately 34 to 86 years. In general, analyses were conducted using linear and logistic multilevel modeling given the nested structure of the data (i.e., days within people).

Collectively, these papers examined various types and dimensions of daily physical health and physiological function as well as their interrelations across the adult lifespan. In addition, the contribution of neuroticism as an important individual difference factor was considered; a developmental and process-oriented approach as applied to the study of health was adopted (Spiro, 2007).

Paper 1

Daily Physical Health Symptoms in Adulthood:

Types, Dimensions, and Relevance

Introduction

Until recently, a large portion of research on physical health symptoms has employed a global approach in regards to timescale and/or content with a reliance on composite checklists assessing occurrence and single reports of weekly, month, or yearly symptoms. This strategy is limited in that it does not provide specific and in-depth knowledge of the topic or characterize the actual experience of physical health symptoms. Therefore, the first purpose of the present study was to present a more fine-grained assessment of physical health symptoms by investigating several symptom types as well as dimensions, specifically temporal factors such as occurrence/frequency in addition to severity, across multiple daily measurements as well as assessing age and gender differences in these experiences. The second goal was to demonstrate the importance and relevance of these symptoms in everyday life across the adult lifespan by examining how levels of and fluctuations in various aspects of daily physical health symptoms are associated with daily cutback in work activities as an index of symptom-related impairment. Both between- and within-person associations were examined. The final set of analyses assessed whether age moderated these associations.

Physical Health Symptoms

Definition, prevalence, and relevance. Physical health symptoms are comprised of a variety of bodily sensations (e.g., dizziness, pain) and involve perceptions, feelings, and beliefs about one's physical state (Kroenke, 2003; Pennebaker, 1982). These symptom experiences are often referred to as 'physical' in the medical disorder literature and 'somatic' in the fields of psychology and psychiatry that focus on mental illness (Kroenke, 2003). The distinction has also been made between medically explained and unexplained symptoms, though the necessity and utility of this separation is a matter of debate (for review, see Kisely & Simon, 2006). The present study adopted a comprehensive view of physical health symptoms, including a variety of symptom types from gastrointestinal to upper respiratory (i.e. cold/flu) as well as several dimensions (i.e., occurrence/frequency and various measures of severity).

Although these health-related symptoms may seem minor, they are not insignificant or inconsequential (Barsky, 2000). Physical health symptoms are both prevalent and relevant. Reporting of physical symptoms is common and constitutes the majority of illness experiences (Merrill & Verbrugge, 1999). In a given month, up to 80% of people will experience at least one symptom (for review, see Kroenke, 2003). These physical health symptoms are associated with a lower quality of life (Tveito, Passchier, Duivenvoorden, & Eriksen, 2004) as well as prompt physician visits (Kroenke, 2003). Specifically, over 50% of all outpatient visits are attributed to physical health symptoms, which are the leading cause of seeking medical treatment in primary care and account for approximately 400 million visits to clinics each year in the United States (Schappert, 1992 as cited in Kroenke, 2003).

Daily perspective and importance of considering symptom types and dimensions. Theoretically, health is comprised of multiple dimensions and levels (Aldwin, Spiro, & Park, 2006), which also applies to symptom reports, specifically. In a seminal article on research and measurement issues related to the study of symptoms, Kroenke (2001) argued that temporal factors (e.g., frequency) and severity are distinct and represent different thresholds. Furthermore, empirical work suggests that various characteristics of symptom experiences such as frequency and severity are not interchangeable; consideration of both is required to more fully understand physical health symptoms, specifically at the daily level (Ferguson, Cassaday, Erskind, & Delahaye, 2004). In addition, although some research adheres to the belief that measures of diverse symptoms are best represented by a summary score (e.g., Ferguson et al., 2004), other work has demonstrated (e.g., factor analysis) that symptoms form particular constellations (e.g., pain, gastrointestinal, upper respiratory, distress, fatigue) (Larsen, 2007; Rosmalen, Neeleman, Gans, & de Jonge, 2007). Moreover, these types of symptoms, such as musculoskeletal and upper respiratory complaints, have been differentially associated with age as well as self-care behaviors (Verbrugge, 1986; Verbrugge & Ascione, 1987). Unfortunately, few studies have examined several dimensions as well as various types of daily physical health symptoms simultaneously, which was done in the present study.

Furthermore, physical health is a state as well as a dynamic and complex process that varies as a function of time, changing across moments, days, and years (Spiro, 2007; Verbrugge, 1986). Given this, research on physical health can be informed by considering multiple indicators within and across health-related measures as well as different timescales (e.g., daily). Examining health within the context of ongoing daily lives provides a more complete understanding of the process of health, including how it fluctuates and changes over time (Larsen, 2007; Larsen & Kasimatis, 1991). Use of daily diaries to assess health, therefore, is advantageous theoretically, methodologically, and empirically (for review, see Verbrugge, 1980). Repeated daily assessments of physical health symptoms provides the opportunity to assess between-person associations (e.g., for people who experience symptoms more frequently compared to people who report symptoms less frequently) and within-person associations (e.g., fluctuation; on symptom days compared to days without symptoms). Another methodological advantage is improved recall given that the symptoms are reported close in time to their occurrence (Verbrugge, 1980).

Until recently, there has been limited national data on and empirical examination of daily physical symptoms across the adult lifespan as well as how they are related to the quality and activities of everyday life (Merrill & Verbrugge, 1999). Initial evidence from a large-scale national sample suggests that daily health symptoms impact daily life and well-being (Charles & Almeida, 2006). Specifically, current day pain, gastrointestinal, and respiratory and cold/flu symptoms predicted same day increased negative affect. Given this promising work and strengths discussed above, a daily perspective and lifespan developmental approach as applied to health (Spiro, 2007) were employed in the present study through consideration of multiple types and dimensions of daily physical health symptoms.

Gender and Age Differences in Daily Physical Health Symptoms

Gender. Women consistently report worse health compared to men across a number of indicators, including multiple aspects of daily physical health symptoms; biological (e.g., physiology and disease development), social (e.g., roles and stress), and psychological (e.g., personality, mood, cognition, and perception) theories have all been provided to help to explain these gender differences (for review, see Cleary, Zaborski, & Ayanian; Gijsbers van Wijk, Huisman, & Kolk, 1999). In general, research suggests that women experience daily physical health symptoms more frequently than men and report more symptoms as well as perceive them to be of higher severity (Gijsbers van Wijk et al., 1999; Kroenke & Spitzer, 1998; Michel, 2007; Verbrugge, 1985a, 1986; Verbrugge & Ascione, 1987). Consideration of the type of symptom may be crucial, however, in clarifying the specific symptoms that contribute to these gender differences. In one study, women reported slightly higher average daily duration of pain and gastrointestinal symptoms, but not cold/flu symptoms (Charles & Almeida, 2006).

Age. Age-related changes and declines are evident in several main physiological systems: immune (for review, see Piazza, Almeida, Dmitrieva, & Klein, 2010; Aw, Silva, & Palmer, 2007; Gruenewald & Kemeny, 2007); endocrine (for review, see Piazza et al., 2010; Chahal & Drake, 2007; Epel, Burke, & Wolkowitz, 2007; Sapolsky, Krey, & McEwen, 1986); and cardiovascular (for review, see Cooper, Katzel, & Waldstein, 2007; De Meersman & Stein, 2007; Ferrari, Radaelli, & Centola, 2003). In addition, aging is generally associated with increased biological vulnerabilities and decline (see discussion of Strength and Vulnerability Integration, Charles, 2010; Charles & Piazza, 2009). Therefore, although the frequency of acute conditions such as accidents declines with age, the likelihood of having a chronic health condition increases rather substantially beginning in midlife (Merrill & Verbrugge, 1999; Verbrugge, 1986).

Research focused on daily physical symptoms, however, has revealed conflicting evidence regarding whether these experiences of health vary as a function of age (Horn-Mallers, Almeida, & Neupert, 2005; Verbrugge, 1986). Recent evidence suggests that compared to older women (56-74 years of age), daily physical health symptoms are more frequent for younger (25-39 years of age) and middle-aged women (40-55 years of age), which was linked to daily environmental stressors, specifically interpersonal tensions (Horn-Mallers et al., 2005). Earlier studies, however, have found that the overall frequency of daily physical health symptoms does not vary as a function of age for women aged 18 to 65+ years (Verbrugge, 1986). In contrast, men demonstrated a curvilinear pattern, with the fewest symptoms in midlife and a significant increase in old age (Verbrugge, 1986).

The type of physical health symptom may play an important role; previous work suggests that the most common daily symptoms reported by younger adults are respiratory-related, while bodily pain symptoms are reported more often with increasing age as well as sensory and cardiovascular symptoms. Furthermore, these symptom experiences were attributed by older adults to diseases while younger individuals named injuries as well as behavioral and environmental factors as causes (Verbrugge, 1986). In contrast, though not the central focus of the study, Charles & Almeida (2006) found that age among adults 25-74 years old was not correlated with the average daily duration of pain and cold/flu symptoms, but was negatively associated with daily duration of gastrointestinal symptoms. The age ranges of these two studies were slightly different, however, as well as assessment of daily physical health symptoms (frequency – Verbrugge, 1986 vs. frequency and intensity combined – Charles & Almeida, 2006).

Furthermore, research examining factors that contribute to symptom reporting suggests that there are age differences concerning the perceived experience and significance of physical health symptoms (for review, see George, 2001). For example, older individuals do not report all of their symptoms during physician visits, focusing instead, on those that are unusual or persistent following self-care (George, 2001). In addition, older adults may be more likely than younger adults to disregard or overlook symptoms despite increased susceptibility to disease as a result of different cognitions and practices related to sickness (Leventhal & Prohaska, 1986; Prohaska, Leventhal, Leventhal, & Keller, 1985). Also, older adults often view their symptoms in context and as part of the normal aging process as well as compare their health to that of same age peers rather than utilize temporal comparisons (i.e., past statuses within themselves) compared to younger individuals (Prohaska et al., 1985). It appears possible that physical health symptoms, particularly at the daily level, are underreported in later life or at least interpreted differently, which could influence symptom reports and/or their meaning.

In sum, basic questions regarding demographic differences in the daily health, specifically physical symptoms, of adults remain unanswered as well as the importance of distinguishing between symptom types and dimensions. This necessitates clarification, which the present study sought to provide by considering multiple aspects of daily physical health symptoms (i.e., temporal characteristics and severity) across several types of symptoms and a large portion of the adult lifespan. In addition, daily symptom experiences may have important consequences for everyday life, resulting in impairment and activity restriction such as work cutback.

Physical Health Symptoms and Work Cutback

Since the 1970s, sickness absenteeism in the workplace (i.e., missing work due to health-related reasons) has been of increasing interest to researchers, particularly in the fields of industrial-organizational psychology as well as occupational health and medicine (Väänänen et al., 2003). Previous research suggests various chronic medical conditions are differentially associated with 30-day work impairment (i.e., work loss and cutback), which highlights the potential utility of examining the association between physical health symptoms and work cutback at the daily level as well as separately by symptom type (Kessler, Greenberg, Mickelson, Meneades, & Wang, 2001). Furthermore, illness-related distress in employees with chronic health conditions has been linked not only to prolonged absence due to sickness, but also job performance and productivity loss as indexed by difficulties in meeting job demands (Munir et al., 2007).

One important contributing factor to employees' sickness absences, including frequency and time lost, does appear to be physical health symptoms (Darr & Johns, 2008; Väänänen et al., 2003). Physical health symptoms are also associated with work-related recovery from sickness. Among employees out sick for greater than 2 weeks, those who did not return to work within 3 months reported a greater number of symptoms (Giri, Poole, Nightingale, & Robertson, 2009). Similarly, in a sample of "sick-listed" employees, a high level of symptom severity (i.e., the amount respondents were troubled by symptoms during the past month) was associated with long-term sickness absence, continued disability, and health-related job loss compared to lower levels (Hoedeman, Blankenstein, Krol, Koopmans, & Groothoff, 2010).

Presenteeism, a more recent construct than absenteeism, is also relevant in that it involves assessment of work productivity loss as a function of health symptoms for those employees that continue working despite illness (for review, see Chapman, 2005). Although the studies reviewed here incorporated occurrence of symptoms as well as severity, they all focused on global reports (in regards to timescale) of physical health symptoms.

In order to understand the potential impact and cost of these experiences in everyday life, it is important to consider how physical health symptoms are associated with cutback in work on a daily basis. In the first wave of the National Study of Daily Experiences, daily impaired work quality and quantity were significantly related to pollen and mold among employed individuals suffering from allergic rhinitis (Kessler, Almeida, Berglund, & Stang, 2001). These findings further highlight the utility of examining work cutback at the daily level. The present study also expanded on this previous research by exploring how daily work cutback is related to several types and dimensions of daily physical health symptoms (i.e., actual experiences of health in everyday life) rather than chronic health conditions such as allergic rhinitis.

In addition, perhaps age may moderate the relationship between daily physical health symptoms and daily work cutback. Symptoms when reported by older adults may be particularly salient, have more impact, and be more strongly related to other aspects of health and well-being in daily life than in younger adults. A competing hypothesis may emerge, however, particularly when considering daily work cutback. Daily physical health symptoms may be particularly associated with cutback in normal work activities in midlife due to characteristics of this stage of the life course such as noticeable changes in health and physical condition as well as high demands across numerous social roles including work (Merrill & Verbrugge, 1999).

Study Aims and Hypotheses

Aim 1. The first objective was to maximize the information available and provide a descriptive account of daily physical health symptoms across individual items and types, including their prevalence (i.e., percentage of participants that endorsed at least one across the daily interviews) and frequency (i.e., proportion of study days) as well as average and maximum severity. The groups of symptoms were compared, and age and gender differences (as well as their interaction) were also of interest in order to further characterize symptom experiences. In line with the prior and fairly consistent literature, it was expected that women would generally endorse symptoms more often and those reported would also be perceived as more severe (Gijsbers van Wijk et al., 1999; Verbrugge, 1985a, 1986; Verbrugge & Ascione, 1987). As reviewed previously, it is not clear if and how experiences of physical health symptoms change with age, particularly rates and at the daily level (Charles & Almeida, 2006; Horn-Mallers et al., 2005; Verbrugge, 1986). It was hypothesized, however, that differences would be seen as a function of symptom type with older adults more frequently reporting musculoskeletal complaints (i.e., bodily pain), for example (Verbrugge, 1986). Older adults were not expected, however, to necessarily report their symptoms as more severe, which was based on research related to symptom perception and processing in older adults (George, 2001; Leventhal & Prohaska, 1986; Prohaska et al., 1985). The present study contributes to and expands upon existing studies by incorporating multiple types and aspects of daily symptom experiences.

Aim 2. The second objective was to demonstrate that the types and dimensions of daily physical health symptoms explored in Aim 1 are relevant and important to daily life by examining their links to cutback in daily normal work activities as an index of symptom-related impairment. Analyses examined how levels of and fluctuations in various aspects of daily physical health symptoms are associated with cutting back on work. It was expected that all dimensions of everyday symptoms would be associated with the odds of reporting any work cutback with possible differences by type, however, similar to a previous study examining the effects of various kinds of chronic health conditions on 30-day work impairment (i.e., loss and cutback) (Kessler, Greenberg, et al., 2001). In addition, the role of age (linear and quadratic effects) as a moderator of the between- and within- person associations among types and dimensions of daily physical health symptom with daily work cutback was explored.

Methods

This section describes the research methods that were employed in the present study and is comprised of a review of the procedures as well as participants, measures, and analytic strategy.

Procedures

Analyses utilized data from participants who completed the second wave of the National Study of Daily Experiences (NSDE II, Project 2), which is the daily diary portion of the second wave of the Midlife in the United States national study of health and well-being (MIDUS II, telephone-mail survey conducted in 2004 to 2006). Refer to Brim, Ryff, and Kessler (2004) and Almeida (2005) as well as Almeida, Wethington, and Kessler (2002) for thorough accounts of the original MIDUS and NSDE procedures, respectively.

The protocol of NSDE II consisted of eight consecutive daily telephone interviews; respondents also collected saliva samples on four of the diary days (4 occasions on 4 consecutive days – generally days 2 to 5), which were assayed for cortisol. Information obtained during the calls included time use, physical symptoms, psychological distress, work cutback, daily stressors, positive events, and discrimination. During the last interview, participants also answered questions regarding the previous week. The initial and final calls were about 15-20 minutes in duration; the other six lasted approximately 10-15 minutes. The daily interview was CATI-(Computer Aided Telephone Interview) programmed which enabled use of various skip patterns and open-ended probes as well as allowed interviewers to enter data during the calls. Daily telephone interviews were conducted by the Pennsylvania State University Survey Research Center (SRC).

Data collection for NSDE II occurred from July 2004 to April 2009 with separate groups or flights of interviews, consisting of the eight-day sequence. In order to control for potential confounding between day of study and day of week, initiation of interview flights was staggered. Participants were compensated $25 for their participation and were provided with a telephone number in order to easily change or schedule daily interviews.

Participants

Of the 3,009 MIDUS II respondents selected, 2,022 participated in the diary study by completing at least one daily interview, 599 refused, 278 could not be reached, and 110 were deceased or incapacitated, which resulted in a response rate of 69.75% (completes/completes +

(refusals + non-contacts). Approximately 92% (over 14, 900) of the 16,176 possible daily telephone interviews were completed. The sample (*N* = 2,022) was comprised of 1,079 random digit dialed (RDD) respondents, 185 siblings, 516 twins, 62 city oversamples, and 180 participants from the Milwaukee African American sample. Participants ranged from 33 to 84 years of age (*M* = 56.24, *SD* = 12.20) at completion of baseline (MIDUS II, Project 1) and approximately 57% were female. Excluding the few don't know and refused responses, 84.5% of the sample described their racial origins as White, 11.3% Black/African American, and 4.2% other. In regards to educational status, approximately 31% reported they had graduated from high school or less. The remainder of the respondents had some college (23%), obtained either an associate's or bachelor's degree (27%), or had at least some graduate level education (19%).

For the present study, respondents were selected who participated in saliva collection in order to be consistent with Study 2, which included cortisol analyses. Furthermore, the sample was limited to unrelated individuals by randomly selecting (via SPSS) one member of each family in order to remove the potentially confounding nesting occurring within families. This strategy was suggested and presented as a guideline by MIDUS staff to address familial dependencies in the data (MIDUS, 2011). Of the 1,735 NSDE II saliva collection participants who provided at least one valid sample, 1,196 were not related. The remaining 539 respondents were members of families that ranged from 2 to 7 family members in the sample.

Random selection as a function of family id and case count resulted in 246 participants; combined with the 1,196 unrelated individuals, this produced a final sample of 1,442 unrelated individuals (83% of original sample). The final sample was comprised of 865 random digit dialed (RDD) individuals, 79 unrelated siblings, 320 unrelated twins, 50 city oversamples, and 128 participants from the Milwaukee African American sample. Only 615 of the 11,536 possible daily telephone interviews were missed or did not produce any valid data across the interview (5%). Participants completed an average of 7.57 (out of 8 total) daily telephone interviews with the majority of respondents (91%) completing 7 or all of the study days. Respondents were 56% female and ranged in age from 33 to 84 years (*M* = 56.46, *SD* = 12.17) at completion of baseline (MIDUS II, Project 1). The lag time between the Project 1 phone interview and Project 2 diary completion date was from 120 days (.33 year) to 1684 days (4.61 years) with an average of 663.32 days (1.82 years) and a standard deviation of 407.01 days (1.12 years). Adding each participant's duration between projects to his or her age at Project 1 resulted in an approximate age range in the sample of 34.42 to 86.46 years (*M* = 58.27, *SD* = 12.05). Excluding the few don't know and refused responses, about 85% of the sample described their racial origins as White, 11% Black/African American, and 4% other; this is very close to the racial origins composition of the full NSDE II sample. Educational status breakdown was also similar to the complete NSDE II sample with approximately 32% reporting they had graduated from high school or less. The remainder of the respondents had some college (23%), obtained either an associate's or bachelor's degree (26%), or had at least some graduate level education (19%).

Measures

Daily physical health symptoms. Daily physical health symptoms were assessed in the NSDE II using a modified and expanded version of the measure utilized in the first wave of the NSDE, which was adapted from the Larsen and Kasimatis (1991) checklist. See Appendix 1-A for a complete list of items in the order they were asked. Participants were asked every day of the diary study whether (i.e., no or yes) they experienced each of 23 physical health symptoms (e.g., headache, nausea, and sore throat). In addition, responses to any other physical symptoms or discomforts were recoded into other categories where applicable based on open-ended responses, including the following added items: (1) skin, (2) eye, (3) ear, (4) teeth, or (5) leg/foot pain-related symptoms, which resulted in a composite of 28 items. In addition, 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*).

For the present study, symptoms were excluded from the major analyses that were mainly relevant to female respondents (e.g., hot flashes/flushes and menstrual-related symptoms) in order to focus on daily symptom experiences across both sexes. However, hot flashes/flushes and menstrual-related symptoms (i.e., female health) were included in an initial table (Table 1-1) for descriptive purposes. The remaining physical health symptoms were combined to create a composite (excluding female health) as well as grouped into the following types: **cold/flu** and respiratory (5 items such as cough); **gastrointestinal** (5 items such as nausea); **bodily pain** (5 items such as headache as well as 5 added symptoms reviewed above); **fatigue** (2 items including fatigue and muscle weakness); **allergies** (1 single item); and "**other"** (catch-all category including 3 items, which did not clearly fit into the other categories, such any other and shortness of breath or difficulty breathing). See Appendix 1-B for a complete list of the items comprising the various symptom categories.

The majority of these types and corresponding specific physical health symptoms are fairly consistent with those utilized in previous diary studies. For example, Charles and Almeida (2006) examined daily reports of symptoms in the first wave of the NSDE and created several groups, including cold/flu and respiratory complaints (i.e., cough, sore throat, fever, chills, and other cold/flu), gastrointestinal discomforts (i.e., nausea, diarrhea, poor appetite, and other stomach problems), and pain symptoms (i.e., headaches, backaches, and muscle soreness). Larsen (2007) also organized a checklist of symptoms into the domains of aches (e.g., muscle soreness), gastrointestinal (e.g., constipation), and upper respiratory (e.g., congestion) as well as an additional, separate factor called distress that included items such as low energy (similar to fatigue). These prior studies were examined for reference and provided the framework for the symptom categories created here with allergies as a stand-alone item since this item more likely represents a condition (Kessler, Almeida, et al., 2001). In addition, a few remaining symptoms (i.e., shortness of breath or difficulty breathing, dizziness, and any other physical symptoms or discomforts) were placed in the "other" category given their unclear or inconsistent fit with the existing types based on review of prior studies.

Daily work cutback. To assess daily work cutback in the NSDE II, participants were asked during each daily interview whether or not (i.e., yes or no) they cut back on their normal work activities (i.e., paid, school, house, and volunteer work). Therefore, this information was available for all respondents. Included in the prompt were possible reasons for cutting back such as problems with physical health, emotions, use of alcohol, and some combination. Given this, models with physical health symptoms predicting reports of any work cutback included two relevant between-person control variables (in addition to age and gender following from the first objective): negative affect or nonspecific psychological distress and alcohol consumption.

