

Conscientiousness and Stress Exposure and Reactivity: A Prospective Study of Adolescent
Females

by

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Abstract

Objective: Conscientiousness is associated with physical health, but the mechanisms remain poorly understood. To explore the role that stress might play, this study followed young women over time to determine whether conscientiousness was associated with their exposure and reactivity to life stress. **Methods:** One hundred and thirty-three healthy adolescent females aged 15-19 completed a measure of conscientiousness at study entry. Every 6 months for 2.5 years they underwent a structured interview to catalogue episodic and chronic forms of stress from a contextual perspective. To measure stress reactivity blood was drawn at each visit and was used to quantify circulating levels of interleukin-6 (IL-6) as a marker of systemic inflammation. Ex vivo leukocyte IL-6 responses to endotoxin and glucocorticoid sensitivity were also measured. **Results:** Regarding exposure, participants who were higher in conscientiousness experienced less severe stressful episodic events that they played a role in causing. They also had lower academic and interpersonal chronic stress throughout the study. In terms of reactivity, conscientious women became more resistant to the anti-inflammatory properties of glucocorticoids at times when they were experiencing relatively high levels of chronic interpersonal stress. **Conclusions:** Higher levels of conscientiousness may protect adolescent women from exposure to certain types of stress. However, when they do experience some forms of chronic stress, highly conscientious individuals showed increased resistance to glucocorticoids, which could place them at risk for inflammatory conditions.

Preface

Parts of the Introduction, Methods, Results, and Conclusion chapters in this thesis have been submitted to be considered for publication in a scholarly journal and are currently undergoing review. The manuscript submitted for review was developed in collaboration with my graduate supervisor Dr. Gregory E. Miller as well as with Dr. Carsten Wrosch. I was responsible for developing the proposed research questions, conducting all of the statistical analyses, and writing the manuscript. Dr. Miller provided the dataset used to test the hypotheses described in the manuscript, supervised both the development and writing of the manuscript, and served as an editor. Dr. Wrosch served as an additional editor of the manuscript.

For the project described in this thesis, written consent was obtained from all study participants and for participants under the age of 18, a parent or legal guardian also provided consent. The Behavioural Research Ethics Board of the University of British Columbia approved this project (UBC BREB Number: H04-80567).

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List of Abbreviations

BDI	= Beck Depression Inventory
BMI	= body mass index
ELISA	= enzyme-linked immunosorbent assay
HLM	= hierarchal linear modeling
IC50	= inhibitory coefficient-50
ICC	= intraclass correlation coefficient
IL-6	= interleukin-6
LPS	= lipopolysaccharide
LSI	= Life Stress Inventory
M	= mean
NSAID	= nonsteroidal anti-inflammatory drug
RCF	= relative centrifugal force
SD	= standard deviation
SE	= standard error
SES	= socioeconomic status
V	= visit

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Finally, I would like to thank my parents, George and Eileen Murphy, my brother, Sean Murphy, and my aunt, Mary Ann MacRae. That I am excited and driven to constantly learn new things and challenge myself is more a result of their mentorship, support, and patient and nurturing tutelage than any inherent quality that I possess.

Dedication

In honor and memory of my grandmothers, M. Jane MacRae and Mable M. Murphy

Introduction

Human personality is a complex and often difficult to explicitly define aspect of humanity that can be characterized both by what is unique and what is similar among individuals (Carver & Connor-Smith, 2010). The difficulty in unequivocally describing personality can be seen in the numerous theoretical frameworks that were proposed during the 20th century for structuring and explaining individual dispositions (Digman, 1990). Although it certainly has its critics (e.g., Block, 1995), the Five Factor Model has become a widely accepted standard for organizing human personality (John, Naumann, & Soto, 2008). This model holds that personality can be conceptualized along five distinct factors, commonly referred to together as the Big Five (Goldberg, 1993). These factors are usually identified as agreeableness, conscientiousness, extraversion, neuroticism, and openness to experience (Olver & Mooradian, 2003). Each of these factors is composed of numerous facets which, while useful, have been the cause of some confusion and have led to difficulties in developing universally accepted definitions (McCrae & John, 1992). However, John and Srivastava (1999) provided a commonly used broad overview of the five dimensions. In their description, agreeableness describes a person's tendency to engage in socially positive behaviors. Conscientiousness refers to the extent to which an individual engages in planning, goal-setting, and careful task management to control impulses in a socially desirable manner. Extraversion denotes the degree to which a person vigorously interacts with the surrounding social world. Neuroticism delineates how emotionally stable an individual is. Finally, openness to experience is characterized by how broad-minded a person is both in terms of how the individual thinks and how he or she responds to the world.