Participants were characterized as an alcohol drinker (1 = yes) if they reported having any alcoholic beverages across the study days; the remainder of the respondents were assigned a value of 0 identifying them as not having consumed alcohol. About half of the participants (48%) were identified as alcohol drinkers.

In regards to negative affect or nonspecific psychological distress, participants were asked daily how much of the time on a 5-point scale from 0 to 4 (*none of the time, a little of the time, some of the time, most of the time,* or *all of the time*) they felt each of 14 items (e.g., worthless, irritable). The scale was expanded and modified for MIDUS II from the version utilized in the first wave of the study (Kessler et al., 2002; Mroczek & Kolarz, 1998). Scores across the 14 items were averaged each day. Average daily negative affect was then created by calculating each individual's mean across the daily interviews (*M* = .20, *SD* = .25). The between-person reliability for the negative mood scale was .91 in the present sample.

Analytic Strategy

Aim 1. In order to provide a person-level descriptive account of daily physical health symptoms, the following summary variables were constructed: frequency, average severity, and maximum severity. **Frequency** (i.e., proportion of days experienced) was calculated for all participants as well as among those reporting at least one relevant symptom during the study. **Average severity** was determined by calculating the person-mean of the average daily severity across all applicable items. The highest individual item severity rating across the days within each symptom type and the composite variables was selected to represent **maximum severity**. These three indicators of symptom experience were calculated across all symptoms (i.e., composite) and then separately by symptom type (i.e., cold/flu, gastrointestinal, bodily pain, fatigue, allergies, and "other"). These aspects of symptom types were compared using *t*-tests and correlations.

To investigate demographic differences in experiences of daily physical health symptoms, logistic and linear regression were used with age and gender entered as predictors simultaneously. The majority of the frequency variables across the symptom types were skewed due to a large number of 0s, representing participants who did not report any across the eight daily interviews. As a result, logistic regression models were employed to model whether *any* symptom occurred across the entire study for each symptom and the composite. Linear regression models were then utilized for analyses predicting frequency, specifically among participants reporting one or more relevant symptoms on at least one study day. Average severity and maximum severity as well as number of symptoms (for the composite category) were also modeled using linear regression techniques. Age was centered at the sample mean and transformed to reflect difference per decade as well as to reduce collinearity given that linear and quadratic effects of age were considered. Interactions with gender were also examined.

Aim 2. Generalized linear mixed models (i.e., fixed and random effects through link functions), specifically logistic multilevel models (Snijders & Bosker, 1999) in SAS PROC NLMIXED (following from Stawski, Almeida, Lachman, Tun, & Rosnick, 2010) were used to *separately* analyze the associations between dimensions (i.e., **symptom occurrence/frequency**, **severity**, and **maximum severity**) of daily physical health symptoms and daily restrictions in normal work activities. This strategy was employed given the nested data structure (i.e., days within individuals), dichotomous outcome (i.e., work cutback: yes or no), and interest in examining within- as well as between-person effects (i.e., shift in focus to the day as unit of analysis). Age was treated as described in Aim 1 and remaining continuous Level 2 predictors (i.e., average daily negative affect and maximum severity) were transformed to *z* units. In regards to any symptoms as well as severity, a person-mean predictor, centered at the grand mean, was included at Level 2 to represent frequency (i.e., proportion of days reported across the study) or average severity, respectively. These were also subtracted from the original time-varying predictors in Level 1 (i.e., person-mean centered) to obtain “pure” within-person effects (i.e., symptom days compared to days with no symptoms or effect of days when severity was more severe than usual) (Hoffman & Stawski, 2009). Interactions with age (linear and quadratic effects) were also examined. Models predicting any daily work cutback were estimated for each of the symptom types as well as the composite variable (7 models * 3 symptom dimensions) in order to examine separate associations. Note that the residual variance for logistic multilevel models such as this is not estimated and fixed at 3.29 ($\pi^2/3$) as the mean (average proportion of successes/probability) and variance of the dependent variable are dependent (Hox, 2002; Snijders & Bosker, 1999).

PROC NLMIXED was selected rather than alternatives such as PROC GLIMMIX for several reasons (for review using dyadic/couple data, which is easily extended to hierarchically structured data where days are nested within individuals, see Flom, McMahon, & Pouget, 2007; McMahon, Pouget, & Tortu, 2006). First and most importantly, better and more accurate estimates are obtained in PROC NLMIXED as a result of the numerical estimation method (adaptive Gaussian quadrature) compared to quasi-likelihood approaches in PROC GLIMMIX. In addition, model deviance comparisons for nested models are permitted in PROC NLMIXED and there is greater flexibility in regards to the distribution of the dependent variable (i.e., several user-defined options). Another difference between the procedures is that PROC NLMIXED requires the user to provide parameter starting values, which allows for control and modification to facilitate model convergence, but also is time intensive and necessitates obtaining initial values from other SAS procedures such as PROC MIXED or PROC GENMOD. Despite the advantages of PROC NLMIXED, it is limited to two levels and models can be difficult to estimate, particularly those that are complex and include multiple random effects (Flom et al., 2007; McMahon et al., 2006).

Finally, there are additional aspects of logistic mixed models and differences from linear mixed models to consider (Hedeker, 2005; Hedeker & Gibbons, 2006; Snijders & Bosker, 1999). Fixed effects are conditional on the random effects ("unit-specific" or "subject-specific" model).

In addition, calculating variance explained, particularly additional variance explained by particular predictors, is complicated by the fact that the variance of the outcome variable is related to the proportion of 1s; it is also fluid and depends on how many variance components and fixed effects are in the model. Furthermore, coefficients cannot be compared across models due to scaling and the fixed residual variance. Adding a random intercept to an empty model increases the total variance in the dependent variable and increases the size of the fixed effects. Also, effects of Level 1 predictors cannot decrease the residual variance, which results in the other estimates (i.e., fixed effects and random intercept variance) increasing (Hedeker, 2005; Hedeker & Gibbons, 2006; Snijders & Bosker, 1999).

Results

Aim 1. Description of Daily Physical Health Symptoms and Types

Table 1-1 presents a description of each daily symptom and two composite variables (with and without the female health items) as well as the six symptom types created (i.e., cold/flu, gastrointestinal, bodily pain, fatigue, allergies, and "other"). First assessed was the percentage and number of participants across the items, types, and composite variables that experienced at least one physical health symptom during the study days (column 1). This assessment was followed by the mean frequency or proportion of interview days a specific symptom or category was experienced for the full sample and then just among those participants reporting at least one relevant symptom across the study days (columns 2 and 3). This information was obtained by aggregating (to the person-level) daily variables indicating whether or not a particular symptom or type was reported.

Finally, the mean of the average symptom severity (column 4) and maximum symptom severity (column 5) across the study days were examined. For the composite variables and symptom groups, average severity was created by aggregating the calculated average daily severity across all pertinent items. On the other hand, maximum severity refers to the highest individual item severity rating across the days within each symptom type and the composite variables.

The first column of the second row of Table 1-1 indicates that approximately 94% of the sample reported at least one physical health symptom (out of a possible 26 symptoms, not including female health items) across the study days. Examination across the symptom categories in column 1 (excluding female health symptoms that are not of primary interest and removed from subsequent tables and analyses as previously described) revealed the following order of types reported by the largest to smallest percentage of participants: bodily pain (83%), fatigue (61%), cold/flu (41%), gastrointestinal (38%), “other” (35%), and allergies (29%). In regards to single symptoms, fatigue was reported by the most participants (58%).

The second row, second column shows that on average, participants in the full sample reported a symptom on 65% of the study days (approximately five of the eight days). Excluding those people who did not report any symptoms during the study (about 6%), the remaining participants experienced at least one symptom on 69% of study days (row 2, column 3). Limited to symptom days and people, the average number of symptoms reported during an interview was 2.41 (SD = 1.61). On average, joint pain was the symptom item experienced the greatest proportion of days for all people (M = .25, SD = .34; column 2) as well as among those who experienced the symptom during the study (M = .49, SD = .33; column 3).

The final two columns of Table 1-1 provide information on the perceived severity of daily physical health symptoms on a scale from 1 (very mild) to 10 (very severe). The mean average severity (row 2, column 4) considering all 26 items was 3.51 (SD = 1.53) and 5.71 (SD =

2.50) for maximum severity (row 2, column 5). Tooth pain was rated as the most severe single symptom with a mean of 5.12 (*SD* = 3.11) for average severity (column 4) and 5.57 (*SD* = 3.55) for maximum severity (column 5). It should be noted, however, that this item was very rarely endorsed and as previously mentioned, was created after data collection from open-ended responses to the any other physical symptom or discomforts item. The next step was to further compare and formally tests differences between the various symptom categories.

Comparisons of frequencies across symptom types. Table 1-2 provides the results from a series of paired comparisons (paired-samples *t*-tests) of means for symptom frequency across symptom types. Again, frequency is the proportion of interview days participants reported each type of symptom. These results mirror what was shown descriptively in Table 1-1. On average, bodily pain (.47) was the most frequently reported symptom type followed by fatigue (.26), cold/flu (.17), allergies (.14), gastrointestinal (.13), and “other” (.12). The mean frequencies of the last three types (i.e., allergies, gastrointestinal, and “other”) were not significantly different from each other.

The correlations among the frequencies of the symptom types are shown in Table 1-3. The frequencies across the categories were all significantly and slightly to moderately positively correlated. Those respondents who reported a particular kind of physical health symptom on a greater proportion of study days were also more likely to experience a greater frequency of the other types. The correlations ranged from $r = .14$ (allergies and “other”) to $r = .50$ (bodily pain and fatigue).

Comparisons of average and maximum severity across symptom types. Table 1-4 gives results from additional tests comparing the symptom types, specifically paired comparisons (paired-samples *t*-tests) of means for average severity and maximum severity. Severity ratings were only available for symptoms experienced and people were excluded who did not have values for both types being examined (i.e., exclusion by analysis). The mean of both average severity and maximum severity for cold/flu symptoms was lower than the other symptom types (i.e., least severe). No symptom type had a mean for average severity that was higher than *all* of the other constellations. For example, the mean for average severity of pain-related symptoms was higher than cold/flu as well as allergy symptoms, lower than fatigue symptoms, and not significantly different from the symptom types of gastrointestinal and "other". A slightly different pattern emerged for maximum severity (i.e., most severe item and day); the mean for bodily pain was higher compared to all of the other symptom types.

Finally, Table 1-5 provides the correlations among frequency, average severity, and maximum severity by symptom type. The pattern of associations was similar across the symptom types. Experiencing symptoms more frequently was associated with reporting more severe symptoms on average across the study for all symptom types but "other". These correlations were stronger when considering maximum symptom severity and associations between this variable and frequency were present for all symptom types. Average symptom severity and maximum symptom severity were highly positively correlated in all instances (see discussion section).

Age and gender differences in symptom experiences. The remainder of the analyses for the first aim of describing symptom experiences focused on exploring age and gender differences within the combined, composite category as well as six symptom types. The results are provided in Table 1-6. A series of logistic and linear regression models were run including gender and age as predictors simultaneously. Age was centered at the sample mean and transformed to reflect the unit of change as a decade in order to facilitate interpretation. An age squared term was also tested to explore nonlinear associations with age but only kept or shown if significant. In addition, the interaction between gender and age was tested in all models but was never significant; therefore, it was not retained or depicted in Table 1-6. Logistic regression was used to model whether any symptom occurred during the study period (0 = no, 1 = yes). Linear regression was employed to model the frequency (excluding 0s), average severity, and maximum severity as well as number of symptoms for the composite category.

The results of the logistic regression models demonstrated that for the composite category, the odds of experiencing at least one physical health symptom across the study days was 2.05 times greater for women compared to men. Age was not associated with the odds of reporting any symptoms from the composite category. Women were also more likely to report any symptoms during the daily diary for all symptom types except for "other". For example, the odds of experiencing at least one fatigue-related symptom was 1.84 times greater for women than men. Across the symptom types, linear age was only associated with greater odds of reporting any symptom in the "other" category (i.e., shortness of breath/difficulty breathing, dizziness, and any other). Specifically, for every unit increase in age (10 years), the odds of reporting any symptoms included in the "other" type increased by 20%. Quadratic age and not linear age was associated with the odds of reporting any fatigue symptoms. This suggests a nonlinear relationship, which was further explored by running this particular logistic model again with age as a categorical variable comprised of three groups (i.e., 34 to 49, 50 to 69, and 70 to 86 years of age). Contrasts comparing each group to the identified reference, revealed that the odds of individuals in their 50s and 60s experiencing any fatigue symptoms were .77 less (*CI* = .60, .99; $p < .05$) or decreased by 23% compared to adults in the youngest group and .68 less (*CI* = .51, .91; $p < .05$) or decreased by 32% compared to the oldest individuals. The odds ratio for the oldest participants was not significantly different from the youngest age category. Descriptively, 64.6% of participants in their 30s and 40s experienced any symptoms in the fatigue category across the study days compared to 58.1% of 50 to 69-year-olds and 66.4% of those from 70 to 86 years of age.

In regards to the linear regression models, for respondents who experienced any symptoms (composite) and fatigue, women reported them on a greater proportion of days. This was not the case for cold/flu, gastrointestinal, bodily pain, allergies, and “other”. Women also reported a higher number of symptoms, on average, compared to men. For participants who experienced bodily pain symptoms, linear age was positively associated with frequency. Quadratic age was positively associated with frequency of gastrointestinal symptoms among those who experienced this type (n = 548). As a follow-up of this nonlinear association, dummy variables indicating presence or absence of group membership were created using the same age categories as above, and the linear regression model was rerun including gender and age. With the youngest individuals as the reference category (i.e., corresponding dummy variable excluded from the model), no significant group differences were found. Setting the oldest individuals as the reference category, however, revealed that the average frequency of the middle group was significantly less than that of the oldest category (B = -.06, SE = .03, p < .05). The mean proportion of study days gastrointestinal symptoms were experienced was .35 for the youngest adults (34 to 49 years of age), .33 for the middle category (50 to 69 years of age) and .39 for the oldest participants (70 to 86 years of age). For average and maximum severity, women always reported their symptoms as more severe except for cold/flu maximum severity. Linear and quadratic age effects were never associated with average and maximum severity ratings.

Aim 2. Daily Physical Symptoms and Work Cutback

Work cutback in regards to paid, school, house, and volunteer work was reported on 8% of the completed daily interviews. Approximately 30% of participants reported cutting back on their normal work activities on at least one of the study days (proportion of days: M = .28, SD = .22). In addition, about 58% of the variance was between-persons (intraclass correlation, ICC). Table 1-7 provides the results from seven separate logistic multilevel models (one for the composite symptom category followed by each symptom type) predicting any work cutback. Of particular interest were between- and within-person effects for any physical health symptoms as well as any interactions with age (see rows in bold) when considering gender, age, alcohol consumption, and average daily negative affect.

Model 1 shows that women were more 2.01 times more likely than men to report any work cutback. One unit increase in age (10 years) was associated with a 22% increase in reporting cutback in normal work activities. Drinking alcohol was not associated with any work cutback, and a one standard deviation increase in average daily negative affect was associated with a 79% greater likelihood of any work cutback. These effects were similar across the subsequent models and not of primary interest; as such, they will not be further reviewed in presentation of results for subsequent models.

Across Models 1 to 7, the fifth and six rows provide the between-person (i.e., for people who, individual differences) and within-person (i.e., on days when) effects for any daily physical health symptoms, respectively. For the between-person effect, people who experienced at least one of the corresponding symptoms on a greater proportion of study days were more likely to report any work cutback compared to people who did not report any of these symptoms across the study days. Specifically, each additional symptom day reported was associated with a 42% increase in the odds of cutting back for the composite category (Model 1), 19% for cold/flu symptoms (Model 2), 25% for gastrointestinal (Model 3), 28% for bodily pain (Model 4), 32% for fatigue (Model 5), and 25% for "other" symptoms (Model 7).

Within-person, on symptom days compared to days without symptoms, the odds of reporting any work cutback were 3.69 times greater for the composite category (Model 1), 2.29 for cold/flu (Model 2), 2.92 for gastrointestinal (Model 3), 3.05 for bodily pain (Model 4), 4.47 for fatigue (Model 5), and 2.90 for "other" symptoms (Model 7). The between- and within-person effects of allergy symptoms (Model 6), however, were not significantly associated work cutback (i.e., the confidence intervals included 1).

In addition, linear age interacted with the within-person effects of symptoms for fatigue (Model 5) as well as "other" symptoms (Model 7). Younger adults in the sample were more likely than older adults to report any work cutback on fatigue symptom days compared to non-fatigue symptom days. A similar pattern was found for "other" symptoms.

Similar models are presented in Table 1-8 but include a different dimension of daily physical health symptoms: maximum severity. Recall that maximum symptom severity is a between-person (i.e., Level 2) variable; it is the highest item severity rating across the study days within each type and composite for participants who endorsed at least one relevant symptom across the daily interviews. Given this, there is no within-person effect to consider. For every one standard deviation increase in maximum symptom severity, the odds of reporting any work cutback on a given day increased by a factor of 2.44 for the composite category, 54% for cold/flu, 48% for gastrointestinal, 85% for bodily pain, 59% for fatigue, 39% for allergies, and 72% for "other" symptoms. No interactions between maximum symptom severity and linear or quadratic age were found.

Finally, Table 1-9 gives the results from multiple logistic multilevel models predicting any daily work cutback from between- and within-person effects of severity, the remaining symptom dimension of interest. For people (row 5) who report their cold/flu symptoms (Model 2), fatigue (Model 5), allergy (Model 6), and “other” symptoms (Model 7) as more severe on average, the likelihood of reporting any work cutback increased by 33%, 23%, 36% and 19%, respectively. In addition, for each of these types, the within-person effects were significant; on days more severe symptoms than usual were experienced the odds of reporting cutback in normal work activities increased by 38% for cold/flu, 46% for fatigue, 26% for allergies, and 32% for “other” symptoms.

For the remaining symptom types (i.e., bodily pain and gastrointestinal) and composite category, linear and/or quadratic age interacted with between- and/or within-effects for severity in predicting any work cutback. For the composite symptom category (Model 1), a unit increase in between-person average severity was associated with a 32% increase in the odds of cutting back in work. The within-person symptom effect, however, interacted with a quadratic effect of age. Separate models by age category revealed that on days symptom severity was more severe than usual, those in their 50s and 60s (i.e., middle group) were most likely to report any work cutback. A similar pattern was evident for bodily pain (Model 4). Higher between-person average severity was associated with a 24% increase in the odds of any work cutback. In regards to the within-person effect, those in the middle age category were more likely to report any work cutback on more severe than usual symptom days. For gastrointestinal symptoms (Model 3), those in the middle age category were also more likely to report any work cutback on more severe than usual symptom days (i.e., within-person effect). In regards to the between-person effect, the youngest individuals who experienced higher average severity, on average, were more likely to report any work cutback; there was no significant association for the middle and oldest groups.

Discussion

Daily Physical Health Symptoms and Demographic Differences

General descriptive points. As previously suggested theoretically and demonstrated empirically, daily physical health symptoms are prevalent and fairly frequent (e.g., Horn-Mallers et al., 2005; Merrill & Verbrugge, 1999; Verbrugge, 1986). At least one physical health symptom was experienced during the study by 94% of the sample, and on average, participants reported a symptom on 65% of the study days. In addition, although they are generally perceived as mildly to moderately severe, some symptoms were rated as more severe or less severe than others (e.g., cold/flu symptoms were the least severe). Therefore, grouping symptoms is helpful and revealed meaningful differences. Furthermore, symptom frequency was modestly correlated among the symptom types. Frequencies of perhaps more subjective symptom types such as fatigue and bodily pain were more strongly related.

Bodily pain was the symptom type experienced by the most participants and most frequently reported in the full sample compared to the other groups, which is not surprising given the age range and distribution of the sample; the majority of participants in the present study were in later midlife (see discussion of musculoskeletal symptoms in Verbrugge, 1986). In undergraduates, however, upper respiratory problems were the most frequently reported symptom type compared to gastrointestinal, distress, and pain symptoms (Larsen, 2007). Consideration and acknowledgement of age and potential age differences may be critical in samples including both young and old adults as well as when interpreting symptom experiences and their consequences.

Also, there was a difference between symptom type frequency and severity, providing support for distinguishing between these factors of symptom reporting (Kroenke, 2001). For example, cold/flu symptoms were the third most frequently reported group, but were the least severe compared to all the other types in regards to both average and maximum severity. In addition, symptom frequency and average severity were only modestly correlated across the symptom types. Finally, slight discrepancies emerged when comparing average severity and maximum severity of the symptom types. For example, the mean for maximum severity of bodily pain was higher compared to all the other symptom types, which was not the case for average severity. This suggests that perhaps when compared to the reports of the other symptom categories, there was a greater range or fluctuation in severity ratings of pain-related symptoms. It should be noted, however, that maximum and average severity were highly correlated; these aspects of symptom reports significantly overlap and likely do not provide distinct information, particularly when the daily assessments are limited in number as in the present study (i.e., 8 days).

Overall, it is clear that diary studies utilizing symptom checklists of this nature provide a significant amount of information to be explored and organized; a variety of summary variables (across substantive dimensions and time scales) can be constructed to maximize the design and provide unique contributions even to just a descriptive account of daily physical health symptoms, which greatly extends global, one-dimensional reports. The present study also contributes to existing, related literature reviewed here by simultaneously considering multiple types and dimensions of symptoms. The validity and usefulness of this approach is reinforced when considering predictors such as gender and age.

Gender differences. As expected, women were more likely than men to report at least one physical health symptom during the study period across the composite category and all symptom types with the sole exclusion of “other”. In addition, all associated average and maximum severity ratings were significantly higher (i.e., more severe) for women except for cold/flu maximum severity, which suggests that the most severe day and item among participants who experienced this symptom type was similar for both sexes. Furthermore, gender was not as strongly associated with the average severity for these respiratory symptoms compared to the other types. Perhaps cold/flu symptoms are different than other types, as suggested by Charles and Almeida (2006), in that they are more specific and easier to observe and measure, which could reduce the influence of potential gender differences in perception of severity. These slight differences as a function of type may further support the construction of groups to more completely characterize symptom experiences.

Contrary to expectations, however, gender was not as consistently associated with frequency across the various symptom categories. Among participants who experienced any symptoms (composite) as well as fatigue-related symptoms, women reported them more frequently (i.e., on a greater proportion of days) during the study. No gender differences in frequency were found, however, for the following symptom types: cold/flu, gastrointestinal, bodily pain, allergies, and “other”. These findings reveal that once men and women report a symptom from a majority of the types considered here (except for fatigue), they experience them a similar proportion of days across the study. Previous studies (e.g., Gijsbers van Wijk et al., 1999) have not directly focused on types or distinguished between symptom reporters and individuals endorsing no symptoms during a particular timeframe, which may contribute to these discrepant results and be particularly important in shorter-term studies. Furthermore, earlier studies have utilized different measurement tools that include assessment of symptom occurrence and intensity/daily duration in the same question (e.g., Gijsbers van Wijk et al., 1999). Adopting a more nuanced approach involving consideration of types as well as multiple variables (i.e., any, frequency, and severity) may contribute to a more in-depth understanding of daily physical health symptom reporting.