Although precisely defining and understanding human personality is itself a fruitful field of study, personality does not exist in a vacuum. Accumulating evidence suggests that a person's dispositions not only play a role in shaping what happens to the individual, but also are a powerful determinant of key life outcomes. Indeed, in their review of the literature, Ozer and Benet-Martínez (2006) outline many important ways in which personality influences life from an individual, interpersonal, and institutional standpoint. At the individual level, personality is related to subjective constructs such as happiness and wellbeing and objective outcomes such as psychopathological processes, physical disease risk, and mortality. At the interpersonal level, personality is associated with peer acceptance, the ability to make friends, and the ability to form and maintain romantic partnerships. Finally, at the institutional level, personality predicts outcomes such as career success and financial stability. As Roberts, Kuncel, Shiner, Caspi, and Goldberg (2007) discuss, these associations are not trivial; indeed, personality traits have a similar influence on outcomes such as divorce, occupational attainment, and mortality as cognitive ability and socioeconomic status.

Conscientiousness and Health

For health, one personality trait that is particularly important in buffering against morbidity and mortality is conscientiousness. In an early landmark study on personality and health, Friedman et al. (1993) demonstrated that childhood conscientiousness was predictive of longevity in a longitudinal community drawing on seven decades worth of data. Indeed, to the extent that individuals were lower in childhood conscientiousness, they had an increased risk of mortality compared to their higher conscientious counterparts, and the effect of conscientiousness on mortality was similar in magnitude to the independent effects of both

systolic blood pressure and serum cholesterol. Since then, several other methodologically rigorous longitudinal studies have corroborated these findings. Notably, Wilson, Mendes de Leon, Bienias, Evans, and Bennett (2004) found that older adults in the 90th percentile of their sample distribution of conscientiousness had a 48% reduction in mortality risk over an approximately five year study compared to individuals in the 10th percentile of the distribution. Similarly, Weiss and Costa (2005) showed that there was no difference in mortality risk between individuals who were of average or lower than average conscientiousness, but participants who were higher in conscientiousness had a 47% reduced risk of dying two years after baseline compared to the low conscientious individuals in their study. In a study of individuals followed for over four decades, Terracciano, Löckenhoff, Zonderman, Ferrucci, and Costa (2008) demonstrated that highly conscientious individuals had a 26% reduced risk of mortality. Indeed, using meta-analytic techniques, Kern and Friedman (2008) outlined that across 20 different samples spanning over 8,900 participants, the average effect size of conscientiousness on mortality was .11. The authors argued that although this effect size may appear small, it is similar in magnitude to the effects of some vaccinations and pharmaceutical treatments routinely employed in the biomedical field. As such, these findings highlight the powerful effect that conscientiousness can have in reducing a person's risk of early death.