In general, however, these findings are fairly consistent with previous literature (Gijsbers van Wijk et al., 1999; Kroenke & Spitzer, 1998; Michel, 2007; Verbrugge, 1985a, 1986; Verbrugge & Ascione, 1987) in that women experienced poorer daily health at least in regards to the likelihood of reporting physical health symptoms across the study days and associated severity. Differences in social roles/position and stress as well as psychological factors such as mood and personality characteristics of neuroticism likely contribute to this pattern of results (Cleary et al., 2004; Gijsbers van Wijk et al., 1999; Popay, Bartley, & Owen, 1993). In regards to stress, research has examined gender differences in appraisal, coping, and health behaviors as well as responses at the physiological level (i.e., hormonal and immune system) (Baum & Grunberg, 1991). Furthermore, Pennebaker and Roberts (1992) argued that men and women use different cues to determine their internal states; men rely on physiological cues while women attend to situational ones. In regards to physical health symptoms, specifically, the symptom perception model has also been applied to the study of gender differences, emphasizing processes related to attention and attribution (Gijsbers van Wijk & Kolk, 1997).

Age differences. As expected, age was not associated with any of the average or maximum severity scores across the symptom types as well as the composite category. This suggests that severity, no matter the kind of symptom, was perceived similarly by participants, regardless of age. Perhaps this is because these symptoms are fairly mild with a somewhat restricted range of severity. In addition, individual factors known to contribute to symptom reporting (likely severity in particular) and characterized by age-related differences (i.e., decreases) such as negative affect (e.g., Charles & Almeida, 2006) are potential confounds not considered in these initial descriptive tables. Also, as reviewed previously, older adults perceive and evaluate their physical health symptoms differently (George, 2001; Leventhal & Prohaska, 1986; Prohaska et al., 1985), so although no age differences were present in severity ratings, the process by which these reports were determined as well as what they reflect may not be equivalent.

Age was also not associated with the odds of reporting any symptoms from the composite category across the study days. Examination across the symptom types, however, revealed that age was positively associated with the likelihood of reporting any symptom from the "other" (i.e., dizziness, shortness of breath/difficulty breathing, other) category during the study. In addition, among those participants who experienced any bodily pain, age was positively associated with frequency of these symptoms (consistent with Verbrugge, 1986). Several nonlinear associations between age and daily symptoms were also found. Participants in their 50s and 60s were least likely to report any fatigue symptoms across the study, compared to both the oldest and youngest age categories. The oldest group had the highest percentage of respondents experiencing any fatigue symptoms, though not statistically different from the youngest individuals. It is important to note, however, that the youngest participant in the sample was 34 years of age, which does not include a large portion of early adulthood and also may be why age was not negatively associated with cold/flu symptoms as expected (Verbrugge, 1986). In addition, the age distribution was not equal with only 19% of the sample at the age of 70 years or above. Finally, among those participants who reported gastrointestinal symptoms, the mean frequency was lowest for the middle category (i.e., 50 to 69 years of age) and significantly different from the oldest group. Again, the mean frequency was highest for individuals aged 70 to 86, but not significantly different from the youngest group. These results highlight the need to consider the age range of the sample and nonlinear effects of age as well as help to clarify the conflicting evidence regarding age differences in experiences of daily physical health symptoms by considering multiple symptom variables and types (Horn-Mallers et al., 2005; Verbrugge, 1986). After describing the prevalence, frequency, and severity of daily physical health symptoms, the next set of analyses focused on demonstrating their significance in daily life, specifically cutback in normal work activities.

Relevance of Daily Physical Health Symptoms: Links to Daily Work Cutback

Limited research has examined how various types and dimensions of daily physical health symptoms are associated with daily cutback in work activities, specifically. This may be an important index of symptom-related impairment (Verbrugge, 1985b, Verbrugge & Ascione, 1987) in daily life that is associated with lost productivity and hidden cost for employers, for example (Kessler, Almeida, et al., 2001; Kessler, Greenberg, et al., 2001). As expected and extending from literature focused on chronic conditions and monthly/daily work cutback (Kessler, Almeida, et al., 2001; Kessler, Greenberg, et al., 2001), being a person who reported symptoms on a greater proportion of the study days was associated with an increased likelihood of reporting any work cutback for the composite variable and each type, excluding allergies. In addition, the odds of reporting cutback in normal work activities was greater on symptom days compared to days without symptoms for all the types, also with the exception of allergies. These symptom experiences at both the person and day level are important in predicting daily work cutback. A follow-up model was estimated including all between- and within-person predictors simultaneously of any symptoms (i.e., occurrence/frequency) for each type: cold/flu, gastrointestinal, bodily pain, fatigue, allergy, and “other” symptoms. All effects reported previously remained significant except for one (i.e., between-person effect for other symptoms – frequency). In addition, fatigue appeared to be most strongly associated with work cutback followed by bodily pain. Caution and further exploration are required, however, when interpreting these results as an issue resulted with the size of the elements of the projected gradient (SAS log).

Allergy symptoms were represented by one single item (i.e., allergies) and it could be argued this is not descriptive as well as more likely represents a condition rather than a symptom (e.g., runny nose). Furthermore, allergies were the second least severe symptom type behind cold/flu symptoms and may also be more easily treated, controlled, and predicted than the other symptom types. Perhaps some of these factors contribute to the occurrence/frequency of allergies not being associated with restricting work-related activities, in contrast to the other symptom types.

In addition, for fatigue and “other” symptoms, the within-person association between any symptoms (i.e., daily occurrence) and work cutback was moderated by age. “Younger” adults were more likely than older adults to report any work cutback on fatigue days compared to days without fatigue as well as on “other” symptom days compared to days without “other” symptoms. Older adults may be better able to cope with these symptoms when they occur as well as expect them. The nature of work cutback and the specific activities being restricted also likely differ as a function of age.

Across the composite category and all symptom types (including allergies), higher maximum severity was associated with an increase in the odds of reporting any work cutback on a given day, which did not vary as a function of age. In addition, the majority of all between- and within-person effects of severity were significant across all symptom types. Adults in their 50s and 60s (i.e., later midlife), however, were more likely to report cutback in normal work activities on days severity was higher than usual for the composite category, gastrointestinal symptoms, and bodily pain. Finally, “younger” individuals who experienced more severe gastrointestinal symptoms were most likely to report a cutback compared to the other age groups. In sum, increases in most aspects of symptom experiences were associated with greater odds of reporting work cutback, however, age moderated some of these relationships.

Limitations and Future Directions

There are several limitations to note and issues to address in future research. Three specific areas necessitate particular consideration: (1) types and dimensions of daily physical health symptoms, (2) study design, and (3) measurement of and analysis with daily work cutback.

Types and dimensions of daily physical health symptoms. Although the grouping of physical health symptoms employed in the present study was based on previous literature and theory, further empirical exploration and validation may be warranted. Categorizing symptoms of this nature may always be somewhat arbitrary, however, given the lack of information related to causes or medical explanations, for example. In addition, the number of symptoms considered per category was unequal, which could have influenced the results, particularly when comparing the types (e.g., frequencies).

Also, associations of the various symptom types with work cutback were not directly compared in these analyses, which prevented determining whether some symptom types are more potent than others. This was not possible or meaningful for models predicting any work cutback from average severity and maximum severity as the samples differed across the symptom types. In regards to any symptoms (between- and within-person effects) where values were available for all participants across symptom types, an attempt was made to estimate one model including all types as concurrent predictors, but model problems (i.e., size of the elements of the project gradient) resulted likely due to the number of parameters and computational intensity. Caution is also required when making inferences and drawing conclusions across the symptom types as reports were made by the same individuals with no adjustment for the resulting correlation.

Finally, future analyses examining if symptom severity predicts work cutback above and beyond frequency may be potentially interesting and informative in understanding the relative role and contribution of various dimensions of symptom experiences.

Study design. The youngest participants were in their 30s, which excludes the period of early and emerging adulthood. In addition, this investigation was also cross-sectional (i.e., age differences vs. age change). As a result, cohort and aging effects cannot be disentangled. Respondents who survive to older age and participate in research studies may differ in important ways from those who do not, as well as younger respondents, with regards to the primary variables of interest here: daily physical health symptoms and work cutback. Generational differences as well as selection may be at least partially responsible for the findings in addition to aging. Future work could also examine change in reports of daily physical health symptoms (i.e., stability or change: increase/decrease) over approximately a decade by focusing on the longitudinal sample who completed both the first and second waves of the National Study of Daily Experiences. Measurement of symptoms differed rather substantially across NSDE I and

II, however, which would present several analytical challenges. The first wave included fewer items and assessed daily duration, while the second wave examined occurrence and severity.

It should also be noted that the study design of both waves is somewhat limited in that reports were obtained once a day on eight consecutive occasions. Momentary assessment (i.e., multiple daily assessments) and/or longer periods of data collection may provide additional information, particularly in regards to temporal dynamics of daily physical health symptoms, though participant burden must be taken into account as well as appropriate sampling period for the major variables of interest (e.g., Larsen, 2007).

Measurement of and analysis with daily work cutback. Third, understanding of the associations between types and dimensions of daily physical health symptoms with work cutback would benefit from additional analysis and clarification. The study design could be further maximized by examining other temporal dynamics of daily physical health symptoms such as lagged associations (present and prior day) with daily work cutback. In addition, employment status and other occupational characteristics were not explored here. The question regarding cutback in normal work activities included paid, school, house, and volunteer activities; work was defined by the participant. The strength of this approach is that all participants can provide a response as it is applicable to everyone, but the interpretation and meaning of work cutback is somewhat unclear. It is also more difficult to link these reports of cutback specifically to the work context and productivity without modifications such as restricting the sample to full-time employees, for example. Furthermore, these analyses could be supplemented and expanded by examining time use as well as cutback and restriction of activities in other domains of life aside from work.

In sum, interpretation of the results is constrained and restricted by these limitations as well as characteristics of the sample and analytic strategy utilized. However, the outlook for future, related research is promising; much remains to be explored and clarified regarding experiences of daily physical health symptoms (i.e., types and dimensions) and how they impact as well as interact with age to influence various aspects of daily life and well-being.

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Table 1-1

Description of Daily Physical Health Symptom Items and Types

	People 1+ Percentage (*n*)	Frequency - all people Mean (*SD*)	Frequency – people 1+ Mean (*SD*)	Average severity Mean (*SD*)	Maximum severity Mean (*SD*)
All symptoms (composite)	94.04% (1356)	0.66 (0.34)	0.70 (0.31)	3.52 (1.53)	5.77 (2.49)
All symptoms (no female health)	93.62% (1350)	0.65 (0.34)	0.69 (0.31)	3.51 (1.53)	5.71 (2.50)
Cold/flu	41.33% (596)	0.17 (0.28)	0.42 (0.30)	2.78 (1.61)	3.75 (2.40)
Cough	29.54% (426)	0.12 (0.25)	0.41 (0.30)	2.64 (1.68)	3.36 (2.34)
Sore throat	12.90% (186)	0.04 (0.14)	0.33 (0.25)	2.84 (1.52)	3.38 (1.95)
Chills	7.21% (104)	0.02 (0.09)	0.25 (0.22)	3.76 (1.91)	4.22 (2.41)
Fever	2.84% (41)	0.01 (0.05)	0.25 (0.17)	3.16 (1.56)	3.76 (2.23)
Other cold/flu	16.78% (242)	0.05 (0.15)	0.31 (0.24)	3.50 (1.86)	4.11 (2.23)
Gastrointestinal*	38.00% (548)	0.13 (0.23)	0.35 (0.26)	3.90 (1.91)	4.90 (2.54)
Diarrhea	12.34% (178)	0.03 (0.11)	0.25 (0.21)	4.20 (2.34)	4.67 (2.56)
Nausea	12.34% (178)	0.03 (0.10)	0.23 (0.18)	3.67 (2.21)	4.08 (2.54)
Poor appetite*	12.21% (176)	0.04 (0.15)	0.36 (0.27)	4.59 (1.81)	5.37 (2.20)
Constipation*	7.84% (113)	0.02 (0.10)	0.28 (0.22)	4.18 (1.97)	4.71 (2.38)
Other stomach*	17.61% (254)	0.05 (0.15)	0.28 (0.24)	4.05 (2.20)	4.57 (2.48)
Bodily pain	82.59% (1191)	0.47 (0.36)	0.57 (0.32)	3.60 (1.69)	5.00 (2.38)
Muscle soreness	55.62% (802)	0.21 (0.28)	0.38 (0.28)	3.59 (1.82)	4.32 (2.29)
Joint pain	51.73% (746)	0.25 (0.34)	0.49 (0.33)	3.80 (1.87)	4.64 (2.30)
Headache	42.44% (612)	0.12 (0.20)	0.29 (0.21)	3.65 (1.81)	4.23 (2.20)
Backache	40.57% (585)	0.17 (0.28)	0.42 (0.31)	3.74 (1.94)	4.49 (2.43)
Chest pain*	7.98% (115)	0.02 (0.10)	0.28 (0.23)	3.48 (2.08)	3.98 (2.45)
Leg/foot	3.12% (45)	0.01 (0.05)	0.23 (0.18)	4.59 (2.27)	4.82 (2.34)
Eyeǂ	1.04% (15)	0.00 (0.03)	0.21 (0.22)	4.89 (2.49)	5.00 (2.65)
Earǂ	0.62% (9)	0.00 (0.02)	0.17 (0.12)	3.75 (2.05)	4.00 (2.18)
Teeth*ǂ	0.55% (8)	0.00 (0.02)	0.25 (0.17)	5.12 (3.11)	5.57 (3.55)
Skinǂ	0.35% (5)	0.00 (0.01)	0.16 (0.05)	3.30 (1.48)	3.60 (2.07)
Fatigue	61.44% (886)	0.26 (0.31)	0.42 (0.29)	3.93 (1.77)	4.99 (2.30)
Fatigue*	57.63% (831)	0.22 (0.28)	0.38 (0.27)	3.96 (1.81)	4.85 (2.28)
Muscle weakness	22.75% (328)	0.09 (0.23)	0.40 (0.32)	3.98 (1.98)	4.72 (2.31)
Allergies	28.71% (414)	0.14 (0.27)	0.47 (0.32)	3.16 (1.65)	3.99 (2.21)
Other*	34.88% (503)	0.12 (0.23)	0.34 (0.28)	4.04 (2.11)	4.87 (2.55)
Shortness breath/difficulty breathing	15.95% (230)	0.06 (0.19)	0.39 (0.31)	3.69 (1.89)	4.36 (2.30)
Dizziness	12.27% (177)	0.03 (0.13)	0.28 (0.25)	3.53 (2.17)	3.99 (2.43)
Any other*	17.82% (257)	0.04 (0.10)	0.21 (0.15)	4.96 (2.41)	5.35 (2.58)
Female health (803 women)	31.26% (251)	0.12 (0.24)	0.38 (0.29)	3.94 (2.05)	4.69 (2.40)
Hot flashes/flushes	24.41% (196)	0.09 (0.22)	0.39 (0.30)	4.03 (2.13)	4.64 (2.37)
Menstrual	10.09% (81)	0.03 (0.11)	0.30 (0.20)	3.59 (1.75)	4.42 (2.38)

Note. *N* = 1442 individuals.
* indicates symptom types and items where the number of valid responses for the severity variables was slightly less than anticipated given missing responses (e.g., don't know). ǂ identifies items for which the average symptom frequency (proportion of days experienced) across all participants appears to be 0 due to number of decimals retained (truncated).

Table 1-2

Paired Comparisons of Means for Frequency across Physical Health Symptom Types

Pair	Mean (*SD*)	*t*	*df*
Cold/flu Gastrointestinal	.17 (.28) .13 (.23)	4.78***	1441
Cold/flu Bodily pain	.17 (.28) .47 (.36)	-27.60***	1441
Cold/flu Fatigue	.17 (.28) .26 (.31)	-8.85***	1441
Cold/flu Allergies	.17 (.28) .14 (.27)	3.93***	1441
Cold/flu Other	.17 (.28) .12 (.23)	6.38***	1441
Gastrointestinal Bodily pain	.13 (.23) .47 (.36)	-35.36***	1441
Gastrointestinal Fatigue	.13 (.23) .26 (.31)	-15.72***	1441
Gastrointestinal Allergies	.13 (.23) .14 (.27)	-.43	1441
Gastrointestinal Other	.13 (.23) .12 (.23)	1.67	1441
Bodily pain Fatigue	.47 (.36) .26 (.31)	24.20***	1441
Bodily pain Allergies	.47 (.36) .14 (.27)	30.43***	1441
Bodily pain Other	.47 (.36) .12 (.23)	36.42***	1441
Fatigue Allergies	.26 (.31) .14 (.27)	12.23***	1441
Fatigue Other	.26 (.31) .12 (.23)	17.02***	1441
Allergies Other	.14 (.27) .12 (.23)	1.77	1441

Note. N = 1442 individuals. ***$p < .001$.

Table 1-3

Correlations among Physical Health Symptom Types for Frequency

Symptom type	Cold/flu	Gastrointestinal	Bodily pain	Fatigue	Allergies
Cold/flu					
Gastrointestinal	.24***				
Bodily pain	.21***	.32***			
Fatigue	.26***	.41***	.50***		
Allergies	.18***	.15***	.15***	.17***	
Other	.28***	.33***	.30***	.39***	.14***

Note. N = 1442 individuals.
***$p < .001$.

Table 1-4

Paired Comparisons of Means for Average Severity and Maximum Severity across Physical Health Symptom Types

	Average severity			Maximum severity		
Pair	Mean (*SD*)	*T*	*df*	Mean (*SD*)	*t*	*df*
Cold/flu Gastrointestinal	3.05 (1.71) 3.88 (1.88)	-7.81***	304	4.20 (2.55) 5.05 (2.59)	-5.32***	304
Cold/flu Bodily pain	2.85 (1.65) 3.69 (1.72)	-11.40***	531	3.86 (2.43) 5.33 (2.45)	-12.35***	531
Cold/flu Fatigue	2.97 (1.64) 4.13 (1.83)	-12.90***	425	4.09 (2.46) 5.41 (2.39)	-10.00***	425
Cold/flu Allergies	2.78 (1.56) 3.34 (1.75)	-5.45***	230	3.74 (2.33) 4.28 (2.31)	-3.55***	230
Cold/flu Other	3.14 (1.73) 4.09 (2.18)	-7.01***	274	4.38 (2.54) 5.05 (2.69)	-3.73***	274
Gastrointestinal Bodily pain	3.92 (1.92) 3.90 (1.74)	.22	506	4.94 (2.52) 5.67 (2.42)	-6.24***	506
Gastrointestinal Fatigue	3.97 (1.91) 4.15 (1.78)	-1.90	426	5.08 (2.56) 5.52 (2.34)	-3.05**	426
Gastrointestinal Allergies	3.86 (1.93) 3.47 (1.83)	2.88**	207	4.96 (2.62) 4.33 (2.35)	3.25**	207
Gastrointestinal Other	4.05 (1.99) 4.21 (2.16)	-1.27	281	5.24 (2.69) 5.20 (2.62)	.22	281
Bodily pain Fatigue	3.75 (1.70) 3.93 (1.76)	-3.42**	808	5.35 (2.40) 5.07 (2.32)	3.71***	808
Bodily pain Allergies	3.60 (1.61) 3.17 (1.65)	5.46***	372	5.12 (2.29) 4.03 (2.23)	8.88***	372
Bodily pain Other	3.99 (1.76) 4.10 (2.11)	-1.23	462	5.75 (2.41) 4.97 (2.54)	6.45***	462
Fatigue Allergies	3.98 (1.76) 3.31 (1.74)	6.17***	294	5.16 (2.25) 4.22 (2.28)	6.45***	294
Fatigue Other	4.18 (1.82) 4.08 (2.06)	.99	393	5.54 (2.32) 5.01 (2.53)	3.99***	393
Allergies Other	3.38 (1.79) 3.92 (2.07)	-3.36**	181	4.24 (2.29) 4.87 (2.59)	-3.26**	181

Note. Degrees of freedom and sample sizes differ because severity ratings were only obtained when the symptom was experienced and cases were excluded by analysis (eliminating people without values for both types examined) in comparisons of means.
***$p < .001$; **$p < .01$.

Table 1-5

Correlations among Frequency, Average Severity, and Maximum Severity by Physical Health Symptom Type

Composite symptoms	Symptom frequency	Average symptom severity
Symptom frequency		
Average symptom severity	.20***	
Maximum symptom severity	.48***	.77***

Cold/flu symptoms	Symptom frequency	Average symptom severity
Symptom frequency		
Average symptom severity	.21***	
Maximum symptom severity	.47***	.87***

Gastrointestinal symptoms	Symptom frequency	Average symptom severity
Symptom frequency		
Average symptom severity	.16***	
Maximum symptom severity	.45***	.86***

Bodily pain symptoms	Symptom frequency	Average symptom severity
Symptom frequency		
Average symptom severity	.24***	
Maximum symptom severity	.46***	.86***

Fatigue symptoms	Symptom frequency	Average symptom severity
Symptom frequency		
Average symptom severity	.19***	
Maximum symptom severity	.49***	.86***

Allergy symptoms	Symptom frequency	Average symptom severity
Symptom frequency		
Average symptom severity	.17***	
Maximum symptom severity	.42***	.89***

Other symptoms	Symptom frequency	Average symptom severity
Symptom frequency		
Average symptom severity	.07	
Maximum symptom severity	.34***	.89***

Note. Sample sizes differ by symptom type because severity ratings were only obtained when the symptom was experienced: composite (1350), cold/flu (596), gastrointestinal (545), bodily pain (1191), fatigue (886), allergy (414), and “other” symptoms (502).

***$p < .001$.

Table 1-6

Age and Gender Differences (Entered Simultaneously) in Physical Health Symptom Experiences Using Logistic and Linear Regression

	Logistic Model Predictors: *OR* (95% *CI*)			Linear Model Predictors: *B* (*SE*)		
Dependent Variable	Gender	Age	Age²	Gender	Age	Age²
Composite						
Any	2.05 (1.33, 3.17)**	1.03 (0.87, 1.23)				
Frequency				.06 (.02)**	.01 (.01)	
Average severity				.47 (.08)***	.02 (.03)	
Maximum severity				.97 (.14)***	.01 (.06)	
Number (symptom days)				.39 (.09)***	.02 (.04)	
Cold/flu symptoms						
Any	1.32 (1.07, 1.63)*	0.95 (0.87, 1.04)				
Frequency				-.02 (.03)	-.02 (.01)	
Average severity				.31 (.13)*	.03 (.06)	
Maximum severity				.28 (.20)	.02 (.08)	
Gastrointestinal						
Any	1.63 (1.31, 2.03)***	0.97 (0.89, 1.06)				
Frequency				.04 (.02)	.01 (.01)	.01 (.01)*
Average severity				.51 (.17)**	-.07 (.07)	
Maximum severity				.74 (.22)**	-.07 (.09)	
Bodily pain						
Any	1.77 (1.35, 2.33)***	0.93 (0.83, 1.04)				
Frequency				.03 (.02)	.03 (.01)***	
Average severity				.48 (.10)***	.03 (.04)	
Maximum severity				.86 (.14)***	.06 (.06)	
Fatigue						
Any	1.84 (1.49, 2.29)***	1.00 (0.91, 1.10)	1.07 (1.00, 1.15)*			
Frequency				.08 (.02)***	.01 (.01)	
Average severity				.44 (.12)***	-.01 (.05)	
Maximum severity				.70 (.16)***	-.03 (.06)	
Allergies						
Any	1.80 (1.42, 2.28)***	1.04 (0.94, 1.14)				

Frequency			-.03 (.03)	-.02 (.01)
Average severity			.54 (.17)**	.10 (.07)
Maximum severity			.61 (.23)**	.01 (.09)
<u>Other</u>				
Any	1.21 (0.97, 1.51)	1.20 (1.09, 1.31)***		
Frequency			.05 (.03)	.02 (.01)
Average severity			.50 (.19)**	-.04 (.08)
Maximum severity			.69 (.23)**	-.01 (.09)

Note. *OR* = odds ratio. *CI* = confidence interval. *B* = unstandardized estimate. *SE* = standard error. Gender: 0 = male, 1 = female. Age was centered at the sample mean and transformed (unit = decade) and also squared (quadratic). Age^2 was only retained and depicted if significant. No gender*age interaction terms were significant (not shown here). Any for the various symptom types and composite represents if at least one symptom was experienced across the study (0 = no, 1 = yes; *N* = 1442). As a follow-up, frequency is the proportion of days experienced for participants who reported at least one physical health symptom by type and composite. *N*s differ by category for average severity and maximum severity as well as frequency.
***p < .001; **p < .01; *p < .05.

Table 1-7

Logistic Multilevel Models Predicting Any Daily Work Cutback from Symptom Occurrence and Frequency for each Physical Health Symptom Type

	Separate Models Predicting Any Work Cutback						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Composite symptoms predicting cutback	Cold/flu symptoms predicting cutback	Gastrointestinal symptoms predicting cutback	Bodily pain symptoms predicting cutback	Fatigue symptoms predicting cutback	Allergy symptoms predicting cutback	Other symptoms predicting cutback
Parameter	Fixed effects: *OR* (95% *CI*)						
Gender	2.01 (1.50, 2.70)***	2.33 (1.72, 3.15)***	2.18 (1.61, 2.95)***	2.11 (1.56, 2.85)***	1.85 (1.36, 2.50)***	2.28 (1.68, 3.09)***	2.28 (1.68, 3.08)***
Age	1.22 (1.08, 1.37)***	1.32 (1.17, 1.49)***	1.26 (1.12, 1.43)***	1.22 (1.08, 1.37)**	1.21 (1.07, 1.38)**	1.30 (1.15, 1.47)***	1.27 (1.12, 1.44)***
Alcohol drinker	0.87 (0.66, 1.16)	0.92 (0.69, 1.23)	0.90 (0.67, 1.21)	0.84 (0.63, 1.12)	0.89 (0.66, 1.19)	0.84 (0.63, 1.13)	0.91 (0.68, 1.21)
Av. daily NA	1.79 (1.58, 2.02)***	2.05 (1.80, 2.32)***	1.83 (1.59, 2.11)***	1.85 (1.62, 2.10)***	1.70 (1.49, 1.95)***	2.21 (1.94, 2.51)***	1.94 (1.70, 2.21)***
BP Symptom/8	**1.42 (1.33, 1.52)*****	**1.19 (1.12, 1.26)*****	**1.25 (1.16, 1.35)*****	**1.28 (1.22, 1.35)*****	**1.32 (1.25, 1.41)*****	1.04 (0.98, 1.11)	**1.25 (1.16, 1.35)*****
WP Symptom	**3.69 (2.61, 5.21)*****	**2.29 (1.73, 3.04)*****	**2.92 (2.24, 3.80)*****	**3.05 (2.34, 3.97)*****	**4.47 (3.49, 5.73)*****	1.43 (0.99, 2.06)	**2.90 (2.17, 3.89)*****
BP Sym. X Age					1.21 (0.86, 1.70)		0.74 (0.48, 1.13)
WP Sym. X Age					**0.79 (0.65, 0.95)*[a]**		**0.68 (0.55, 0.85)***[b]**
Intercept	-4.26 (0.17)***	-4.23 (0.17)***	-4.19 (0.17)***	-4.22 (0.17)***	-4.20 (0.17)***	-4.15 (0.17)***	-4.21 (0.17)***
Random int. var.	2.80 (0.29)***	3.11 (0.32)***	3.15 (0.32)***	2.98 (0.31)***	3.03 (0.31)***	3.22 (0.33)***	3.13 (0.32)***
-2 log likelihood	4780.90	4888.50	4856.80	4797.90	4707.20	4950.80	4860.20

Note. Parameters in bold indicate parameters of interest that were significant. *OR* = odds ratio. *CI* = confidence interval. Gender: 0 = male, 1 = female. Age was centered at the sample mean and transformed (unit = decade). Interactions with age and between- and within-person effects of any symptoms are shown only if one was significant. All age^2 effects and interactions with age^2 and between- as well as within-person effects of any symptoms were not significant and excluded from analysis. Alcohol drinker: 0 = no, 1 = yes. Av. daily NA = average daily negative affect (transformed to *z* units). Random int. var. = random intercept variance. BP Symptom = between-person effect for any symptoms (i.e., proportion of days at least one was reported/frequency centered at sample mean); the resulting estimate was divided by 8 to reflect change in odds with each additional symptom day across the study. WP Symptom = within-person effect for any symptoms, which was person-mean centered and reflects symptom days compared to days without symptoms (in the absence of random slope effect). Intercept reflects log-odds of endorsing any work cutback, conditional on variables included in the model. *N* = 1442 people, 10921 completed days for all models.

[a]Older adults (approximately 68 years) *OR*: **3.52**; younger adults (approximately 48 years) *OR*: **5.69**.

[b]Older adults (approximately 68 years) *OR*: **1.98**; younger adults (approximately 48 years) *OR*: **4.25**.

****p* < .001; ***p* < .01; **p* < .05.

Table 1-8

Logistic Multilevel Models Predicting Any Daily Work Cutback from Maximum Severity for each Physical Health Symptom Type

	Separate Models Predicting Any Work Cutback						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Composite symptoms predicting cutback	Cold/flu symptoms predicting cutback	Gastrointestinal symptoms predicting cutback	Bodily pain symptoms predicting cutback	Fatigue symptoms predicting cutback	Allergy symptoms predicting cutback	Other symptoms predicting cutback
Paremeter	Fixed effects: *OR* (95% *CI*)						
Gender	1.61 (1.21, 2.16)**	2.09 (1.42, 3.08)***	1.73 (1.18, 2.55)**	1.74 (1.29, 2.36)***	1.67 (1.21, 2.31)**	1.67 (0.98, 2.82)	2.06 (1.36, 3.14)***
Age	1.23 (1.10, 1.38)***	1.24 (1.06, 1.45)**	1.14 (0.99, 1.32)	1.26 (1.12, 1.42)***	1.32 (1.17, 1.49)***	1.26 (1.04, 1.54)*	1.13 (0.96, 1.33)
Alcohol drinker	0.96 (0.72, 1.27)	0.74 (0.51, 1.08)	0.96 (0.66, 1.38)	0.96 (0.72, 1.28)	0.99 (0.73, 1.34)	0.98 (0.61, 1.59)	0.67 (0.44, 1.01)
Av. daily NA	1.65 (1.46, 1.85)***	1.64 (1.43, 1.88)***	1.59 (1.39, 1.82)***	1.78 (1.58, 2.01)***	1.74 (1.54, 1.97)***	2.06 (1.71, 2.48)***	1.60 (1.38, 1.86)***
Max. severity	**2.44 (2.09, 2.86)***	**1.54 (1.29, 1.85)***	**1.48 (1.23, 1.79)***	**1.85 (1.59, 2.14)***	**1.59 (1.36, 1.86)***	**1.39 (1.10, 1.75)**	**1.72 (1.40, 2.10)***
Intercept	-3.92 (0.16)***	-3.40 (0.20)***	-3.19 (0.21)***	-3.79 (0.17)***	-3.46 (0.17)***	-3.77 (0.30)***	-3.23 (0.22)***
Random int. var.	2.53 (0.26)***	2.36 (0.33)***	2.20 (0.31)***	2.52 (0.27)***	2.26 (0.27)***	2.56 (0.45)***	2.43 (0.35)***
-2 log likelihood	4762.10	2703.20	2754.70	4489.50	3881.60	1648.30	2484.30
N people, *N* days	1350, 10230	596, 4528	545, 4139	1191, 9017	886, 6725	414, 3128	502, 3817

Note. Parameters in bold indicate parameters of interest that were significant. *OR* = odds ratio. *CI* = confidence interval. Gender: 0 = male, 1 = female. Age was centered at the sample mean and transformed (unit = decade). All age² effects and interactions between age² as well as age and maximum symptom severity were not significant and excluded from analysis. Alcohol drinker: 0 = no, 1= yes. Av. daily NA = average daily negative affect (transformed to *z* units). Random int. var. = random intercept variance. Max. severity = maximum severity (i.e., highest item severity rating across the study days within each type and composite for people who reported at least one relevant symptom during the daily diary), which is a between-person effect (transformed to *z* units). Intercept reflects log-odds of endorsing any work cutback, conditional on variables included in the model.

***$p < .001$; **$p < .01$; *$p < .05$.

Table 1-9

Logistic Multilevel Models Predicting Any Daily Work Cutback from Severity for each Physical Health Symptom Type

	Separate Models Predicting Any Work Cutback						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Composite symptoms predicting cutback	Cold/flu symptoms predicting cutback	Gastrointestinal symptoms predicting cutback	Bodily pain symptoms predicting cutback	Fatigue symptoms predicting cutback	Allergy symptoms predicting cutback	Other symptoms predicting cutback
Parameter	Fixed effects: *OR* (95% *CI*)						
Gender	1.82 (1.34, 2.47)***	2.36 (1.41, 3.93)**	1.99 (1.21, 3.27)**	2.14 (1.53, 2.99)***	1.64 (1.11, 2.42)*	2.29 (1.14, 4.58)*	2.04 (1.18, 3.53)*
Age	1.23 (1.08, 1.40)**	1.23 (1.00, 1.51)	1.15 (0.95, 1.40)	1.15 (1.00, 1.31)	1.17 (1.01, 1.36)*	1.24 (0.97, 1.59)	0.90 (0.74, 1.11)
Alcohol drinker	0.84 (0.63, 1.13)	0.69 (0.42, 1.14)	0.65 (0.40, 1.05)	0.86 (0.63, 1.18)	0.97 (0.67, 1.40)	0.82 (0.44, 1.50)	0.62 (0.37, 1.06)
Av. daily NA	1.70 (1.50, 1.93)***	1.66 (1.40, 1.97)***	1.45 (1.25, 1.69)***	1.68 (1.48, 1.91)***	1.55 (1.34, 1.78)***	1.89 (1.52, 2.36)***	1.52 (1.26, 1.84)***
BP Severity	**1.32 (1.16, 1.51)*** **	**1.33 (1.15, 1.55)*** **	1.12 (0.95, 1.33)	**1.24 (1.09, 1.41)*** **	**1.23 (1.10, 1.37)*** **	**1.36 (1.14, 1.63)*** **	**1.19 (1.05, 1.35)** **
WP Severity	**1.73 (1.54, 1.94)*** **	**1.38 (1.20, 1.59)*** **	**1.29 (1.07, 1.55)** **	**1.57 (1.39, 1.77)*** **	**1.46 (1.32, 1.61)*** **	**1.26 (1.07, 1.48)** **	**1.32 (1.15, 1.52)*** **
BP Sev. X Age	0.94 (0.87, 1.02)		**0.86 (0.77, 0.96)**[b]**	0.95 (0.88, 1.03)			
WP Sev. X Age	0.98 (0.92, 1.05)		1.12 (1.00, 1.25)	1.04 (0.96, 1.11)			
Age²	1.04 (0.95, 1.14)		0.93 (0.81, 1.07)	1.06 (0.97, 1.17)			
BP Sev. X Age²	1.04 (0.97, 1.10)		1.04 (0.96, 1.13)	1.05 (0.99, 1.11)			
WP Sev. X Age²	**0.93 (0.89, 0.98)**[a]**		**0.89 (0.83, 0.97)**[c]**	**0.94 (0.89, 0.99)*[d]**			
Intercept	-3.65 (0.19)***	-3.15 (0.28)***	-2.38 (0.29)***	-3.57 (0.20)***	-2.76 (0.22)***	-3.81 (0.42)***	-2.53 (0.30)***
Random int. var.	2.67 (0.30)***	2.84 (0.62)***	2.37 (0.56)***	2.54 (0.33)***	2.66 (0.44)***	2.65 (0.69)***	2.67 (0.65)***
-2 log likelihood	4110.70	1365.90	1284.50	3296.10	2330.60	860.70	1147.50
N people, *N* days	1350, 7076	596, 1862	545, 1413	1191, 5126	886, 2776	414, 1470	502, 1297

Note. Parameters in bold indicate parameters of interest that were significant. *OR* = odds ratio. *CI* = confidence interval. Gender: 0 = male, 1 = female. Age was centered at the sample mean and transformed (unit = decade). Interactions with age/age² and between- and within-person effects of symptom severity are shown only if one was significant. Alcohol drinker: 0 = no, 1 = yes. Av. daily NA = average daily negative affect (transformed to *z* units). Random int. var. = random intercept variance. BP Severity = between-person effect for symptom severity (person mean and then centered at sample mean). WP Severity = within-person effect for symptom severity, which was person-mean centered and reflects variation around an individual's own mean level. Intercept reflects log-odds of endorsing any work cutback, conditional on variables included in the model.

[a]Young (34 to 49 years): **1.49 (1.27, 1.76)*****; middle (50 to 69 years): **1.72 (1.52, 1.95)*****; old (70 to 86 years): **1.31 (1.11, 1.54)****.

[b]Young (34 to 49 years): **1.50 (1.20, 1.88)*****; middle (50 to 69 years): **1.09 (0.90, 1.31)**; old (70 to 86 years): **1.03 (0.77, 1.39)**.

[c]Young (34 to 49 years): **0.79 (0.61, 1.15)**; middle (50 to 69 years): **1.33 (1.08, 1.64)****; old (70 to 86 years): **1.06 (0.81, 1.38)**.

[d]Young (34 to 49 years): **1.27 (1.07, 1.50)****; middle (50 to 69 years): **1.53 (1.34, 1.73)*****; old (70 to 86 years): **1.36 (1.16, 1.60)*****.

****p* < .001; ***p* < .01; **p* < .05.

Appendix 1-A

Daily Physical Health Symptom List (NSDE II)

1. Headache
2. Backache
3. Muscle soreness
4. Fatigue
5. Joint pain
6. Muscle weakness
7. Cough
8. Sore throat
9. Fever
10. Chills
11. Other cold and flu symptoms
12. Nausea
13. Allergies
14. Diarrhea
15. Constipation
16. Poor appetite
17. Other stomach problems
18. Chest pain
19. Dizziness
20. Shortness of breath or difficulty breathing
21. Menstrual-related symptoms**
22. Hot flashes or flushes**
23. Any other physical symptoms or discomforts
24. Skin-related symptoms*
25. Eye-related symptoms*
26. Ear-related symptoms*
27. Teeth-related symptoms*
28. Leg- or foot-related symptoms*

Note. * indicates additional category created based on open-ended responses to any other physical symptoms or discomforts. ** represents female health symptoms that were excluded from major analyses.

Appendix 1-B

Daily Physical Health Symptom Categories and Corresponding Items

<u>Cold/flu</u>
Cough
Sore throat
Fever
Chills
Other cold/flu

<u>Gastrointestinal</u>
Nausea
Diarrhea
Constipation
Poor appetite
Other stomach

<u>Bodily Pain</u>
Headache
Backache
Muscle soreness
Joint pain
Chest pain
Skin*
Eye*
Ear*
Teeth*
Leg/foot*

<u>Fatigue</u>
Fatigue
Muscle weakness

<u>Allergies</u>

<u>Other</u>
Dizziness
Shortness of breath or difficulty breathing
Any other

Note. * indicates additional category created based on open-ended responses to any other physical symptoms or discomforts.

Paper 2

Associations among Neuroticism, Multiple Aspects of Daily Physical Health Symptoms, and Parameters of Diurnal Salivary Cortisol

As an extension of Paper 1, the present study further examined daily physical health symptom types and dimensions with a focus on the role of neuroticism as an important individual difference factor in symptom reporting. The personality trait of neuroticism has been both conceptually and empirically linked to physical health. The first aim of the present analyses, therefore, was to examine how neuroticism was associated with daily occurrence and symptom severity (level of and fluctuation in) by symptom type. The second aim was to investigate how both neuroticism and physical symptom experiences (i.e., frequency and average severity for the various types) were associated with parameters of diurnal cortisol, specifically the cortisol awakening response and afternoon/evening decline. In addition, interactive effects between neuroticism and physical symptom experiences on diurnal cortisol were tested.

Neuroticism: Brief Historical Background and Definition

There is a long and rich history of personality research, which first focused on structural aspects and identification of traits. Traits are considered consistent characteristics that vary between persons and refer to a propensity to behave in a particular manner or a general tendency (Brown & Ryan, 2003; Fleeson, 2001; Mroczek, Spiro, & Griffin, 2006). For example, scholars such as Cattell (1946) identified primary factors of personality. Neuroticism is one such trait that is included in five-factor models of personality (Costa & McCrae, 1985a, 1992a; Goldberg, 1990, 1992, 1993) as well as other major frameworks such as the three-factor model proposed by Eysenck (Eysenck & Eysenck, 1985). For a historical account and review of the development of the “Big Five”, see Goldberg (1993).

Neuroticism has also been referred to as emotional instability (Goldberg, 1990, 1992) and trait negative affectivity (Watson & Clark, 1984). In addition, Costa and McCrae (1992b) argued that neuroticism is a dimension comprised of several facets (i.e., anxiety, angry/hostility, depression, self-consciousness, impulsiveness, and vulnerability). Increased stressor exposure and reactivity as well as ineffective coping also characterize more neurotic individuals (Bolger & Zuckerman, 1995; Suls & Martin, 2005).

As mentioned above, the construct of neuroticism was mainly developed within the context of trait theories and structural approaches to the study of personality. Despite this rather static perspective, there is a growing interest in investigating personality as a dynamic process that is manifested in everyday experiences and behavior (Tennen, Affleck, & Armeli, 2005). This perspective was adopted in the present study by assessing how neuroticism was associated with daily assessments of physical health symptoms and salivary cortisol.

In addition, recent theoretical and empirical work has sought to integrate the structural and process approaches. For example, Hooker and McAdams (2003) developed a model of personality comprised of six foci with three structural constructs (i.e., traits, personal action constructs, and life stories) and three parallel processes (i.e., states, self-regulation, and self-narration). In this model, it is assumed that consideration of both traits (e.g., neuroticism) and corresponding states (e.g., negative affect) is necessary for a complete understanding of personality (Hooker & McAdams, 2003). Therefore, the present study included measures of both (i.e., neuroticism and negative affect) in order to examine the unique effects of neuroticism independent of negative affect.

Neuroticism and Physical Health

Features of the self, including neuroticism, significantly contribute to the study of physical health (for review, see George, 2001). According to Hampson and Friedman (2008), the interest in personality and health has a long history and began with discussion by Hippocrates and Galen regarding bodily humors. Empirical inquiry and scientific investigation commenced in earnest in the middle of the 20th century (Hampson & Friedman, 2008).

Since this time, the association between neuroticism and physical health has been widely investigated, providing strong support for the negative impact of neuroticism on various and diverse health-related outcomes from illness and disease to mortality (for review, see Hampson & Friedman, 2008; Smith, 2006; Smith & MacKenzie, 2006; Smith & Spiro, 2002). The general consensus is that neuroticism is a risk factor for poor health and may accelerate the process of aging (Aldwin, Spiro, & Park, 2006). Furthermore, Lahey (2009) argued that neuroticism is of great importance and relevance to public health, providing support for the focus on neuroticism.

A number of mechanisms underlying the link between neuroticism and health have been proposed and examined. First, health behavior models argue that neuroticism is related to health through poor habits such as smoking and excessive alcohol use (for review, see Hampson & Friedman, 2008; Lahey, 2009, Mroczek, Spiro, & Turiano, 2009; Smith, 2006; Smith & MacKenzie, 2006; Smith & Spiro, 2002). Other major models and mechanisms are centered on stress and the fight-or-flight response (for review, see Hampson & Friedman, 2008; Mroczek, Spiro, Griffin, & Neupert, 2006). Noncausal models, such as the constitutional predisposition model, suggest that neuroticism and health are related as a result of an underlying third variable such as genetics (Hampson & Friedman, 2008; Smith, 2006; Smith & MacKenzie, 2006; Smith & Spiro, 2002).

Neuroticism also 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 intraindividual variability in constructs such as negative affect (Eid & Diener, 1999) as well as weakened circadian rhythmicity in body temperature (Murray, Allen, Trinder, & Burgess, 2002). This body of work provides support for examining how neuroticism is associated with within-person (i.e., day-to-day) variation in severity of physical health symptoms and parameters of diurnal cortisol (i.e., cortisol awakening response and afternoon/evening decline) in the present study. Previous research specific to neuroticism and daily physical health symptoms suggests higher scores on neuroticism are associated with stability (i.e., less within-person/day-to-day variation) in symptom severity using a composite checklist (King, 2008). Therefore, neuroticism may be differentially related to intraindividual variability across various domains.

Multiple indicators of physical health. When considering the relationship between neuroticism and physical health, it is important to note that health is comprised of multiple dimensions and levels, which has received limited attention in the relevant literature (Aldwin, et al., 2006). Physical health is a state as well as a dynamic process that varies as a function of time, changing across moments, days, and years (Spiro, 2007; Verbrugge, 1986). In addition, Spiro (2007) argued that health is both multifaceted and multidirectional. An individual may demonstrate good health in one domain and poor health in another; both gains and losses are possible. Given this, consideration of the links between neuroticism and multiple indicators of health as well as different time scales (e.g., daily) is critical. Larsen (2007) also suggested that personality and health research should expand by investigating various processes and mechanisms as opposed to merely correlating traits with disease. These ideas were applied to the present study through inclusion of daily measures such as self-reported physical symptoms, including various symptom types and dimensions (e.g., occurrence, frequency, and severity) to more objective outcomes (e.g., diurnal cortisol as a biomarker of physiological function, specifically the awakening response and daily decline), which may provide a more complete and in-depth understanding of how neuroticism is associated with physical health, both in the immediate (i.e., short term) as well as potentially over longer periods of time.

Although health may vary across domains, it is also important to consider interactions and commonalities among specific domains, which may reveal shared pathways (for discussion of comorbidity, see Kaplan, Haan, & Wallace, 1999). Spiro (2007) suggested that broad constructs may be moderately associated with a wide variety of health-related indices, while constructs that are narrow or facets may be more strongly related to specific outcomes. Neuroticism is a broad dimension of personality that is made up of several lower-order traits (Costa & McCrae, 1992b). Neuroticism may be a risk factor for poor health generally, but may also be more closely tied to specific systems or conditions and related to health in a particular way, which was able to be explored to an extent in the present study through consideration of multiple types and dimensions of physical health symptoms (i.e., aspects of self-reported health) as well as parameters of diurnal cortisol as markers of physiological function. Specific hypotheses are reviewed below.