In addition to being protective against mortality in community samples, conscientiousness has also been linked to improved medical outcomes in patient samples. In one study, individuals who were lower in conscientiousness had increased reports of physician-rated illnesses (Chapman, Lyness, & Duberstein, 2007). Another study demonstrated evidence that individuals suffering from HIV who were higher in

conscientiousness had increased numbers of CD4+ lymphocytes one year later. These are the cells that become infected by the HIV virus, and whose numbers serve as a marker of immunologic control over the disease. Those high in C also had a lower HIV viral load at f/u. (O'Cleirigh, Ironson, Weiss, & Costa, 2007). Additionally, higher conscientiousness has been shown to be associated with reduced risk of dying from chronic renal disease over a four year longitudinal study, such that individuals lower in conscientiousness had a 38% increase in risk of mortality compared to their higher conscientious counterparts (Christensen et al., 2002). Finally, Wilson, Schneider, Arnold, Bienias, and Bennett (2007) found that conscientiousness was associated with a reduced risk of developing Alzheimer's Disease and mild cognitive impairment. Participants in the 90th percentile of their study's sample distribution of conscientiousness had an 89% reduced risk of developing Alzheimer's Disease during a 12 year follow-up compared to participants in the 10th percentile of the distribution. Taken together, these findings highlight that conscientiousness is an important predictor of health in both community and patient populations.

Mechanisms

Given the amount of evidence supporting a link between conscientiousness, health, and mortality, it is important to consider how conscientiousness might “get under the skin” to influence health processes. One obvious candidate for a mechanism whereby conscientiousness may confer its protective effect against poor health outcomes is through its influence on health behaviors. Individuals who are more conscientious may be less likely to engage in risky behaviors that would put them at increased risk of health related problems. And in fact, there is a large body of literature that supports this idea. Various studies have demonstrated that conscientiousness is associated with decreased alcohol consumption, less

smoking, better exercise habits, proper sleep hygiene, increased fruit and vegetable consumption, regular seatbelt use, careful automobile practices, maintaining a generally “safe” environment, better employment stability, and general self-care tendencies (Boothkewley & Vickers, 1994; Friedman, 2000; Friedman et al., 1995; Hampson, Andrews, Barckley, Lichtenstein, & Lee, 2000; Raynor & Levine, 2009). These individual studies are further supported by a quantitative review of the literature conducted by Bogg and Roberts (2004) that found conscientiousness to robustly be inversely related to exercise, alcohol, tobacco and drug use, poor diet, unsafe driving and sex, suicide, and violence. These various behaviors are strongly linked to mortality risk, and as such, it is reasonable to conclude that a behavioral mechanism can describe at least some of the relationship between conscientiousness and health.

However, although its influence on health-related behaviors is clearly an important mechanism underlying the association between conscientiousness and morbidity and mortality, it is not the only pathway. Indeed, using data from the Lewis Terman Life-Cycle Study Archives, a large longitudinal study conducted over seven decades, Friedman et al. (1995) and Martin, Friedman, and Schwartz (2007) demonstrated that participants in the highest tier of childhood conscientiousness had up to an 81% reduction in mortality risk compared to participants in the lowest tier and that this persisted even after controlling for many of the health behaviors previously discussed. Similar evidence suggesting that additional mechanisms may underlie the relationship between conscientiousness and health comes from a study by Hampson, Goldberg, Vogt, and Dubanoski (2007). Using structural equation modeling, the authors found that in addition to childhood conscientiousness indirectly affecting adult health status through various health behaviors, there was also a

direct and independent link between childhood conscientiousness and adult health. Finally, Chapman et al. (2011) documented an association between conscientiousness and levels of inflammatory molecules linked to increased risk of morbidity and mortality circulating in peripheral blood that persisted even after controlling for health behaviors, further supporting the concept that other mechanisms exist between conscientiousness and health.

Conscientiousness and Stress

One such mechanism through which conscientiousness may further shape health is through its influence on stress. Although stress can be conceptualized in many different ways, one common definition is that stress is a process that entails a stimulus, an appraisal of the stimulus, and a response (Cohen, Kessler, & Gordon, 1995). This view draws on a classic model holding that when stimuli, commonly referred to as stressors, are appraised as threatening and unmanageable, they elicit a psychological state that is experienced as stress, as well as a cascade of behavioral and biological adjustments (Lazarus & Folkman, 1984). Thus, going forward in this paper, “stress” is used as an umbrella term meant to capture situations when people were exposed to a stimulus judged to be an unmanageable threat.