Finally, perhaps neuroticism moderates associations among different types of physical health indices such as subjective and objective health (Costa & McCrae, 1985b). Neuroticism may not just predict but also interact with dimensions of physical health to influence other health-related variables. For example, perhaps different aspects of health are less related among individuals higher in neuroticism if this aspect of personality is solely associated with exaggerated somatic complaints (Costa & McCrae, 1985b). The alternative is also plausible, however. Wrosch, Miller, Lupien, and Pruessner (2008) argued and demonstrated that the relationship between number of physical symptoms and disturbances in cortisol output (i.e., area under the curve) specifically, may only exist among older adults (over 60 years of age) experiencing emotional and behavioral issues such as high negative affect and poor sleep. The present study expanded on this previous research by examining the interactive effects between neuroticism (holding negative affect constant) and multiple aspects of physical symptoms (i.e., types and dimensions – frequency and average severity) on other measures of diurnal cortisol (i.e., cortisol awakening response and afternoon/evening decline) among adults ranging in age from approximately 34 to 86 years.

Neuroticism and Physical Health Symptoms

It has been hypothesized that neuroticism may influence physical health symptoms by (1) directly causing them as result of physiological dysregulation and reactivity or (2) a distinct way of attending to, perceiving, evaluating, remembering, and coping with symptoms (Costa & McCrae, 1985b; Kirmayer, Robbins, & Paris, 1994). The extant literature suggests higher neuroticism is associated with poor self-reported health in regards to physical symptoms; however, it is not clear if this is true of all dimensions and types of symptoms.

Neuroticism was positively associated with reports of physical health symptoms in a study of undergraduate students (Ebert, Tucker, & Roth, 2002) as well as in a male sample with a wider age range of 17 to 97 years (Costa & McCrae, 1980). Ebert et al. (2002) measured physical symptoms using an inventory comprised of 54 items that assesses frequency during the past year. Costa and McCrae (1980) utilized an index of 144 items, which evaluates the experience of physical symptoms across 12 domains. In addition to the total number of self-reported physical symptoms, neuroticism was also associated with each of the symptom types (e.g., respiratory, digestive) when analyzed separately (Costa & McCrae, 1980).

Rosmalen, Neeleman, Gans, and de Jonge (2007) asked participants whether or not they regularly experience 22 physical health symptoms. In addition, the sample was fairly large and population-based, ranging in age from 32 to 80 years of age. Similar to the studies reviewed above, the results demonstrated that high neuroticism is associated with reporting more symptoms, controlling for psychological distress, as well as the odds of reporting experiencing each individual symptom. A factor analysis of the symptoms was also conducted revealing two factors: 1) symptoms involving pain, fatigue, and gastrointestinal complaints and 2) symptoms related to allergies, cold, and upper respiratory problems. Neuroticism was more strongly correlated with the first factor. This specificity is in contrast to the general pattern reported by Costa and McCrae (1980).

In addition, change in physical health symptoms over approximately 18.5 years in an adult male sample, 21 to 80 years of age at study entry, was linked to neuroticism (Aldwin, Spiro, Levenson, & Cupertino, 2001). A wide range of physical symptoms were assessed and a summary score was created. A trajectory characterized by having fewer symptoms and slow increases over time was associated with a high level of emotional stability, reflecting low neuroticism (Aldwin et al., 2001). This suggests that neuroticism is associated with both level of and change in physical health symptoms.

These studies are somewhat limited, however, in that they could be influenced by memory and recall bias. Larsen (2007) reduced the influence of these issues by utilizing ecological momentary assessment to investigate associations between aspects of personality and physical health symptoms. A sample of undergraduate students indicated whether or not they experienced each of 25 symptoms (4 factors: distress, aches, gastrointestinal, and upper respiratory) 3 times a day for 8 consecutive weeks. It was argued that this methodology also contributes to the study of health by focusing on process (e.g., frequency of symptoms as well as duration) and recognizing that health changes daily. Neuroticism was positively correlated with frequency of distress and gastrointestinal symptoms, specifically (Larsen, 2007). This study lacks generalizability, however, as a result of the focus on college students and also did not consider symptom severity. The present study addressed these limitations by utilizing a sample that represents a larger portion of the adult lifespan as well as examining symptom severity.

Overall, neuroticism is clearly associated with reports of physical symptoms assessed in different ways and in a variety of samples of varying ages. Questions remain, however, regarding whether neuroticism is related to all symptom types and dimensions (e.g., severity was not explored in these studies reviewed) as well as levels of and fluctuations in daily experiences of symptoms across the adult lifespan, which were explored in the present study. It is also important to note that although subjective health and objective health are related (George, 2001), the correlation is often modest (Costa & McCrae, 1980, 1985b). Furthermore, symptom reports of individuals high in neuroticism may be overstated and not reflect actual health status (Costa & McCrae, 1985b). Some have argued that neuroticism reflects a tendency towards over-reporting of self-reported illnesses as a function of memory and recall bias (Schwarz & Sudman, 1994), though this may depend on the type of ailment and period of retrospection. Nevertheless, it is important to examine how neuroticism is associated with additional and more objective indicators of health and physiological function that are not susceptible to style of reporting. The present study attempted to address this issue by assessing the links between neuroticism and daily physical health symptoms with indices of diurnal cortisol.

Cortisol

Cortisol is a hormone and marker of activity of the hypothalamic-pituitary-adrenal (HPA) axis, part of the neuroendocrine system, which is activated under stress (Dickerson & Kemeny, 2004). Corticotropin releasing hormone, controlled by the hypothalamus, triggers the anterior pituitary gland to release adrenocorticotropin hormone, signaling the adrenal cortex to secrete cortisol (for review, see Dickerson & Kemeny, 2004). Cortisol is also characterized by a diurnal pattern; levels of cortisol typically peak in the morning shortly after waking (approximately 30 to 40 minutes) then gradually decline throughout the rest of the day (Kirschbaum & Hellhammer, 1989; Pruessner et al., 1997). Evidence suggests that these components merit independent examination as they are regulated by different mechanisms (for review, see Ferguson, 2008). The cortisol awakening response (CAR) and afternoon/evening decline were examined in the present study.

The HPA axis plays an important role in promoting normal physiological functions and influences many biological systems. For example, cortisol is involved in metabolism and in regulation of the immune response (Dickerson & Kemeny, 2004). Continued atypical levels have been associated with disease and ill-health (Dickerson & Kemeny, 2004; Miller Chen, & Zhou, 2007). Prolonged abnormal patterns of cortisol release (e.g., too high, too low), can uncouple cortisol's ability to regulate the HPA axis, which may have potentially serious physiological consequences and negatively impact physical health and well-being (e.g., depression) over time (e.g., Sapolsky, Krey, & McEwen, 1986).

Neuroticism and Cortisol

Recently, researchers have investigated the association between cortisol and neuroticism. Several studies suggest that more neurotic individuals exhibit higher levels of cortisol and increased cortisol reactivity than those low in neuroticism (Miller, Cohen, Rabin, Skoner, & Doyle, 1999; Portella, Harmer, Flint, Cowen, & Goodwin, 2005; Vedhara, Tuin stra, Miles, Sanderman, & Ranchor, 2006; Zobel et al., 2004). Specifically, high neuroticism was linked to higher basal plasma cortisol levels in healthy adults (18-55 years of age) (Miller et al., 1999) as well as higher morning salivary cortisol (21-57 years of age) (Portella et al., 2005), and a greater salivary cortisol awakening response in newly diagnosed breast cancer patients (30-75 years of age) (Vedhara et al., 2006) compared to low neuroticism. The results of another study of adults (average age of 35.9 years) revealed that high neuroticism is related to higher levels of cortisol (obtained via blood samples) following a pharmacologic challenge (combined dexamethasone/corticotrophin-releasing hormone – Dex/CRH test) (Zobel et al., 2004). This neuroticism-cortisol association existed solely for the male participants, and the cortisol profiles of individuals with high and low neuroticism was most distinct in adults 40 years of age and older (Zobel et al., 2004). The evidence suggests that prolonged elevated cortisol levels are linked to chronic illnesses such as diabetes and damage to neurons in the hippocampus involved in memory (for review, see Dickerson & Kemeny, 2004; Sapolsky et al., 1986).

In contrast, another set of empirical work indicates that neuroticism is associated with lower cortisol reactivity (McCleery & Goodwin, 2001; Oswald et al., 2006; Phillips, Carroll, Burns, & Drayson, 2005). Oswald et al. (2006) found that high neuroticism in healthy, young adults (ages 18 to 30 years) is associated with blunted, rather than greater, plasma cortisol responses to a modified Trier Social Stress Test; these findings were specific to female respondents. Similarly, McCleery & Goodwin (2001) demonstrated that high neuroticism in college students is related to a lower plasma cortisol response to the Dex/CRH test, contrary to the results of Zobel et al. (2004). A large number of these participants, particularly in the high neuroticism group, however, had a history of mental illness and disorder, which may have influenced the results (McCleery & Goodwin; Zobel et al. 2004). Similarly, university students high in neuroticism exhibited blunted salivary cortisol reactivity to a mental arithmetic task (Phillips et al., 2005). Decreased responsiveness may be harmful, contributing to poor health outcomes such as chronic fatigue syndrome (for review, Miller et al., 2007). In addition, others have demonstrated that there is no or little evidence for a relationship between neuroticism and cortisol, including basal cortisol levels as well as responses to a stressor (Chida & Hamer, 2008; Schommer, Kudielka, Hellhammer, & Kirschbaum, 1999).

The literature does not provide a clear picture regarding the association between neuroticism and cortisol with evidence for a positive, negative, and null relationship. Measurement and modeling of cortisol in the studies reviewed differed (e.g., free cortisol levels vs. cortisol responses to a stressor). It is important to distinguish between an individual's tonic/basal physiological activity and physiological responses to particular stressful events; these are often entangled and not acknowledged in the literature, which may contribute to discrepant findings. In addition, these studies used small samples that differed in physical and mental health status. The present study addressed this issue by utilizing a large, national sample.

Physical Health Symptoms and Cortisol

Cortisol may also be related to reports of physical health symptoms assuming both are reflections of physiological function and activity and/or overall health status. The present literature regarding the relationship between salivary cortisol and physical symptoms is mixed, however. First, the results of several studies suggest that increased activity of the HPA axis, indexed by higher levels of cortisol, is positively related to reports of physical health symptoms (Edwards, Hucklebridge, Clow, & Evans, 2003; Volkmann & Weekes, 2006; Wrosch et al., 2008). In college students, a steeper salivary cortisol awakening response has been associated with more upper respiratory symptoms (Edwards et al., 2003). Another study of undergraduate students found that individuals with higher levels of salivary cortisol (i.e., high cortisol secretors) at baseline experienced a greater number of upper respiratory symptoms during a stressful period compared to baseline as well as higher rates of symptom incidence during the stressful time than low cortisol secretors (Volkmann & Weekes, 2006). It is important to note, however, that the measure utilized combined occurrence and severity. In addition, among older adults experiencing high negative affect and poor sleep, higher salivary cortisol secretion (i.e., area under the curve) was associated with increases in number of physical symptoms (sum of a variety of common symptoms experienced over three daily assessments at baseline and follow-up) over a two-year period (Wrosch, et al., 2008). The findings of this particular study suggest that cortisol and physical health symptoms are only related in the context of behavioral and emotional difficulties, which supports examining if and how neuroticism and physical symptoms interact and are associated with cortisol. Combined, these studies indicate that increased activity of the HPA axis (i.e., higher levels of cortisol) is connected to poor self-reported physical health in regards to symptoms.

In contrast, physical health symptoms such as exhaustion have been linked to a flattened diurnal rhythm of salivary cortisol (i.e., lower variability) in a sample of employed individuals identified as exhausted or not, mainly driven by lower cortisol levels in the morning (Lindeberg et al., 2008). This highlights the possibility that lower levels of cortisol are related to reporting of specific physical health symptoms.

Finally, the results of several studies suggest that there is no relationship between cortisol and physical health symptoms. Ferguson (2008) found no association between symptoms (i.e., frequency and severity) and salivary cortisol (i.e., average level and slope) in healthy employed adults. In addition, results of another study revealed no relationship in older adults between multiple parameters of salivary cortisol (i.e., area under the curve, levels at waking, morning rise, and slope) and physical symptoms (Wrosch, Bauer, Miller, & Lupien; 2007). Both included checklists with 12 common physical symptoms assessed daily across three days – number (Wrosch et al., 2007) or once during the study period, representing symptom severity and frequency over the preceding six months (Ferguson, 2008). This is unlike the majority of other studies reviewed in that the type of symptom was not considered, which may be critical.

Clearly, the results of these individual studies are both similar and dissimilar, likely as a function of variation in measurement of physical symptoms, cortisol collection protocols and assessment, and sample selection as well as participant characteristics. Additional research is needed to resolve this conundrum. The present study was uniquely positioned to address some of these issues given the breadth of the daily physical health symptom assessment and exploration of multiple types and dimensions as well as a large sample size with a wide age range.

Study Aims and Hypotheses

Aim 1. The first objective was to examine how neuroticism was associated with daily occurrence and symptom severity (level of and fluctuation in) separately by symptom type. It was hypothesized that neuroticism would be associated with daily occurrence and severity when considering all symptoms (i.e., composite), but might be more strongly related to particular types such as gastrointestinal, bodily pain, and fatigue symptoms (following from Rosmalen et al., 2007). It should be noted however, that Costa and McCrae (1980) found that neuroticism is associated with all symptom types (i.e., general rather than specific pattern) and results reported by Larsen (2007) indicated that neuroticism is positively correlated with frequency of distress and gastrointestinal, but not aches and upper respiratory symptoms.

In addition, these studies did not consider symptom severity. It could be hypothesized that a similar pattern to daily occurrence would emerge in regards to symptom severity with neuroticism being more strongly associated with specific types. Furthermore, symptom-specific scales have been created to assess severity, indicating there is the expectation of differences in severity and its effects as a function of symptom type (for review, see Kroenke, 2001). Alternatively, Kroenke (2001) also argued in this seminal article on sampling and measurement issues related to studying physical health symptoms that severity is a distinct threshold from temporal factors that relies almost exclusively on self-report, resulting in more subjectivity. Therefore, neuroticism may be differentially associated with symptom occurrence and severity across types (i.e., either being related to all types or different ones for severity compared to occurrence). Finally, consistent with previous research (King, 2008), higher scores on neuroticism were also expected to be associated with less within-person/day-to-day variation in composite symptom severity, however, it was not clear if this would vary as a function of symptom type.

Aim 2. The second goal was to determine how (1) neuroticism as well as (2) dimensions (i.e., frequency and average severity) and types of physical health symptoms were associated with and interacted to predict parameters of diurnal cortisol, specifically the cortisol awakening response (CAR) and afternoon/evening decline. It was rather difficult to formulate specific hypotheses given the inconsistency of the findings. In terms of neuroticism and the specific constructed cortisol variables considered in the present study, it was not expected that neuroticism would be associated with the afternoon/evening decline, as previous research did not find a relationship between this aspect of personality and daily slope as well as cortisol levels later in the day (Portella et al., 2005; Vedhara et al., 2006). In these studies, however, higher scores on neuroticism were associated with higher levels of cortisol from 30 to 60 minutes after waking as well as a larger cortisol awakening response, respectively. Therefore, perhaps more neurotic participants will demonstrate a steeper cortisol awakening response in the present study. In addition, neuroticism may be associated with more within-person variation in the cortisol awakening response or afternoon/evening decline similar to prior research demonstrating more neurotic individuals are characterized by larger intraindividual variability in certain constructs (Eid & Diener, 1999). With regards to physical health symptoms, it was hypothesized that the parameters of diurnal cortisol may be differentially associated with symptom types (Edwards et al., 2003; Lindeberg et al., 2008; Volkmann & Weekes, 2006). Finally, it was also expected that there would be interactive effects of neuroticism and daily physical health symptoms on cortisol (Wrosch et al., 2008). In particular, it was hypothesized that cortisol disturbances would be most apparent for individuals higher in neuroticism experiencing poor daily self-reported physical health.

Methods

This section describes the research methods of the present study, specifically the procedures, including daily saliva collection and cortisol assaying, as well as participants, measures, and analytic strategy. The sample was taken from the first paper. As a result, there is some overlap and repetition in the information provided here as well as reference to Paper 1 for specifics such as creation of symptom types. The focus of this methods section is to repeat critical information with a focus on differences related to the sample, etc. and material not reviewed previously (e.g., details of cortisol collection).

Procedures

As with and described in Paper 1, analyses utilized data from participants who completed the second wave of the National Study of Daily Experiences (NSDE II, Project 2), which is the daily diary portion of the second wave of the Midlife in the United States national study of health and well-being (MIDUS II, telephone-mail survey conducted in 2004 to 2006). Refer to Brim, Ryff, and Kessler (2004) and Almeida (2005) as well as Almeida, Wethington, and Kessler (2002) for thorough accounts of the original MIDUS and NSDE procedures, respectively.

The protocol of NSDE II consisted of eight consecutive daily telephone interviews; respondents also collected saliva samples on four of the diary days (4 occasions on 4 consecutive days – generally days 2 to 5), which were assayed for cortisol. Information obtained during the calls included time use, physical symptoms, psychological distress, work cutback, daily stressors, positive events, and discrimination. During the last interview, participants also answered questions regarding the previous week. The initial and final calls were about 15-20 minutes in duration; the other six lasted approximately 10-15 minutes. The daily interview was CATI-(Computer Aided Telephone Interview) programmed which enabled use of various skip patterns and open-ended probes as well as allowed interviewers to enter data during the calls. Daily telephone interviews were conducted by the Pennsylvania State University Survey Research Center (SRC).

Data collection for NSDE II occurred from July 2004 to April 2009 with separate groups or flights of interviews, consisting of the eight-day sequence. In order to control for potential confounding between day of study and day of week, initiation of interview flights was staggered. Participants were compensated $25 for their participation and were provided with a telephone number in order to easily change or schedule daily interviews.

Daily saliva collection and cortisol assaying. On study days two through five of the eight-day telephone diary, participants were instructed to collect four saliva samples (i.e., at waking, 30 minutes after waking, before lunch, and at bedtime) that were later assayed for cortisol. The time each sample was provided was documented on a paper-pencil log that was part of the collection kit and if missing, was substituted with information from the daily telephone interviews. In addition, a portion of the respondents received a “smart box” to store their salivettes (Cayuga Design, Ithaca, NY). These boxes provided an additional check on compliance as they contained a computer chip that recorded the time participants opened and closed the box.

Saliva was obtained using salivette collection devices supplied by Sarstedt (Nümbrecht, Germany). Participants received a home saliva collection kit prior to beginning the telephone diary. 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. The telephone interviewers also reviewed the saliva collection procedures and answered any questions.

To minimize the influence of factors that may compromise the samples (see Kirschbaum, Read, & Hellhammer, 1992), the instructions included in the home saliva collection kit stated that samples were to be collected before eating, drinking, and brushing teeth. In addition, caffeinated products (e.g., coffee, tea, soda, and chocolate) were not to be consumed prior to taking the samples. Information regarding prescription and over-the-counter medications taken during the saliva collection period were obtained during the telephone interview on the last day of saliva collection. The sample's pH was checked and corrected if outside the acceptable range (pH 4-9) prior to immunoassaying for cortisol (Granger et al., 2007; Kirschbaum et al., 1992).

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 for 5 minutes, yielding a clear fluid with low viscosity. Concentrations of cortisol were measured in singlet with a commercially available luminescence immunoassay (IBL, Hamburg, Germany) with intra-assay and inter-assay coefficients of variation below 5% (see previous studies, Dressendörfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992; Polk, Cohen, Doyle, Skoner, & Kirschbaum, 2005). Cortisol assaying was conducted at the Biological Psychology Laboratory at the Technical University of Dresden.

Participants

Of the 3,009 MIDUS II respondents selected, 2,022 participated in the diary study by completing at least one daily interview, 599 refused, 278 could not be reached, and 110 were deceased or incapacitated, which resulted in a response rate of 69.75% (completes/completes + (refusals + non-contacts). Approximately 92% (over 14, 900) of the 16,176 possible daily telephone interviews were completed. The sample (*N* = 2,022) was comprised of 1,079 random digit dialed (RDD) respondents, 185 siblings, 516 twins, 62 city oversamples, and 180 participants from the Milwaukee African American sample. Participants ranged from 33 to 84 years of age (*M* = 56.24, *SD* = 12.20) at completion of baseline (MIDUS II, Project 1) and approximately 57% were female. Excluding the few don't know and refused responses, 84.5% of the sample described their racial origins as White, 11.3% Black/African American, and 4.2% other. In regards to educational status, approximately 31% reported they had graduated from high school or less. The remainder of the respondents had some college (23%), obtained either an associate's or bachelor's degree (27%), or had at least some graduate level education (19%).

The majority (86%) of the respondents (*n* = 1,736) participated in saliva collection. All but one of these participants provided at least one useable and reliable sample. Of the 27,776 possible cortisol values (1,736 respondents X 16 saliva samples), there were 874 (< 3%) missed samples (418), unreliable samples (40), samples that could not be linked to a specific interview day (24), or samples with insufficient volume to detect cortisol (392). These data resulted in 26,902 total samples (97%).

For the present study and as with Paper 1, respondents were selected who participated in saliva collection. Furthermore, the sample was limited to unrelated individuals by randomly selecting (via SPSS) one member of each family in order to remove the potentially confounding nesting occurring within families. This strategy was suggested and presented as a guideline by MIDUS staff to address familial dependencies in the data (MIDUS, 2011). Of the 1,735 NSDE II saliva collection participants who provided at least one valid sample, 1,196 were not related. The remaining 539 respondents were members of families that ranged from 2 to 7 family members in the sample. Random selection as a function of family id and case count resulted in 246 participants; combined with the 1,196 unrelated individuals, this produced a final sample of

1,442 unrelated individuals (83% of original sample). Characteristics of this specific group of participants were provided in Paper 1. The sample for the present study was also slightly further reduced given missing data for neuroticism scores (*n* = 42).

The final sample of 1,400 participants was comprised of 834 random digit dialed (RDD) individuals, 79 unrelated siblings, 309 unrelated twins, 50 city oversamples, and 128 participants from the Milwaukee African American sample. Only 594 of the 11,200 possible daily telephone interviews were missed or did not produce any valid data across the interview (5%). Participants completed an average of 7.58 (out of 8 total) daily telephone interviews with the majority of respondents (91%) completing 7 or all of the study days. Respondents were 56% female and ranged in age from 33 to 84 years (*M* = 56.54, *SD* = 12.15) at completion of baseline (MIDUS II, Project 1). The lag time between the Project 1 phone interview and Project 2 diary completion date was from 120 days (.33 year) to 1684 days (4.61 years) with an average of 652.94 days (1.79 years) and standard deviation of 405.83 days (1.11 years). Adding each participant's duration between projects to his or her age at Project 1 resulted in an approximate age range in the sample of 34.42 to 86.46 years (*M* = 58.32, *SD* = 12.04). Excluding the few don't know and refused responses, about 85% of the sample described their racial origins as White, 11% Black/African American, and 4% other. In regards to educational status, approximately 33% of the sample reported they had graduated from high school or less. The remainder of the respondents had some college (22%), obtained either an associate's or bachelor's degree (26%), or had at least some graduate level education (19%). The characteristics of this sample are similar to the composition of the full NSDE II sample and that utilized in Paper 1.

A portion of the participants (*n* = 123 individuals, 9%) collected their saliva outside of the instructed study days. Of the 22,400 possible cortisol values (1,400 respondents X 16 saliva samples), there were 712 (3%) missed samples (326), unreliable samples (22), samples that could not be linked to a specific interview day (16), or samples with insufficient volume to detect cortisol (348). These data resulted in 21,688 total samples (97%). The majority of the respondents (90%) had values for 15 or all 16 samples (*M* = 15.49, *SD* = 1.37) as well as participated in all 4 days of saliva collection with at least one sample value across the 4 occasions: at waking, 30 minutes after waking, before lunch, and at bedtime (99%; *M* = 3.98, *SD* = .18).

Measures

Daily physical health symptoms. Daily physical health symptoms were assessed in the NSDE II using a modified and expanded version of the measure utilized in the first wave of the NSDE, which was adapted from the Larsen and Kasimatis (1991) checklist. See Appendix 2-A for a complete list of items in the order they were asked. Participants were asked every day of the diary study whether (i.e., no or yes) they experienced each of 23 physical health symptoms (e.g., headache, nausea, and sore throat). In addition, responses to any other physical symptoms or discomforts were recoded into other categories where applicable based on open-ended responses, including the following added items: (1) skin, (2) eye, (3) ear, (4) teeth, or (5) leg/foot pain-related symptoms, which resulted in a composite of 28 items. In addition, 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*).

For the present study, symptoms were excluded from the analyses that were mainly relevant to female respondents (e.g., hot flashes/flushes and menstrual-related symptoms) in order to focus on daily symptom experiences across both sexes. The remaining physical health symptoms were combined to create a composite (excluding female health) as well as grouped into the following types: **cold/flu** and respiratory (5 items such as cough); **gastrointestinal** (5 items such as nausea); **bodily pain** (5 items such as headache as well as 5 added symptoms reviewed above); **fatigue** (2 items including fatigue and muscle weakness); **allergies** (1 single item); and "**other"** (catch-all category including 3 items, which did not clearly fit into the other categories, such any other and shortness of breath or difficulty breathing). See Appendix 2-B for a complete list of the items comprising the various symptom categories. In addition, see Paper 1 for justification of and reasoning for these types. Basically, previous studies were reviewed for reference and provided the framework for the symptom categories.

For the composite category and each symptom type, daily scores for **any** (i.e., whether or not a pertinent symptom was experienced – occurrence) and **severity** (i.e., average across relevant ratings on a symptom day) were created. These daily variables were also aggregated across the study days reflecting **frequency** (i.e., proportion of days) and **average severity**.

Neuroticism. As part of the MIDUS II, Project 1 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 (i.e., moody, worrying, nervous, and calm). The items, except calm, were reverse-coded such that higher scores reflected higher standings in each dimension. 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. Coefficient alpha for the neuroticism scale was.74 in the present sample and the average score on neuroticism was 2.04 with a standard deviation of

.63. 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).

Average daily (state) negative affect. Given the interest in neuroticism (also referred to as trait negative affectivity; e.g., Watson & Clark, 1984), average daily negative affect was included in the analyses in order to examine the effects of neuroticism when controlling for this variable and in an attempt to distinguish between these trait and more state-like constructs. NSDE II participants were asked daily how much of the time on a 5-point scale from 0 to 4 (*none of the time*, *a little of the time*, *some of the time, most of the time*, or *all of the time*) they felt each of 14 items (e.g., worthless, irritable). The scale was expanded and modified for MIDUS II from the version utilized in the first wave of the study (Kessler et al., 2002; Mroczek & Kolarz, 1998). Scores across the 14 items were averaged each day. Average daily negative affect was then created by calculating each individual's mean across the daily interviews (M = .20, SD = .25). The between-person reliability for the negative mood scale was .91 in the present sample.

Daily cortisol. Following from previous studies using this (NSDE II) and other data (e.g., Adam, Hawkley, Kudielka, & Cacioppo, 2006; Almeida, Piazza, & Stawski, 2009), all cortisol values were natural log-transformed (after being added to 1) due to positive skew in the data. In addition, raw cortisol values above 60 nmol/l were removed (i.e., recoded to missing); these values are rather extreme and may represent clinical subgroup(s). Cortisol values also had to have a corresponding collection time to be included in analyses. Furthermore, a number of person-level control variables were also considered: smoking status, medication use, and average wake-up time (following from Almeida et al., 2009). A participant was considered a smoker (1 = yes; 227 out of 1,400 – 16%) if they reported smoking at least one cigarette across the daily interviews. In regards to medications, a participant was considered a medication user (1 = yes; 513 out of 1,400 – 37%) if they reported using (during saliva collection) over-the-counter or prescription allergy medications, a steroid inhaler, other steroid medications, medications/creams containing cortisone, birth control pills, other hormonal medications, or anti-depressant/anti-anxiety medications. For a review of medication classes that may potentially influence salivary cortisol through a variety of ways, see Granger, Hibel, Fortunato, and Kapelewski (2009). Average wake-up time was available for all but one of the respondents (M = 6.67, SD = 1.38). These times reflect 24-hour times with decimals reflecting fraction of an hour.

Also, for analyses with both the cortisol awakening response and afternoon/evening decline, days were flagged and then excluded when participants woke up prior to 4 a.m. or after 11:00 a.m. Finally, for analyses with the afternoon/evening decline, days were also identified for removal on which participants were awake for more than 20 hours or less than 12 hours. These decisions were made in order to address outliers and non-normative schedules following from research related to cortisol and the importance of sleep patterns and timing (Federenko et al., 2004; Leproult, Copinschi, Buxton, & Van Cauter, 1997).

In addition, elements of noncompliance with the saliva collection protocol were examined, specifically time between collection of the first and second samples, which was to differ by 30 minutes in order to capture the cortisol awakening response (Kirschbaum & Hellhammer, 1989; Pruessner et al., 1997). For analyses with the cortisol awakening response, a flag was constructed to exclude days on which participants reported collecting the 30 minutes after waking sample earlier than 15 or later than 60 minutes after waking.

A daily cortisol awakening response variable was then calculated by subtracting the first two natural log-transformed cortisol samples (i.e., at waking and 30 minutes after) and dividing by the time difference between the samples: (Sample2-Sample1)/(Sample2Time-Sample1Time). This strategy was modeled from Almeida et al. (2009), and the constructed variable reflects change in morning cortisol levels in +1, natural log units per hour (i.e., an index of the cortisol awakening response; *M* = .60, *SD* = .78). The average duration between the Time 1 and Time 2 samples was .57 (*SD* = .12) of an hour (approximately 34 minutes). This approach was also applied to create an index of the daily afternoon/evening decline; the difference between the second (i.e., 30 minutes after waking – peak) and fourth (i.e., at bedtime) samples was taken and divided by the duration that transpired between the samples: (Sample4-Sample2)/(Sample4Time-Sample2Time) (*M* = -.11, *SD* = .05). The average duration between the Time 2 and Time 4 samples was approximately 15.10 hours (*SD* = 1.19). These values of the cortisol awakening response and decline throughout the afternoon and evening approximate ordinary least squares estimates across individuals and days. Diurnal cortisol parameters from the full NSDE II sample are similar to those reported in other studies as well as the subsample utilized here (for review, see Almeida, McGonagle, & King, 2009).

Analytic Strategy

Linear (SAS PROC MIXED) and logistical multilevel level models (SAS PROC NLMIXED) were used to analyze the data given the nested structure (i.e., days within persons) (Snijders & Bosker, 1999).

Aim 1. Physical health symptom occurrence was modeled using a logistic multilevel model (Equation 1), where the experience of a symptom on a given day *d* for person *i* is the log odds of the probability of reporting a symptom to have occurred (p_{di}), $Symptom_{di} = log(p_{di}/1\text{-}p_{di})$.

Equation 1: Level 1: $Symptom_{di} = \beta_{0i}$

$$\text{Level 2: } \beta_{0i} = \gamma_{00} + \gamma_{01}(Gender_{i}) + \gamma_{02}(Age_{i}) + \gamma_{03}(\text{Average Daily Negative Affect}_{i}) + \gamma_{04}(Neuroticism_{i}) + U_{0i}$$

At Level 1, $Symptom_{di}$ is a function of an individual's intercept (β_{0i}). The residual variance for logistic multilevel models such as this is not estimated and fixed at 3.29 ($\pi^2/3$) as the mean (average proportion of successes/probability) and variance of the dependent variable are dependent (Hox, 2002; Snijders & Bosker, 1999). At Level 2, β_{0i} is a function of the between-person fixed intercept (γ_{00}), which reflects the log odds of experiencing a physical health symptom for a male of average age, daily negative affect (average), and neuroticism. Parameters γ_{03} and γ_{04} indicate the odds of experiencing a daily symptom associated with a one standard deviation increase in average daily negative affect and neuroticism, respectively. γ_{01} reflects the gender difference in the odds of reporting a daily symptom (i.e., difference in odds associated with being female). Finally, γ_{02} indicates the odds of experiencing a symptom associated with a 10-year increase in age. U_{0i} is the variance component for the intercept (i.e., Level 2 person-specific random effect). These Level 1 and 2 models can be combined into a mixed model via substitution.

Physical health symptom severity was modeled using a linear multilevel model (Equation 2).

Equation 2: Level 1: Symptom Severity$_{di}$ = $\beta_{0i} + e_{di}$

Level 2: $\beta_{0i} = \gamma_{00} + \gamma_{01}(\text{Gender}_i) + \gamma_{02}(\text{Age}_i) + \gamma_{03}(\text{Symptom Frequency}_i) +$

$\gamma_{04}(\text{Average Daily Negative Affect}_i) + \gamma_{05}(\text{Neuroticism}_i) + U_{0i}$

At Level 1, Symptom Severity$_{di}$ is the score on the variable of interest (i.e., symptom severity) on day *d* for person *i*, and is a function of an individual's intercept/average (β_{0i}) and day- and person-specific residual deviation (e_{di}). At Level 2, β_{0i} is a function of the between-persons fixed intercept (γ_{00}) (represents the mean for a male of average age, symptom frequency, average daily negative affect, and neuroticism), the between-persons effect of gender (γ_{01}), age (γ_{02}), symptom frequency (γ_{03}), average daily negative affect (γ_{04}), and neuroticism (γ_{05}), as well as the person-specific random effect (U_{0i}).

In addition, linear multilevel models can be used to simultaneously examine individual differences in within-person variation (see Hoffman, 2007). Substantively significant heterogeneity in residual variance can occur at Level 1, which may be modeled as a function of predictor variables such as neuroticism, which is of interest here. The residual deviations were be allowed to vary across individuals, σ_i^2, in order to test whether the within-person variations in severity of daily physical health symptoms as well as the diurnal cortisol parameters (i.e., cortisol awakening response and afternoon/evening decline) were associated with neuroticism (incorporated in Equation 2):

Equation 2: Level 1: Symptom Severity$_{di}$ = $\beta_{0i} + e_{di}$

Level 1 residual: $\sigma_i^2 = z_0\{\exp[z_5(\text{Neuroticism}_i)]\}$

Level 2: $\beta_{0i} = \gamma_{00} + \gamma_{01}(\text{Gender}_i) + \gamma_{02}(\text{Age}_i) + \gamma_{03}(\text{Symptom Frequency}_i) +$

$\gamma_{04}(\text{Average Daily Negative Affect}_i) + \gamma_{05}(\text{Neuroticism}_i) + U_{0i}$

The exponential function was utilized to limit the influence of the mean and normalize the variance in order to employ a linear prediction model.

Separate models were estimated for each of the symptom types as well as the composite variable. Neuroticism and average daily negative affect were transformed to *z* units. Age was centered at the sample mean and transformed (unit of change = decade). Finally, symptom frequencies (included only in models predicting symptom severity) were centered at the sample mean.

Aim 2. The variables constructed representing the daily cortisol awakening response and afternoon/evening decline were modeled similarly to physical health symptom severity. Models were estimate separately for the cortisol awakening response and afternoon/evening decline for each symptom type. First, models included neuroticism as well as the following Level 2 control variables: age, gender (1 = female), smoker (1 = yes), medication user (1 = yes), average daily wake-up time, and average daily negative affect. Next, symptom frequency was added and interactions with neuroticism were tested. Finally, average symptom severity was included and interactions with neuroticism and this variable were also tested. Interaction terms were added to Level 2.

As with previous models, neuroticism and average daily negative affect were transformed to *z* units as well as average daily wake-up time. Age was centered at the sample mean and transformed (unit of change = decade). Finally, symptom frequency and average symptom severity were centered at the sample mean.

Results

Descriptive statistics for the variables included in the present study, which were also reviewed in the methods section, are provided in Table 2-1.

Aim 1. Neuroticism and Daily Physical Health Symptoms

Table 2-2 presents the correlations among the following variables: age, gender, average daily negative affect, neuroticism, and symptom frequency across the study days for the composite category and each of the types (i.e., cold/flu, gastrointestinal, bodily pain, fatigue, allergy, and "other" symptoms). Of particular interest, neuroticism was positively associated with all symptom frequencies. In other words, participants scoring higher on neuroticism reported experiencing all symptom types on a greater proportion of study days. The correlation was "smaller" between neuroticism and frequency of allergy as well as cold/flu symptoms and "larger" between neuroticism and frequency of composite, gastrointestinal, bodily pain, fatigue, and "other" symptoms.

Additional correlations between these study variables (i.e., age, gender, average daily negative affect, neuroticism, and symptom frequency) with average symptom severity are shown in Table 2-3, separately for each symptom type. Higher scores on neuroticism were associated with higher average symptom severity for five out of the seven categories: composite, cold/flu, gastrointestinal, bodily pain, and fatigue symptoms. Neuroticism was not associated with average severity for allergy and "other" symptoms.

Table 2-4 presents the results from a series of logistic multilevel models (7) predicting the experience of any daily physical health symptoms on a given day (no or yes) by symptom type when adjusting for age, gender, and average daily negative affect. Controlling for average daily negative affect provides a stronger test of neuroticism. This strategy examines independent effects of trait and state negative affectivity. When considering these variables, neuroticism was associated with greater odds of reporting any symptom for the composite category (Model 1) and three of the symptom types: bodily pain (Model 4), fatigue (Model 5), and "other" symptoms (Model 7). Specifically, for every one standard deviation increase in neuroticism, the odds of reporting any symptoms on a given day increased by 26% for composite symptoms, 31% for bodily pain, 18% for fatigue, and 38% for the "other" symptoms category. These associations were age invariant. Participants higher in neuroticism were not more likely to report experiencing any cold/flu, gastrointestinal, or allergy symptoms.

Finally, Table 2-5 provides the results from multiple, separate linear multilevel models predicting daily physical health symptom severity for each symptom type when controlling for age, gender, average daily negative affect, and symptom frequency. As with average daily negative affect, the latter (i.e., symptom frequency) was included in these models to provide a stronger test of the effects of neuroticism and given the correlations among neuroticism, symptom frequency, and average symptom severity across the symptom types. Higher scores on neuroticism were related to higher severity for composite symptoms (Model 1), but just for two of the symptom types: cold/flu symptoms (Model 2) and bodily pain symptoms (Model 4). These effects of neuroticism did not interact with age.

In addition to level (fixed effect), neuroticism was explored as predictor of day-to-day variation in severity of symptoms. Higher scores on neuroticism were associated with less within-person variation in severity for composite symptoms (Model 1) and bodily pain symptoms (Model 4), but more within-person variation in severity for fatigue symptoms (Model 5) (see neuroticism effect on residual variance at bottom of Table 2-5). In other words, higher neuroticism was associated with more stability in severity ratings from day-to-day across all the symptoms combined (i.e., composite category) as well as for bodily pain symptoms, specifically.

The opposite pattern emerged in regards to severity of fatigue symptoms; individuals higher in neuroticism varied more from day-to-day compared to their lower neuroticism counterparts.

Aim 2. Neuroticism and Daily Physical Health Symptoms Predicting Diurnal Cortisol

The next analyses examined how neuroticism and types/dimensions of daily physical health symptoms were independently associated with and interacted to predict parameters of diurnal cortisol, specifically the cortisol awakening response and afternoon/evening decline. There were no within-person effects of any daily symptoms (i.e., occurrence) on parameters of daily cortisol and power was limited to investigate daily effects of symptom severity, therefore, analyses focused on between-person frequencies and average severities across the symptom types.

Daily cortisol awakening response. Table 2-6 provides results from linear multilevel models predicting the cortisol awakening response. Across the composite category and all symptom types, symptom frequency and average symptom severity were not associated with this parameter of diurnal cortisol (not shown). Model 1, however, shows that neuroticism was negatively associated with the cortisol awakening response. A one standard deviation increase in neuroticism was associated with an 11% flatter (less steep) cortisol awakening response. Neuroticism was not associated with the residual variance (i.e., within-person or day-to-day variation in the cortisol awakening response).

Next, interactions were tested between neuroticism and symptom frequency as well as average symptom severity across the symptom types. Significant interactions are shown in Models 2 and 3, respectively. Neuroticism interacted with frequency of gastrointestinal symptoms (Figure 2-1) as well as average cold/flu symptom severity (Figure 2-2) to predict the cortisol awakening response. As displayed in Figure 2-1, individuals higher in neuroticism who reported gastrointestinal symptoms on all study days experienced the smallest cortisol awakening response. Similarly, shown in Figure 2-2, more neurotic participants reporting higher average severity for cold/flu symptoms demonstrated the flattest cortisol awakening response.

Daily cortisol afternoon/evening decline. Tables 2-7 and 2-8 provide results from linear multilevel models predicting the afternoon/evening decline in cortisol. Neuroticism was not associated with level of daily cortisol afternoon/evening decline, but higher scores on neuroticism were associated with more within-person/day-to-day variation in cortisol afternoon/evening decline (see note in Table 2-7 for specifics). As shown in Table 2-7, experiencing cold/flu (Model 2), gastrointestinal (Model 3), and "other" (Model 7) symptoms on a greater proportion of study days was associated with a less steep daily decline. A model (not shown) including all symptom type frequencies (i.e., cold/flu, gastrointestinal, bodily pain, fatigue, allergy, and "other" symptoms) as simultaneous predictors revealed that significant effects remained for frequency of gastrointestinal and "other" symptoms. In addition, symptom frequency for fatigue symptoms interacted with neuroticism in predicting the cortisol afternoon/evening decline, which is displayed in Figure 2-3 (also, see Table 2-7, Model 5). Having fatigue symptoms on all study days (compared to none of the study days) was associated with a less steep decline among individuals lower in neuroticism. No difference in the cortisol afternoon/evening decline as a function of fatigue symptom frequency was found among more neurotic individuals.

Table 2-8 demonstrates that for all types but cold/flu symptoms (Model 2), higher average severity was related to a less steep cortisol afternoon/evening decline. Average severity for "other" symptoms also interacted with neuroticism in predicting the afternoon/evening decline in cortisol (see Figure 2-4 as well as Table 2-8, Model 7). Similar to Figure 2-3, experiencing higher average severity for "other" symptoms was related to a flatter decline among individuals with lower scores on neuroticism, which was not the case for more neurotic participants.

Discussion

Summary of Main Findings and Their Relation to Previous Research

Neuroticism and daily physical health symptoms. As expected, participants higher in neuroticism were more likely to report any physical health symptoms from the composite category (i.e., all symptom types and items combined) on a given day. This is consistent with previous studies examining total number of symptoms among undergraduate students (Costa & McCrae, 1980) as well as overall symptom number and frequency among adults (Ebert et al., 2002; Rosmalen et al., 2007). The present study is also an extension in that symptoms were assessed daily, which more accurately characterizes everyday symptom experiences and may reduce the influence of memory and recall bias associated with retrospective reporting as well as neuroticism.

Also as hypothesized, neuroticism was associated with daily occurrence of particular symptom types, specifically bodily pain, fatigue, and "other" symptoms, which provides support for consideration of symptom types. Higher scores on neuroticism were not associated with the odds of reporting any cold/flu, gastrointestinal, and allergy symptoms, however, which may be more related to different factors (e.g., virus, bacteria, pollen). This suggests that neuroticism, independent of current negative affect, may be more associated with temporal features of diffuse or general symptoms such as pain and fatigue, which are less objectively measured compared to those that are more obvious and easily detectable (for discussion, see Charles & Almeida, 2006).

These specific results of the present study are in contrast to the general pattern reported by Costa and McCrae (1980) where neuroticism was related to levels of all symptom types. Larsen (2007), however, found that neuroticism was associated with daily frequency of gastrointestinal as well as distress symptoms among college students, but not aches or upper respiratory complaints. Rosmalen et al. (2007) demonstrated that neuroticism was more strongly related to experiencing psychosomatic symptoms (i.e., factor comprised of pain, fatigue, and gastrointestinal symptoms) than a symptom group of allergies, cold, and upper respiratory complaints. Across these studies, the age of the respective samples and how symptoms were measured, including the specific temporal factor of interest and separation into types/factors appear to be important, as well as what other variables were considered related to symptom reporting (i.e., separating effects of trait and state negative affect; controlling for mood and psychological distress). For example, perhaps an association between neuroticism and bodily pain symptoms was found in the present and other studies (Rosmalen et al., 2007) as opposed to Larsen (2007) where the sample was much younger and the age range was restricted. Musculoskeletal problems and pain in many areas of the body are more common among older than younger adults (Verbrugge, 1986).

Also as hypothesized, higher neuroticism was related to higher reported severity of composite symptoms. In addition, neuroticism was differentially associated with severity across the various symptom types. Similar to daily occurrence, higher neuroticism was associated with higher severity of bodily pain symptoms, though this was not the case for fatigue and “other” symptoms as well as gastrointestinal and allergy symptoms. Somewhat contrary to expectations, participants with higher scores on neuroticism also reported more severe cold/flu symptoms. This particular result differs from previous research reviewed that found no association between neuroticism and upper respiratory symptoms, though these studies (Larsen 2007; Rosmalen et al., 2007) did not examine severity and focused instead on temporal characteristics, which have been distinguished from severity as representing a different threshold of symptom reporting (Kroenke, 2001).

Finally, neuroticism was examined as a predictor of within-person variation in symptom severity by symptom type. Consistent with prior research, higher neuroticism was associated with less day-to-day fluctuation (i.e., more stability) in severity across all the symptoms (i.e., composite category), which was also found specifically for bodily pain symptoms in the present study (King, 2008). Interestingly, the opposite pattern emerged for fatigue symptoms. Participants higher in neuroticism did not report higher mean levels of severity for fatigue symptoms, but fluctuated more in these ratings from day-to-day. Perhaps this is because severity of fatigue symptoms for more neurotic individuals is linked to fluctuations in other daily experiences such as stressors and environmental challenges like overload.

In addition, follow-up analyses indicated that all associations between neuroticism and experiences of daily physical health symptoms were age invariant; neuroticism operated similarly across the age range considered. In sum, neuroticism may not be associated with symptom types in the same manner within (i.e., levels of vs. fluctuations in severity ratings) and across dimensions (i.e., occurrence vs. severity). It does appear that neuroticism is most consistently associated with pain symptoms across analyses (i.e., occurrence; level of and within-person variation in severity) and to a lesser extent, fatigue symptoms (i.e., occurrence and within-person variation in severity). Perhaps pain and fatigue are more subjective experiences that rely on more internal and less objective cues as compared to gastrointestinal symptoms (e.g., diarrhea) or cold/flu symptoms (e.g., cough), for example. Associations were found between neuroticism and a composite category including all symptoms; however, these relationships appear to be driven by particular symptom types, which would not have otherwise been detected. Consideration of multiple symptom types as well as dimensions of symptom experiences provides a more complete and in-depth understanding of how neuroticism is associated with daily self-reported physical health.