From a stress perspective, conscientiousness may be associated with health by either exposing individuals to different levels of stress or by determining whether stress levels affect outcomes (Bolger & Zucherman, 1995). Although Bolger and Zucherman articulated this specific framework for studying the effects of personality on stress, such an idea was originally postulated by Friedman et al. (1993) as an attempt to explain why a link between conscientiousness and mortality persisted after controlling for numerous health behaviors. Because they tend to engage in careful planning, conscientious individuals may prevent stressful situations from occurring and thus avoid the potential ramifications these situations

pose for health. This is important because stress, particularly when chronic, is associated with the development and progression of a variety of illnesses that are associated with decreased quality of life and early mortality, such as cardiovascular disease, some forms of cancer, HIV/AIDS, and depression (Cohen, Janicki-Deverts, & Miller, 2007; Reiche, Nunes, & Morimoto, 2004; Rozanski, Blumenthal, & Kaplan, 1999).

Although the hypothesis that conscientiousness is associated with stress exposure has received little empirical attention to date, preliminary support comes from a recent study that found that individuals higher on one facet of conscientiousness, self-discipline, prospectively experienced fewer daily hassles than their low-conscientiousness counterparts (O'Connor, Conner, Jones, McMillan, & Ferguson, 2009). However, this study only followed participants for four weeks, which may not have provided enough time to accurately estimate general stress exposure tendencies. Additionally, this research relied on a self-report questionnaire of stress. Such techniques for assessing stress have been shown to have serious problems with reliability (Monroe, 2008). Furthermore, they do not allow stress to be distinguished along conceptually important dimensions like chronicity or dependency. As outlined below, these distinctions may be important when considering how conscientiousness influences a person's exposure to stress.

In addition to experiencing less stress in their lives, conscientious individuals may also differ in their reactivity to stress, or the psychophysiological changes that they experience as a result of a stress. Again, because they tend to employ careful planning, conscientious individuals may find especially effective ways to overcome stress that arises in their lives by developing a clear and practical plan for overcoming the problem and persisting in this plan when other people might give up (Watson & Hubbard, 1996). By doing so,

conscientious individuals may be able to successfully terminate a stressful situation before it spirals into a more persistent and serious problem. As such, these actions could attenuate the physiological consequences of stress and, in doing so, protect the individual against later health problems (for reviews, see McEwen, 2008; Miller, Chen, & Cole, 2009).

However, a conscientious individual's reactivity to stress may be dependent on the context of the stressor. When a person is in full control over a situation being highly conscientiousness might result in decreased reactivity to the stress as the individual would be able to develop a plan for handling the situation and would be in control over his or her ability to follow this plan. For example, when preparing for an exam in school, an individual who is highly conscientious would be more likely to develop a clear set of study goals and to set aside time and resources to meet these goals and thus avoid the stress of being ill prepared for the exam. By contrast, when a person is not in full control of the resolution of a stressful situation, behaviors associated with conscientiousness may interfere with flexible problem solving (Hogan & Ones, 1997). In such situations, highly conscientious individuals may actually experience increased reactivity. Consider a situation where a conscientious individual gets into a fight with a romantic partner. The individual can develop his or her own plan and list of goals for resolving the situation. However, if the partner is uninterested or unwilling to follow this plan, the conscientious individual may not be able to effectively eliminate the stress, as it would be outside of his or her control. In support of this argument, Sieber et al. (1992) demonstrated that a need for control was inversely associated with natural killer cell activity in individuals exposed to acute uncontrollable stress. Similarly, Segerstrom, Castañeda, and Spencer (2003) found that individuals who were higher in

optimism had impaired delayed type hypersensitivity skin responses after being exposed to acute uncontrollable stress, and that this effect was explained by conscientiousness.