Neuroticism and parameters of diurnal cortisol. As expected and consistent with prior research, more neurotic individuals did not have a flatter or steeper cortisol decline throughout the afternoon and evening, on average (Portella et al., 2005; Vedhara et al., 2006). However, higher neuroticism was associated with more within-person variation in this parameter of diurnal cortisol. In other words, more neurotic individuals were more variable than their lower neuroticism counterparts in regards to their daily decline in cortisol from day to day, which was not found for the cortisol awakening response. Perhaps this measure of cortisol is more sensitive to varying aspects of the daily environment (e.g., stressors) for those with higher scores on neuroticism, however, daily variation in and differences related to collection times and compliance may play a role as well.

Contrary to and in direct opposition to several previous studies demonstrating neuroticism is positively associated with the cortisol awakening response and levels 30 to 60 minutes after waking (Portella et al., 2005; Vedhara et al., 2006), higher neuroticism was related to a less steep cortisol awakening response in the present study. Blunted cortisol responses to awakening have also been found among individuals with high levels of burnout (Pruessner, Hellhammer, & Kirschbaum, 1999). Follow-up analyses indicated that this association was significant for older but not for younger adults. Mroczek, Spiro, Griffin, and Neupert (2006) argued that little is known about older adults high in neuroticism. It was hypothesized these individuals may exhibit heightened sensitivity and reactivity as a result of kindling effects. Older adults may also be more biologically sensitive to the negative effects of neuroticism due to physical vulnerabilities and declines (theory of Strength and Vulnerability Integration; Charles, 2010; Charles & Piazza, 2009). Alternatively, and assuming relative stability in this personality trait for these individuals, older adults high in neuroticism could exhibit inadequate physiological activity and responses as seen here, which is a type of allostatic load – wear and tear the body experiences as a result of repeated adaptation to a variety of stressful circumstances (McEwen, 2000). More neurotic individuals are characterized by greater stressor exposure and reactivity (Bolger & Zuckerman, 1995; Suls & Martin, 2005).

Characteristics of the samples and procedures of the prior studies (i.e., gender/age composition as well as measurement of and selection related to neuroticism) may contribute an extent to the discrepant results. Vedhara et al. (2006) utilized a sample of 85 recently diagnosed breast cancer patients (i.e., female participants only) ranging in age from 30 to 75 years of age. Portella et al. (2005) recruited participants specifically on the basis of extremely low (n = 15) and high scores (n = 15) on neuroticism (21 to 57 years of age). The sample of the present study included both males and females ranging in age from 34 to 86 years (slightly older) and was not limited to individuals with a disease such as cancer or extreme scores on neuroticism, which represent particular subsamples of individuals.

Daily physical health symptoms and parameters of diurnal cortisol. There were no main effects of symptom frequency or average severity by symptom type on the cortisol awakening response. This is in contrast to a study of college students, which found that a steeper cortisol awakening response was associated with more upper respiratory symptoms (Edwards et al., 2003). The present study, however, did not include individuals of this age. Another study found individuals identified as exhausted exhibited lower levels of cortisol in the morning among working individuals, but the measurement of exhaustion was rather global (i.e., vitality scale of the Medical Outcomes Study Short Form general health survey, SF-36; Lindeberg et al., 2008).

Greater frequency of cold/flu, gastrointestinal, and "other" symptoms was related to a less steep decline in cortisol throughout the day, however. In addition, the same pattern was found for higher average symptom severity for the composite category as well as the majority of the types: gastrointestinal, bodily pain, fatigue, allergy, and "other" symptoms. Flatter slopes and rhythms have been associated with mortality among cancer patients and disease states, for example (Abercrombie et al., 2004; Septhton, Sapolsky, Kraemer, & Spiegel, 2000). Several previous studies have not found an association with symptoms and slope, but both did not consider symptom type (Ferguson, 2008; Wrosch et al., 2007).

Interactive effects of neuroticism and symptom experiences on diurnal cortisol. A blunted cortisol awakening response was demonstrated by more neurotic participants who experienced gastrointestinal symptoms on a greater proportion of the study days as well as for those who reported higher average severity of cold/flu symptoms. As with the cortisol awakening response, there were also interactive effects between neuroticism and some symptom types and characteristics on the afternoon/evening decline in cortisol, though not in the same manner. Specifically for individuals with lower scores on neuroticism (as compared to more neurotic participants), less steep daily declines in cortisol were exhibited by those experiencing fatigue symptoms more frequently during the study as well as for those reporting higher average severity for "other" symptoms. These findings highlight the importance of examining how the combination of aspects of personality (i.e., neuroticism) and self-reported daily health (i.e., symptom experiences) are associated with HPA axis dysregulation.

Limitations and Future Directions

There are several limitations to mention and specific areas to address in future research: (1) types of daily physical health symptoms; (2) measurement of neuroticism; and (3) difficulties associated with salivary cortisol measurement, analysis, and interpretation.

In the present study, daily physical health symptoms were grouped according to a review of the literature. As a result, further empirical validation may be necessary as well as exploration of alternative symptom types/item compositions and the best method to compare results across symptom types. Another potential limitation is related to the measurement of the personality trait neuroticism, which was measured using a rather short (i.e., 4-item: moody, worrying, nervous, calm) scale. Although the reliability and construct validity were adequate and reasonable (see discussion of the measure in the methods section), the scope of the measure is somewhat limited, overlaps with assessment of daily negative affect, and may not fully represent the construct of neuroticism, specifically associated lower-order traits. Personality theorists have argued that neuroticism is a dimension comprised of several facets (i.e., anxiety, angry/hostility, depression, self-consciousness, impulsiveness, and vulnerability) (Costa and McCrae, 1992b). Unfortunately, facet-level analysis was not possible in the present study. In addition, future work in this area would benefit from considering not only the unique, independent effects of neuroticism and negative mood but their interaction as well.

In addition, there are several issues to consider in regards to salivary cortisol measurement, analysis, and interpretation. First, compliance to the saliva collection protocol is critical in naturalistic studies. Although this study attempted to address aspects of noncompliance by identifying and excluding days when participants took some of their samples outside the proper timeframe, for example, the collection times were self-reported (primarily on home collection sheets) and not confirmed or compared to another source. In addition, it is unclear if respondents followed other directions such as those related to brushing teeth, eating, drinking, and caffeine consumption. Furthermore, adherence (or lack thereof) to saliva collection procedures may be related to variables of interest such as neuroticism, which confounds analyses and results. Second, there are a number of other indices of cortisol that were not considered in the present study as well as alternative methods of calculation and modeling to be explored in future research. There also does not appear to be a clear consensus in the literature regarding dysregulated cortisol and exactly what levels of cortisol are considered "normal" and "typical" as well as the consequences of potentially abnormal patterns. Identification of atypical cortisol appears to generally be sample-driven, as was the approach in the present study. Interpretation of the findings and their implications is complicated as a result. Furthermore, the direction of the effects is not clear, particularly in regards to the relationship between cortisol and daily physical health symptoms as both have been treated as predictors and outcomes in the literature; additional data and longitudinal studies would aid in clarification.

In conclusion, several major points are worth highlighting. First, the personality trait of neuroticism was associated both with worse self-reported daily physical health across dimensions (i.e., symptom occurrence and level of and fluctuation in severity, particularly for pain and fatigue symptoms) as well as a blunted cortisol awakening response as an indicator of physiological function (i.e., possible dysregulation). Neuroticism may have important intervention implications. In fact, further exploration of interventions targeting neuroticism and/or "middle units" such as cognitive and affective processes has been suggested as a direction for future research (Lahey, 2009; Smith, 2006; Smith & MacKenzie, 2006; Smith & Spiro, 2002). Second, frequency and average severity of daily physical health symptoms were associated with a less steep afternoon/evening decline in cortisol. Third, there were interactive effects of neuroticism and symptom experiences on parameters of diurnal cortisol; this is an area which would benefit from additional research. Finally, associations varied as a function of type and dimension of daily physical health symptoms; consideration of both of these aspects of symptoms reports is valuable.

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Table 2-1

Descriptive Statistics

Variable	*N*	*M* (*SD*)	Percentage %
Gender	1400		56% female (784)
Smoker	1400		16% smokers (227)
Medication user	1400		37% medication users (513)
Age	1400	58.32 (12.04)	
Average daily negative affect	1400	.20 (.25)	
Neuroticism	1400	2.04 (.63)	
Composite symptoms frequency	1400	.65 (.34)	
Composite symptoms average severity	1312	3.51 (1.54)	
Cold/flu symptoms frequency	1400	.17 (.28)	
Cold/flu symptoms average severity	580	2.79 (1.62)	
Gastrointestinal symptoms frequency	1400	.13 (.23)	
Gastrointestinal symptoms average severity	532	3.91 (1.92)	
Bodily pain symptoms frequency	1400	.47 (.36)	
Bodily pain symptoms average severity	1158	3.60 (1.70)	
Fatigue symptoms frequency	1400	.26 (.31)	
Fatigue symptoms average severity	860	3.93 (1.77)	
Allergy symptoms frequency	1400	.13 (.27)	
Allergy symptoms average severity	401	3.16 (1.67)	
Other symptoms frequency	1400	.12 (.23)	
Other symptoms average severity	490	4.04 (2.11)	
Average daily wake-up time[a]	1399	6.67 (1.38)	
Average daily cortisol awakening response[b]	1322	.60 (.78)	
Average daily cortisol afternoon/evening decline[b]	1354	-.11 (.05)	

Note. Scores for daily variables were averaged across the study days. Frequency for the symptom variables reflects proportion of days reported across the study days. Average severity ratings were only available for participants who experienced the symptom type on at least one of the study days.

[a]Days were excluded from analysis with cortisol on which participants reported waking up before 4 a.m. or after 11:00 a.m. as described in methods section.

[b]Values after exclusion based on all daily flags described in methods section. Steeper average daily cortisol awakening response associated with a steeper average daily cortisol afternoon/evening decline (r = -.32, n = 1310, p < .001).

Table 2-2

Correlations among Study Variables for Aim 1

Variable	1	2	3	4	5	6	7	8	9	10
1. Age										
2. Gender	-.05									
3. Average daily negative affect	-.16***	.11***								
4. Neuroticism	-.22***	.14***	.37***							
5. Composite symptoms frequency	.04	.11***	.32***	.20***						
6. Cold/flu symptoms frequency	-.06*	.03	.25***	.11***	.41***					
7. Gastrointestinal symptoms frequency	.00	.12***	.46***	.20***	.40***	.24***				
8. Bodily pain symptoms frequency	.06*	.10***	.31***	.19***	.79***	.20***	.32***			
9. Fatigue symptoms frequency	.03	.17***	.42***	.20***	.55***	.26***	.41***	.50***		
10. Allergy symptoms frequency	-.01	.09**	.14***	.09**	.36***	.18***	.15***	.15***	.16***	
11. Other symptoms frequency	.11***	.06*	.35***	.18***	.37***	.28***	.34***	.31***	.40***	.13***

Note. Scores for daily variables were averaged across the study days (i.e., negative affect). Frequency for the symptom types (i.e., variables 5 to 11) reflects proportion of days reported across the study days. Gender: 0 = male, 1 = female. N = 1400 individuals.
***p < .001; **p < .01; *p < .05.

Table 2-3

Additional Correlations between Study Variables and Average Severity Separately for each Physical Health Symptom Type for Aim 1

Variable	Composite symptoms average severity	Cold/flu symptoms average severity	Gastrointestinal symptoms average severity	Bodily pain symptoms average severity	Fatigue symptoms average severity	Allergy symptoms average severity	Other symptoms average severity
Age	.01	.02	-.05	.01	-.02	.07	-.03
Gender	.16***	.10*	.13**	.14***	.13***	.17**	.12**
Average daily negative affect	.24***	.22***	.19***	.22***	.26***	.20***	.13**
Neuroticism	.17***	.16***	.13**	.18***	.13***	.10	.06
Symptom type frequency	.21***	.22***	.15***	.25***	.19***	.18***	.07
N (number of individuals)	1312	580	532	1158	860	401	490

Note. Scores for daily variables were averaged across the study days (i.e., negative affect and severity). Symptom type frequency reflects proportion of days reported across the study days, which varies by symptom type. Gender: 0 = male, 1 = female. Number of individuals varies because average severity ratings were only available for participants who experienced the symptom type on at least one of the study days.
***$p < .001$; **$p < .01$; *$p < .05$.

Table 2-4

Logistic Multilevel Models Predicting Any Daily Symptoms (i.e., Occurrence) by Physical Health Symptom Type

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Any composite symptoms	Any cold/flu symptoms	Any gastrointestinal symptoms	Any bodily pain symptoms	Any fatigue symptoms	Any allergy symptoms	Any other symptoms
Parameter	Fixed effects: *OR* (95% *CI*)						
Age	1.33 (1.19, 1.49)***	0.94 (0.80, 1.10)	1.19 (1.05, 1.35)**	1.32 (1.18, 1.48)***	1.26 (1.14, 1.40)***	1.15 (0.94, 1.41)	1.65 (1.43, 1.90)***
Gender	1.45 (1.11, 1.89)**	1.10 (0.75, 1.60)	1.71 (1.26, 2.31)***	1.41 (1.08, 1.84)*	1.98 (1.53, 2.55)***	2.76 (1.66, 4.60)***	1.10 (0.78, 1.53)
Average daily negative affect	3.13 (2.57, 3.80)***	2.11 (1.74, 2.55)***	2.79 (2.38, 3.26)***	2.37 (2.01, 2.80)***	2.92 (2.50, 3.41)***	1.60 (1.27, 2.02)***	2.38 (2.02, 2.81)***
Neuroticism	**1.26 (1.09, 1.45)****	1.07 (0.87, 1.31)	1.18 (1.00, 1.38)	**1.31 (1.13, 1.51)*****	**1.18 (1.03, 1.36)***	1.30 (1.00, 1.68)	**1.38 (1.16, 1.66)*****
Intercept	1.02 (.10)***	-3.26 (.16)***	-3.54 (.14)***	-0.33 (.10)**	-2.14 (.10)***	-4.94 (.24)***	-3.65 (.15)***
Intercept variance	4.49 (.31)***	7.87 (.64)***	4.21 (.38)***	4.78 (.31)***	3.74 (.27)***	10.43 (.83)***	5.15 (.48)***
-2 log likelihood	10471.0	6860.7	6194.5	11140.0	9218.7	5227.2	5713.2

Note. *OR* = odds ratio. *CI* = confidence interval. Scores for daily variables (i.e., negative affect) were averaged across the study days. Gender: 0 = male, 1 = female. Age was centered at the sample mean and transformed (unit = decade). In addition, average daily negative affect and neuroticism were transformed to *z* units. Neuroticism did not interact with linear or quadratic effects for age. Prior to inclusion of negative affect, higher neuroticism was associated with greater odds of experiencing any symptoms on a given day for all physical health symptom types. Intercept reflects log-odds of endorsing any symptoms for a man of average age, daily negative affect (average), and neuroticism. Between-person variation in any daily physical health symptoms (intraclass correlation) calculated from random intercept only models was 63% for composite symptoms, 73% for cold/flu symptoms, 64% for gastrointestinal symptoms, 63% for bodily pain symptoms, 61% for fatigue symptoms, 77% for allergy symptoms, and 67% for “other” symptoms. N = 1400 individuals, 10606 days across all models.
***$p < .001$; **$p < .01$; *$p < .05$.

Table 2-5

Linear Multilevel Models Predicting Daily Severity by Physical Health Symptom Type

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Composite symptoms severity	Cold/flu symptoms severity	Gastrointestinal symptoms severity	Bodily pain symptoms severity	Fatigue symptoms severity	Allergy symptoms severity	Other symptoms severity
Fixed effects							
Intercept	3.25 (.06)***	2.32 (.12)***	3.41 (.15)***	3.24 (.08)***	3.56 (.10)***	2.44 (.17)***	3.69 (.16)***
Age	.07 (.03)*	.11 (.06)	-.02 (.07)	.06 (.04)	.02 (.05)	.15 (.06)*	-.01 (.08)
Gender	.39 (.08)***	.24 (.13)	.43 (.17)*	.39 (.10)***	.35 (.12)**	.50 (.17)**	.39 (.19)*
Symptom frequency	.63 (.14)***	1.09 (.21)***	.56 (.31)	1.01 (.16)***	.53 (.21)*	.93 (.25)***	.23 (.34)
Average daily negative affect	.26 (.04)***	.20 (.06)***	.21 (.07)**	.22 (.05)***	.32 (.05)***	.26 (.07)***	.19 (.08)*
Neuroticism	**.12 (.04)****	**.15 (.07)***	.09 (.08)	**.16 (.05)****	.08 (.06)	.05 (.08)	.01 (.10)
Random effects							
Intercept variance	1.74 (.08)***	1.61 (.13)***	2.19 (.20)***	2.08 (.10)***	1.88 (.13)***	1.73 (.17)***	2.81 (.27)***
Residual variance	1.29 (.02)***	1.48 (.06)***	2.08 (.10)***	1.44 (.03)***	1.93 (.06)***	1.54 (.07)***	2.16 (.12)***
Neuroticism effect on residual	**-.06 (.02)*****	.06 (.03)	.01 (.04)	**-.07 (.02)****	**.07 (.03)***	-.00 (.04)	-.01 (.04)
-2 log likelihood	23800.4	6609.0	5563.5	17998.3	10588.0	5196.0	5183.7
N people, *N* days	1312, 6877	580, 1803	532, 1380	1158, 4976	860, 2709	401, 1413	490, 1260

Note. Scores for daily variables (i.e., negative affect) were averaged across the study days. Gender: 0 = male, 1 = female. Age was centered at the sample mean and transformed (unit = decade). In addition, average daily negative affect and neuroticism were transformed to *z* units and symptom frequency was centered at sample mean. The fixed effect of neuroticism did not interact with linear or quadratic effects for age. Prior to inclusion of negative affect, neuroticism (fixed effect) was positively associated with daily severity for all physical health symptom types but “other”. Neuroticism effects on residual variances remained when including negative affect effect on residual. Between-person variation in severity (intraclass correlation) calculated from random intercept only models was 61% for composite symptoms, 56% for cold/flu symptoms, 55% for gastrointestinal symptoms, 63% for bodily pain symptoms, 53% for fatigue symptoms, 57% for allergy symptoms, and 58% for “other” symptoms.

***$p < .001$; **$p < .01$; *$p < .05$.

Table 2-6

Linear Multilevel Models Predicting Daily Cortisol Awakening Response from Neuroticism and Interaction with Symptom Experiences

	Model 1	Model 2[a]	Model 3[b]
Fixed effects			
Intercept	.475 (.035)***	.482 (.035)***	.561 (.066)***
Age	.046 (.018)**	.047 (.018)**	.057 (.028)*
Gender	.164 (.042)***	.162 (.043)***	.176 (.069)*
Smoker	.255 (.058)***	.262 (.058)***	.294 (.082)***
Medication user	.020 (.043)	.024 (.043)	-.084 (.067)
Average daily wake-up time	-.011 (.025)	-.008 (.025)	.029 (.036)
Average daily negative affect	.011 (.024)	.028 (.026)	.018 (.033)
Neuroticism	**-.053 (.022)***	-.049 (.022)*	-.056 (.036)
Symptom frequency (gastrointestinal)		-.021 (.101)	
Neuroticism X symptom frequency (gastrointestinal)		**-.189 (.077)***	
Symptom frequency (cold/flu)			-.112 (.111)
Average symptom severity (cold/flu)			-.003 (.021)
Neuroticism X average symptom severity (cold/flu)			**-.044 (.021)***
Random effects			
Intercept variance	.263 (.022)***	.261 (.022)***	.265 (.034)***
Residual variance	.918 (.023)***	.918 (.023)***	.919 (.036)***
-2 log likelihood	13240.6	13234.0	5387.2
N people, *N* days	1322, 4489	1322, 4489	534, 1825

Note. Scores for daily variables were averaged across the study days. Gender: 0 = male, 1 = female. Smoker: 0 = no, 1 = yes. Medication user: 0 = no, 1 = yes. Age was centered at the sample mean and transformed (unit = decade). Average daily negative affect, neuroticism, and average daily wake-up time were transformed to *z* units. There was not an effect of neuroticism on the residual variance (Model 1 – not shown). Fixed effect of neuroticism interacted with linear age (*est.* = -.037, *SE* = .018, $p < .05$); effect of neuroticism (i.e., blunted cortisol awakening response) significant only for older adults (extension of Model 1). Between-person variation in cortisol awakening response (intraclass correlation) calculated from random intercept only model was 31% (ICC = 55% when weighted by number of assessments). No symptom variables were associated with the cortisol awakening response (models not shown). Symptom frequencies and average symptom severities were centered at the sample means.

[a]In Model 2, interactions between neuroticism and symptom frequency for each type were tested; significant results shown.

[b]In Model 3, interactions between neuroticism and average symptom severity for each type were tested; significant results shown.

***$p < .001$; **$p < .01$; *$p < .05$.

Table 2-7

Linear Multilevel Models Predicting Daily Cortisol Afternoon/Evening Decline from Symptom Frequency for Each Type and Interaction with Neuroticism

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Composite symptoms predicting decline	Cold/flu symptoms predicting decline	Gastrointestinal symptoms predicting decline	Bodily pain symptoms predicting decline	Fatigue symptoms predicting decline	Allergy symptoms predicting decline	Other symptoms predicting decline
Fixed effects							
Intercept	-.116 (.002)***	-.116 (.002)***	-.116 (.002)***	-.116 (.002)***	-.115 (.002)***	-.116 (.002)***	-.116 (.002)***
Age	.003 (.001)**	.003 (.001)**	.003 (.001)**	.003 (.001)**	.003 (.001)**	.003 (.001)**	.002 (.001)*
Gender	.001 (.003)	.001 (.003)	.001 (.003)	.001 (.003)	.001 (.003)	.001 (.003)	.001 (.003)
Smoker	.011 (.003)**	.011 (.003)**	.011 (.003)**	.011 (.003)**	.012 (.003)***	.011 (.003)***	.011 (.003)**
Medication user	-.002 (.003)	-.002 (.003)	-.001 (.003)	-.001 (.003)	-.001 (.003)	-.001 (.003)	-.002 (.003)
Average daily wake-up time	-.003 (.001)*	-.003 (.001)*	-.003 (.001)*	-.003 (.001)*	-.003 (.001)*	-.003 (.001)*	-.003 (.001)*
Average daily negative affect	.003 (.001)*	.003 (.001)	.002 (.002)	.003 (.001)*	.004 (.002)*	.003 (.001)*	.002 (.001)
Neuroticism	.000 (.001)	.000 (.001)	.000 (.001)	.001 (.001)	.000 (.001)	.000 (.001)	.000 (.001)
Symptom frequency	.003 (.004)	**.012 (.004)***	**.018 (.006)****	-.001 (.004)	.004 (.004)	.002 (.005)	**.020 (.006)****
Symptom frequency X neuroticism					**-.008 (.004)***		
Random effects							
Intercept variance	.001 (.000)***	.001 (.000)***	.001 (.000)***	.001 (.000)***	.001 (.000)***	.001 (.000)***	.001 (.000)***
Residual variance	.002 (.000)***	.002 (.000)***	.002 (.000)***	.002 (.000)***	.002 (.000)***	.002 (.000)***	.002 (.000)***
-2 log likelihood	-14500.8	-14506.8	-14508.9	-14500.2	-14504.9	-14500.4	-14512.0

Note. Scores for daily variables were averaged across the study days. Gender: 0 = male, 1 = female. Smoker: 0 = no, 1 = yes. Medication user: 0 = no, 1 = yes. Age was centered at the sample mean and transformed (unit = decade). Average daily negative affect, neuroticism, and average daily wake-up time were transformed to *z* units. Higher scores on neuroticism were associated with more within-person variation in daily cortisol afternoon/evening decline (i.e., residual variance, Model 1 – not shown; *est.* = .093, *SE* = .025, $p < .001$). Between-person variation in cortisol afternoon/evening decline (intraclass correlation) calculated from random intercept only model was 43%. Symptom frequencies were centered at the sample means. Only significant interactions between neuroticism and symptom frequencies are shown. A model (not shown) including all symptom type frequencies (i.e., cold/flu, gastrointestinal, bodily pain, fatigue, allergy, and “other” symptoms) as simultaneous predictors revealed that significant effects remained for frequency of gastrointestinal and “other” symptoms (done prior to testing interactions with neuroticism). $N = 1354$ individuals, 4751 days across all models.
***$p < .001$; **$p < .01$; *$p < .05$.