Stress, Immune Function, and Disease

Although research attempting to elucidate how exactly stress exerts its influence on disease outcomes is ongoing, one of the biological mechanisms thought to play an important role is dysregulation of the immune system resulting in systemic inflammation (Cohen et al., 2007). Detailed descriptions of these processes are beyond the scope of this paper, and thus only an overview necessary for understanding the topics discussed in this project will be provided. For more information, the reader is encouraged to consult with any number of reviews on the topic (Elenkov, Iezzoni, Daly, Harris, & Chrousos, 2005; Gabay & Kushner, 1999; O'Leary, 1990; Sternberg, Chrousos, Wilder, & Gold, 1992).

The immune system primarily functions as a protector of the body. Immune cells are formed in bone marrow and are housed in a variety of organs including the thymus, peripheral lymphoid organs, the spleen, and lymph nodes. They are released as needed into peripheral blood and can be found throughout the body serving various functions involved with finding, identifying, and destroying foreign materials, referred to as antigens, such as bacteria, viruses, parasites, and fungi. Of particular importance to immune system function is a class of cells called leukocytes, which are also commonly referred to as white blood cells. There are three primary classes of leukocytes. These consist of lymphocytes, granulocytes, and macrophages and monocytes. Lymphocytes make up the adaptive immune system and consist of four primary types: B cells, T-helper cells, T-cytotoxic cells, and natural killer cells. Granulocytes are named such as they are cells filled with granules containing destructive enzymes. They are involved with phagocytosis, a process with the purpose of

eliminating foreign materials. Monocytes and macrophages bridge the innate and the adaptive immune systems and are also involved with the destruction of foreign materials. Monocytes are immature macrophages that are found in peripheral blood. When they enter tissue they go through a differentiation process and become macrophages. Immune processes involving monocytes are far more commonly studied in humans as samples can be readily obtained from peripheral blood via a simple venipuncture, whereas macrophage samples require actual tissue extraction.

In healthy humans, when the body becomes injured or infected, leukocytes aggregate at the scene and initiate an immune response leading to the release of proteins that stimulate the acute-phase response and help clear pathogens and heal wounded tissues. These proteins are called cytokines and serve both pro- and anti-inflammatory roles. One particularly important cytokine is interleukin-6 (IL-6), which plays a central role in orchestrating acute-phase protein changes. This response is critical for survival and generally adaptive. However, it must be regulated and terminated when the threat has dissipated. Otherwise, a persistent inflammatory response can take hold and contribute to pathogenic processes that ultimately result in chronic illnesses of aging, including heart disease, some cancers, and some neurodegenerative conditions (Ershler & Keller, 2000; Kaplanski, Marin, Montero-Julian, Mantovani, & Farnarier, 2003; Pai et al., 2004).

Conscientiousness and Inflammation

As stress is associated with the dysregulation of inflammatory processes that ultimately result in systemic inflammation, the effects of conscientiousness on health may involve changing the nature of the inflammatory response to stress. Indeed, recent work has provided some initial support for this theory. In a cross-sectional study, Sutin et al. (2010)

found that individuals in the lowest tier of conscientiousness had a significantly increased risk of developing clinically high levels of IL-6. However, as the authors did not evaluate stress, it remains unclear whether differential exposure or reactivity was a mechanism underlying this association. Furthermore, as the study was cross-sectional, it is unclear whether conscientiousness predicted differences in IL-6, or if the opposite may have been true. Longitudinal findings on conscientiousness and IL-6 further support the association between conscientiousness and IL-6 in that individuals higher in conscientiousness had lower serum levels of the cytokine across the 34 week study (Chapman et al., 2011). However, IL-6 was stable in individuals across the study, so it is unclear as to the direction of the effect.

The Present Research

To examine this gap in the literature the current project analyzed five waves of data from a sample of adolescent girls over two and a half years. To the author's knowledge, this is the first study to prospectively examine the effect of conscientiousness on both stress exposure and biological reactivity. In addition, it addresses methodological problems of measuring stress using self-report checklists (Dohrenwend, 2006) by utilizing a semi-structured interview to assess stress exposure, which is heralded as a "gold standard" for stress assessment (Monroe, 2008). This interview evaluates stressful events in a variety of life domains and allows contextual judgments about their severity, whether they are acute or chronic in duration, and how much of a role the participant had in causing them to occur.