Table 2-8

Linear Multilevel Models Predicting Daily Cortisol Afternoon/Evening Decline from Average Symptom Severity for Each Type and Interaction with Neuroticism

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Composite symptoms predicting decline	Cold/flu symptoms predicting decline	Gastrointestinal symptoms predicting decline	Bodily pain symptoms predicting decline	Fatigue symptoms predicting decline	Allergy symptoms predicting decline	Other symptoms predicting decline
Fixed effects							
Intercept	-.115 (.002)***	-.117 (.004)***	-.116 (.004)***	-.116 (.002)***	-.114 (.003)***	-.112 (.005)***	-.114 (.004)***
Age	.003 (.001)**	.005 (.002)**	.002 (.004)	.003 (.001)**	.004 (.001)**	.002 (.002)	.004 (.002)
Gender	-.001 (.003)	.003 (.004)	.002 (.004)	.000 (.003)	-.002 (.003)	-.001 (.005)	-.001 (.004)
Smoker	.010 (.003)**	.007 (.005)	.004 (.006)	.009 (.004)*	.009 (.004)*	.007 (.007)	.009 (.006)
Medication user	-.002 (.003)	.001 (.003)	-.006 (.004)	-.001 (.003)	.001 (.003)	-.003 (.005)	.005 (.004)
Wake-up time	-.004 (.001)*	-.003 (.002)	-.003 (.002)	-.004 (.002)**	-.002 (.002)	-.007 (.002)**	-.003 (.002)
Negative affect	.002 (.001)	.005 (.002)**	.003 (.002)	.004 (.001)*	.003 (.002)*	.007 (.002)**	.005 (.002)*
Neuroticism	-.000 (.001)	-.004 (.002)	-.003 (.002)	-.000 (.001)	-.001 (.002)	-.001 (.002)	-.004 (.002)
Symptom frequency	.002 (.004)	.011 (.006)	.023 (.009)**	.001 (.004)	-.000 (.006)	.000 (.007)	.012 (.008)
Average symptom severity	**.004 (.001)*** **	.002 (.001)	**.002 (.001)***	**.004 (.001)*** **	**.003 (.001)*** **	**.004 (.001)*** *	**.004 (.001)*** **
Average symptom severity X neuroticism							**-.002 (.001)***
Random effects							
Intercept variance	.001 (.000)***	.001 (.000)***	.001 (.000)***	.001 (.000)***	.001 (.000)***	.001 (.000)***	.001 (.000)***
Residual variance	.002 (.000)***	.002 (.000)***	.002 (.000)***	.002 (.000)***	.002 (.000)***	.002 (.000)***	.002 (.000)***
-2 log likelihood	-13565.5	-5931.1	-5167.8	-11996.7	-8796.1	-4298.3	-4904.4
N people, *N* days	1265, 4440	557, 1931	506, 1740	1115, 3923	827, 2892	390, 1370	466, 1637

Note. Scores for daily variables were averaged across the study days. Gender: 0 = male, 1 = female. Smoker: 0 = no, 1 = yes. Medication user: 0 = no, 1 = yes. Age was centered at the sample mean and transformed (unit = decade). Average daily negative affect, neuroticism, and average daily wake-up time were transformed to *z* units. Symptom frequencies and average symptom severities were centered at the sample means. Only significant interactions between neuroticism and average symptom severities are shown.
***$p < .001$; **$p < .01$; *$p < .05$.

Figure 2-1

Cortisol awakening response as a function of neuroticism, gastrointestinal symptoms frequency, and their interaction

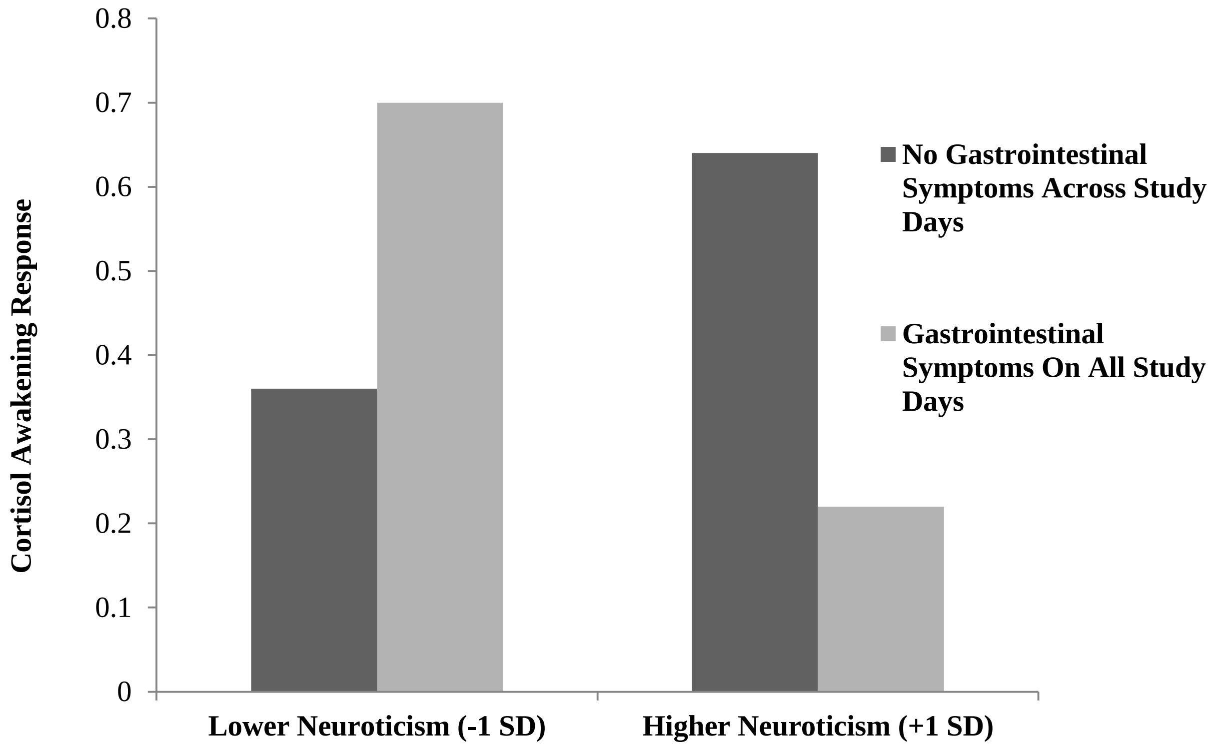


Figure 2-2

Cortisol awakening response as a function of neuroticism, cold/flu symptoms average severity, and their interaction

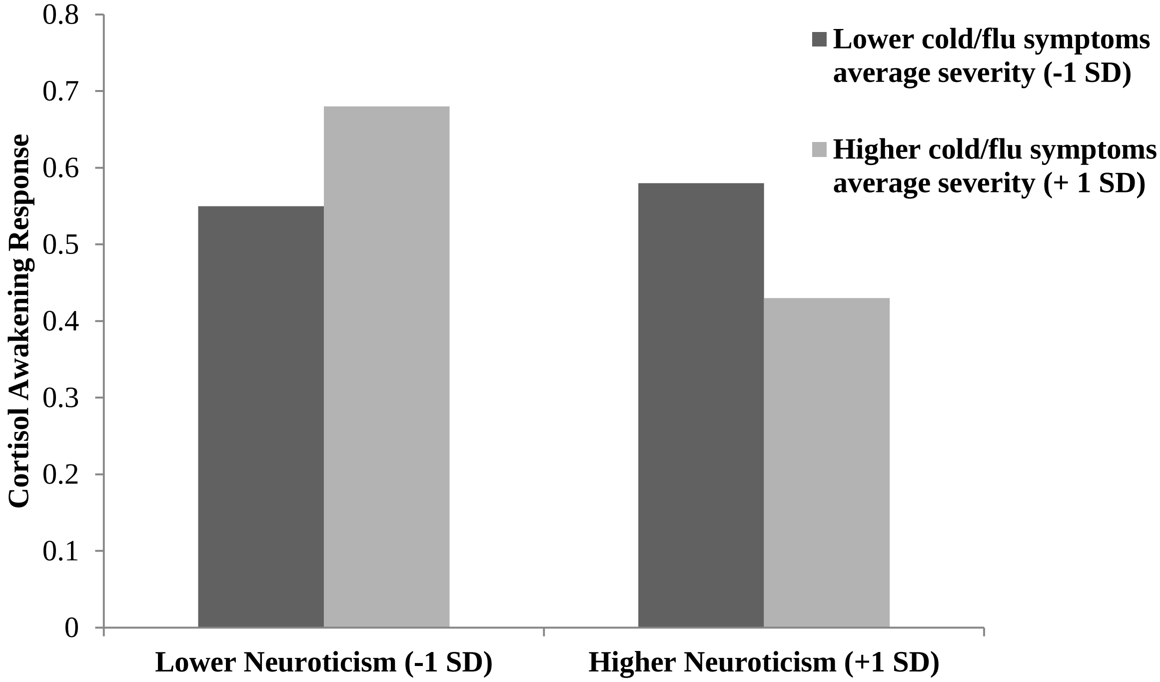


Figure 2-3

Cortisol afternoon/evening decline as a function of neuroticism, fatigue symptoms frequency, and their interaction

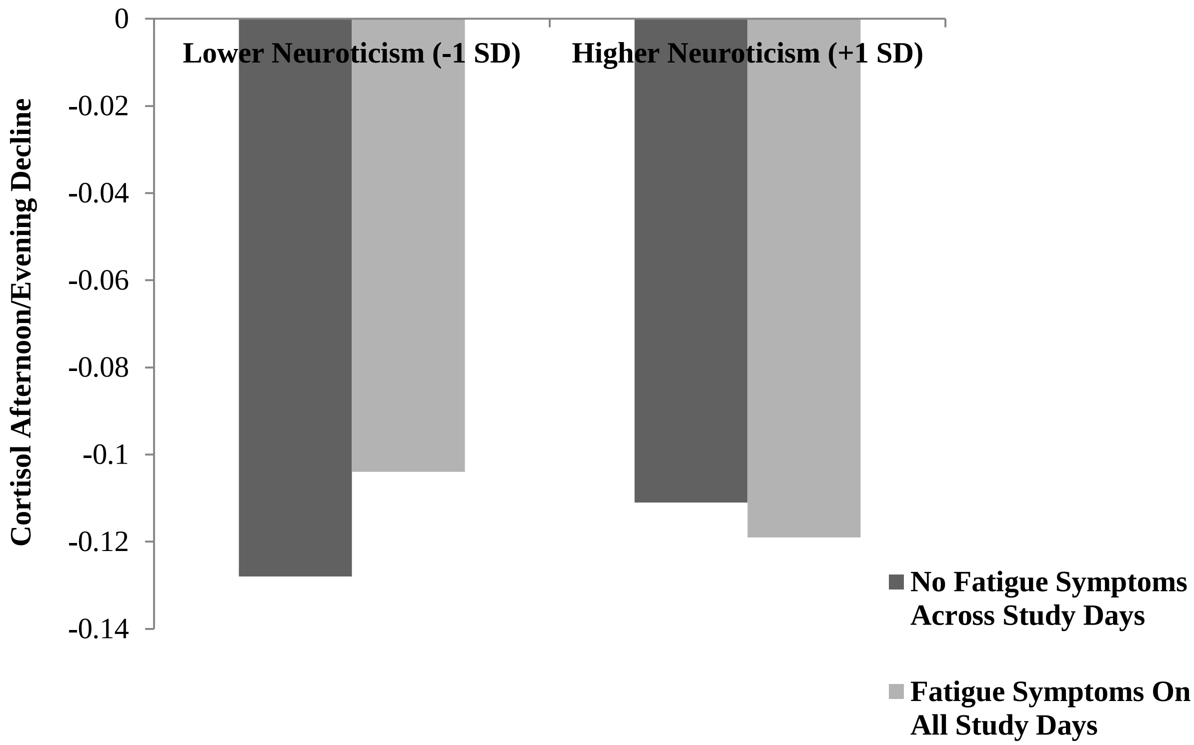
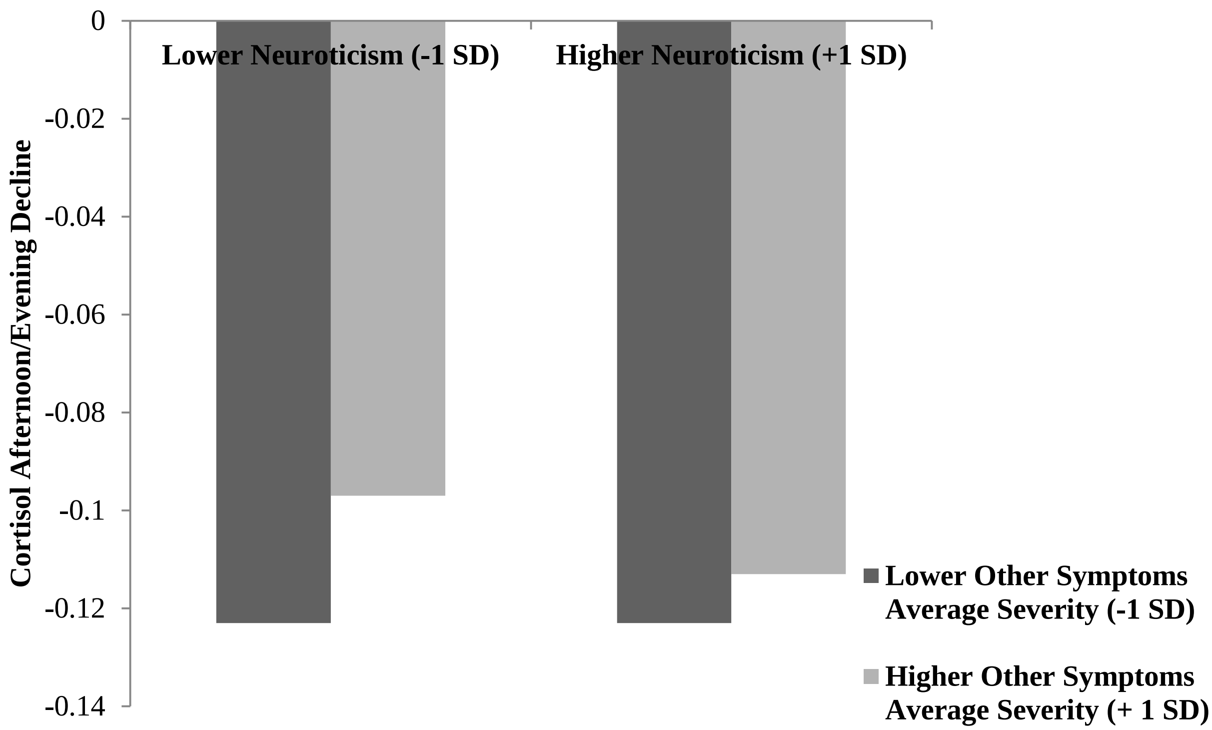


Figure 2-4

Cortisol afternoon/evening decline as a function of neuroticism, "other" symptoms average severity, and their interaction



Appendix 2-A

Daily Physical Health Symptom List (NSDE II)

1. Headache
2. Backache
3. Muscle soreness
4. Fatigue
5. Joint pain
6. Muscle weakness
7. Cough
8. Sore throat
9. Fever
10. Chills
11. Other cold and flu symptoms
12. Nausea
13. Allergies
14. Diarrhea
15. Constipation
16. Poor appetite
17. Other stomach problems
18. Chest pain
19. Dizziness
20. Shortness of breath or difficulty breathing
21. Menstrual-related symptoms**
22. Hot flashes or flushes**
23. Any other physical symptoms or discomforts
24. Skin-related symptoms*
25. Eye-related symptoms*
26. Ear-related symptoms*
27. Teeth-related symptoms*
28. Leg- or foot-related symptoms*

Note. * indicates additional category created based on open-ended responses to any other physical symptoms or discomforts. ** represents female health symptoms that were excluded from major analyses.

Appendix 2-B

Daily Physical Health Symptom Categories and Corresponding Items

<u>Cold/flu</u>
Cough
Sore throat
Fever
Chills
Other cold/flu

<u>Gastrointestinal</u>
Nausea
Diarrhea
Constipation
Poor appetite
Other stomach

<u>Bodily Pain</u>
Headache
Backache
Muscle soreness
Joint pain
Chest pain
Skin*
Eye*
Ear*
Teeth*
Leg/foot*

<u>Fatigue</u>
Fatigue
Muscle weakness

<u>Allergies</u>

<u>Other</u>
Dizziness
Shortness of breath or difficulty breathing
Any other

Note. * indicates additional category created based on open-ended responses to any other physical symptoms or discomforts.

Conclusion

This section includes a brief summary of the major results and general conclusions across the two papers included in this dissertation. Strengths of the approach and contributions to the existing research are also identified. Finally, possible medical applications and intervention implications are reviewed.

Summary and Contributions

The overarching purpose of this dissertation was to describe multiple aspects of physical health symptoms in daily life and examine behavioral (i.e., daily work cutback), personality (i.e., neuroticism), and hormonal (i.e., parameters of diurnal cortisol) correlates. First, the initial results of Paper 1 suggest that symptom reports are multidimensional; factors such as frequency and severity are not necessarily interchangeable and the symptom types (i.e., cold/flu, gastrointestinal, bodily pain, fatigue, allergies, and "other") examined differed in these dimensions among the individuals considered. In addition, women generally reported worse daily physical health than men, as measured by self-reported symptoms, particularly in regards to the likelihood of symptom occurrence across the study as well as severity for the majority of symptom types. Age, however, was not associated with any severity ratings, though some age differences were present for symptom occurrence and frequency across the daily diary. For example, older adults experienced pain symptoms more frequently. Finally, the majority of symptom variables characterizing people and days were linked to work cutback with the exception of daily occurrence and frequency of allergy symptoms. Furthermore, temporal characteristics of fatigue and pain bodily pain symptoms appear to be particularly associated with cutback in normal work activities. In addition, some of these associations were moderated by age with various symptom experiences mattering less for older adults and more for those in earlier or later midlife in regards to work cutback.

In regards to Paper 2, neuroticism was primarily associated with bodily pain symptoms and to a slightly less extent, fatigue symptoms across dimensions of daily symptom reporting. In addition, individuals with higher scores on neuroticism exhibited a less steep decline in the cortisol awakening response, specifically among older adults. Particular symptom type frequencies (e.g., gastrointestinal) and the majority of symptom type average severity scores were associated with a less steep afternoon/evening decline in cortisol. Finally, neuroticism and symptom experiences interacted in some instances to predict diurnal cortisol.

Generally speaking, this dissertation expands on previous research by adopting a process-oriented approach and applying lifespan developmental principles (e.g., multidimensional, contextual, etc.) to the study of daily physical health as well as neuroticism. Collectively, the papers provide a more fine-grained analysis of self-reported daily physical health symptoms (levels of and fluctuations across multiple assessments) through consideration of different symptom types as well as dimensions of symptom reporting, including temporal factors such as daily occurrence and frequency in addition to severity. These various aspects of symptom experiences were compared as well as described; furthermore, individual difference factors such as age and gender were included. The relevance and importance of these reports to activities of daily life and physiological function (i.e., linking across levels of health) were also examined to illustrate their consequences and significance. Specifically, daily work cutback was assessed as an index of symptom-impairment and parameters of diurnal cortisol (i.e., cortisol awakening response and afternoon/evening decline in cortisol) were incorporated to determine whether reports of symptom experiences translated to actual physiological dysregulation. Finally, this dissertation investigated the role of neuroticism in symptom reporting and independent as well as interactive effects with symptom experiences on diurnal cortisol. In sum, this dissertation provides a rather in-depth and comprehensive examination of daily physical health symptoms.

Medical Applications and Intervention Implications

Ultimately, this dissertation may have important applications to and implications for both medical research and practice as well as intervention efforts aimed at personality and physical health. First, distinguishing between types and dimensions of daily physical health symptoms in health psychology and medical research as well as by physicians in treatment settings is critical. This could even improve patient care through providing an in-depth assessment of symptoms, including identification of symptom clusters, temporal characteristics, intensity, and associated impairment. Furthermore, consideration of individual difference factors in symptom reporting such as age and gender is critical as well as the role of personality traits like neuroticism. A more complete understanding of health is gained from considering it within the context of the individual and his/her psychological, emotional, and behavioral characteristics as these impact both the reports and actual, objective health experiences. Furthermore and as suggested by some of the results of this dissertation, aspects of personality such as neuroticism also interact with health to predict parameters of physiological activity. In addition, neuroticism likely plays an important role in treatment adherence and patient-provider interactions as well as patient-centered and tailored interventions, which are becoming increasingly common in behavioral medicine.

Finally, intervention programs aimed at more neurotic individuals may not be successful at altering levels of neuroticism per se as this is likely not a directly modifiable risk factor. However, intervention efforts could decrease the deleterious effects of this particular personality trait on physical health and well-being more indirectly by targeting specific, related cognitive and affective processes as well as poor health behaviors (i.e., “middle units” and mechanisms). For example, programs have been developed to improve the stress response, specifically coping and emotional as well as cognitive reactivity (e.g., unconstructive repetitive thought) and recovery, which are also related to physiological activity. In addition, programs aimed at increasing characteristics negatively correlated with neuroticism such as mindfulness may be useful. In fact, I will expand on this dissertation and related research interests as a postdoctoral fellow in health services research where I will investigate associated applications and implications for healthcare and clinical interventions.

VITA

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King, H. A., Almeida, D. M., Mroczek, D. K., Gerstorf, D., Turiano, N. A., & Stawski, R. S. (2010, November). Neuroticism, age, and daily cortisol at waking. In H. A. King (Chair), *Personality and health research in adulthood and old age*. Symposium presented at the 63rd annual meeting of the Gerontological Society of America, New Orleans, LA.

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