The primary hypothesis concerning stress exposure in this project was that participants higher in conscientiousness at the beginning of the study would experience less acute and chronic stress over follow-up. An additional prediction was that when stress did occur, it would be less severe among participants high in conscientiousness. Finally, as it

would not make sense for people's personalities to be associated with stressful events that they could not have played a role in causing (e.g., an earthquake), only those events that were dependent on the actions of the participant were predicted to be associated with conscientiousness.

To examine how conscientiousness might influence reactivity to stress, blood was also collected from participants every six months to evaluate key features of the inflammatory response. To provide a measure of ongoing inflammation the amount of IL-6 present in serum harvested from circulation was enumerated. Additionally, the magnitude of participants' inflammatory response to a microbial challenge was measured by exposing their leukocytes to a bacterial product in vitro and quantifying the amount of IL-6 produced. Finally, how well participants' immune cells were able to regulate the inflammatory process was assessed by treating their bacterially stimulated leukocytes with the anti-inflammatory hormone cortisol. This served as a test of how sensitive cells were to signals that normally inhibit the inflammatory response. Conscientiousness was hypothesized to serve in a protective manner, attenuating any pro-inflammatory response brought about by the occurrence of life stress when such stress was theoretically controllable in nature. However, for interpersonal life stress that is in theory less controllable, the hypothesis was that being higher in conscientiousness would be associated with increased reactivity.

Methods

Participants

Data for this project were collected as part of a larger longitudinal study on depression and atherosclerosis among adolescent women at high risk for developing depression. Participants were recruited from the Vancouver, British Columbia community through advertisements in schools, newspapers, and magazines. Young women were eligible for the study if they were (a) between 15 and 19 years old, (b) fluent in the English language, (c) free of acute and chronic medical conditions, (d) without a lifetime history of psychiatric disorders, and (e) at high risk for developing a first episode of major depression. To qualify as high risk an individual had to either have a first-degree relative with a history of major depression, or had to score in the top quartile of the sample distribution if either the Dysfunctional Attitudes Scale (Weissman & Beck, 1978, March) or the Adolescent Cognitive Style Questionnaire (Hankin & Abramson, 2002).

A total of 157 participants were enrolled in the study between October 2004 and July 2007. One hundred and forty-seven of these participants were at high risk for developing depression, and the remaining 10 were included as a low-risk comparison group. To be eligible for this comparison group, young women had to be (a) between 15 and 19 years old, (b) fluent in the English language, (c) free of acute and chronic medical conditions, (d) without a lifetime history of psychiatric disorders, and (e), not have a family history of major depression, and score at or below the 25th percentile of the DAS and the ACSQ. The current article focuses on 133 of these women who completed a baseline personality assessment and at least three of five possible follow-up visits where episodic stress was measured. This cut-off was chosen because major episodic stress was a relatively rare occurrence within a six-

month window. Thus, to more accurately estimate stress occurrence, participants needed to be observed for at least 18 months following baseline. Of the original sample of 157 adolescent women, 22 (14%) participants withdrew before completing at least three follow-up visits. Eight dropouts gave no reason for their decision. The others cited schedule conflicts ($n = 1$), having moved away from the area ($n = 5$), or having lost interest in the project ($n = 8$). Two others did not complete a baseline assessment of personality and were excluded from this analysis. Baseline differences between the participants who did and did not meet inclusion criteria for this report are detailed below. Participants were paid 50 CAD for each visit they attended and received an additional 20 CAD for completing post-visit home monitoring not related to the current project. They also received an additional 50 CAD if they completed the first three visits of the study, and another 50 CAD for completing the entire study. Thus, participants could receive up to 520 CAD for participating in the study. The Research Ethics Board of the University of British Columbia approved this project. Written consent was obtained from all participants and for participants under the age of 18, a parent or guardian also provided consent.

Procedures

At baseline, the Structured Clinical Interview for the DSM-IV (First, Spitzer, Gibbon, & Williams, 2002) was given to screen for psychiatric disorders. Candidates without a history of Axis I disorders were then enrolled in the project. During the rest of the visit they completed questionnaires and interviews, and had a blood sample drawn via antecubital venipuncture to assess inflammatory processes. Blood draws were conducted between 8am and 11am to control for diurnal variations in biological assessments. Subsequent visits occurred every six months over two and a half years and followed a similar protocol.

Conscientiousness

Conscientiousness was assessed at the baseline visit using the conscientiousness subscale from the Big Five Inventory (John, Donahue, & Kentle, 1991), a widely used and extensively validated self-report measure of personality (John et al., 2008). The conscientiousness subscale consists of nine statements (e.g., “I am someone who does a thorough job”) and participants are asked to indicate the extent to which they agree with each statement on a scale ranging from 1 (*disagree strongly*) to 5 (*agree strongly*). Internal consistency of the scale was high in the current sample (Cronbach’s $\alpha = .80$).

Life Stress

To examine how conscientiousness shapes stress processes, exposure to stressors was assessed and quantified based on the potential these events had for being unmanageably challenging. Exposure to such stressful life experiences was measured using an adolescent version of the Life Stress Interview (LSI) developed from previous versions of the interview for adults and children (e.g., Hammen, 1991). The LSI is a semi-structured interview made up of open-ended questions used to probe the occurrence of episodic and chronic forms of stress over the past six months. Episodic stress was defined as an event having a distinct beginning and ending. An example of episodic stress would be having had a fight with a friend that did not result in any long-term impact on the friendship. When a probe revealed that episodic stress had occurred, the interviewer followed up with questions exploring the context and fallout surrounding the event. The interviewer later presented each event to the project’s research team, taking care to not disclose the participant’s emotional response to the event. The team then rated by consensus the long-term contextual threat each event posed. Operationally, this meant considering the impact the stressful event would have on a

“typical” person within the same situational and biographical context. Ratings were made on a scale from 1 (*no negative impact*) to 5 (*severe impact*). For example, a small argument with a friend was rated as 1.5 as such arguments are common and not expected to pose a lasting threat for the “typical” person. However, having one’s parents divorce was rated as a 4 as parental separation typically poses a lasting threat to most adolescent individuals.

Additionally, the team assigned a dependence rating to each event, reflecting the extent to which the occurrence of the event depended on the actions of the participant. For example, an earthquake is a stressful situation that would not be dependent on an individual’s behavior. Conversely, picking a fight with a friend would be dependent on the individual’s actions. Dependence ratings ranged along a continuum from 1 (*almost certainly independent*) to 5 (*almost certainly dependent*).

The LSI episodic data were used to create three variables for analysis. The first reflected the total number of stressful episodic events experienced over the follow-up period. Only stressful events with impact ratings of 1.5 or higher were counted. Events with ratings of 1, *no negative impact*, were not counted towards the total as such events occur commonly and are not expected to elicit stress from the “typical” person. The other variables reflected the number of dependent and independent stressful events experienced over follow-up, using the midpoint of the rating scale as a breakpoint for differentiating them. Because some of the participants missed follow-up sessions, all of the stress variables were corrected for the number of visits attended. Hence, these variables reflect the average number of stressful episodic events a participant experienced in a typical six-month window of the study. Additionally, to determine whether conscientiousness might relate to the severity of stress, severity variables were created that reflected the highest impact score a participant received

during the study. This was done separately for dependent and independent events, as well as for all events, regardless of dependence status.

Besides probing for the occurrence of stressful episodic events, interviewers gathered information about chronic, ongoing difficulties in participants' lives. They focused on nine specific domains: Romantic relationships, close friendships, broader social life, family, school, work, finances, and personal and family health. In each domain the interviewer made a rating between 1 and 5, with higher numbers indicating more severe and persistent difficulties. The present project focuses on two domains of life that would theoretically be most directly affected by conscientiousness. The first domain tapped interpersonal chronic stress. To assess this variable, a composite score was generated by averaging ratings across the romantic relationships, closest friend, family, and broader social life domains to form a single variable. This composite was validated in an earlier cross-sectional analysis of these data, in which it showed robust associations with inflammatory outcomes (Marin, Martin, Blackwell, Stetler, & Miller, 2007). The second domain pertained to academic stress. Financial stress was not examined as most of the participants were reliant on their parents, and it seemed unlikely that a teenager's degree of conscientiousness would strongly impact her family's economic stability. Finally, stress related to the workplace and health were not considered as there was too little variance in these outcomes to merit analysis. To evaluate the team's interrater reliability, audiotapes of interviews were periodically rated by all members. On 91% of occasions all members gave chronic stress ratings within half a point of each other. The average *ICC* for ratings in the domains used in the current project was .74. Regarding individual domains, the *ICCs* for the family, close friendships, romantic relationships, broader social life, and school domains were .65, .82, .78, .80, and .62

respectively. Taken together, these statistics indicate adequate to excellent team interrater reliability.

Inflammatory Measures

Peripheral blood was collected at each visit and used to model three features of the inflammatory response. First, the extent of systemic inflammation was assessed via levels of IL-6 in serum. For this, blood was drawn into serum-separating tubes and centrifuged at 1200 RCF for 10 minutes. The serum was then aspirated and frozen at -30°C until analysis. Interleukin-6 levels were measured in duplicate using commercially available high-sensitivity enzyme-linked immunosorbent assay (ELISA) kits (HS600B; R&D Systems, Minneapolis, MN), which have a minimum detection threshold of 0.039 pg/ml and inter- and intra-assay variability of less than 10%.

The second biological feature measured indicated how well the participants' white blood cells responded to a lipopolysaccharide (LPS) challenge. LPS triggers monocytes to secrete IL-6 (in addition to other proteins) in an effort to eliminate microbes. Thus, this assay indicates how aggressively these leukocytes make IL-6 following LPS exposure. For this assay, whole blood was drawn into lithium-heparin Vacutainers (Becton-Dickinson, Oakville, Ontario, Canada), diluted 10:1 with saline, and incubated with LPS (50 ng/ml; Sigma, St. Louis, MO) for six hours at 37°C in 5% carbon dioxide. The supernatants were collected and frozen at -80°C until analysis. Interleukin-6 was measured in duplicate with DuoSet ELISA Development kits (R&D Systems, Minneapolis, MN), which have a detection threshold of 0.7 pg/ml and inter- and intra-assay variability of less than 5%.

The final biological measurement pertained to monocyte sensitivity to signals that regulate inflammation. To do this, IL-6 production was quantified in cells that had been

incubated with LPS and cortisol. Cortisol conveys anti-inflammatory messages to immune cells, and this assay measured their ability to respond to these signals by dampening IL-6 production. Blood was diluted in a 10:1 ratio with saline and dispensed into culture plates (Sigma Chemicals, St. Louis, MO) with LPS (50 ng/ml). Doses of hydrocortisone were added to four of the wells in four different concentrations (2.76×10^{-5} M, 2.76×10^{-6} M, 2.76×10^{-7} M, 2.76×10^{-8} M). The fifth well contained only the blood and LPS. After six hours of incubation at 37° C in 5% carbon dioxide, the supernatants were collected and frozen until analysis. Interleukin-6 levels were measured in duplicate using DuoSet ELISA Development Systems kits (R&D Systems). Dose-response curves were then generated for each participant's data. From these dose-response curves, the concentration of hydrocortisone needed to diminish IL-6 production by 50% was calculated. This is called the inhibitory coefficient-50 (IC50). Inhibitory coefficient-50s are inversely proportional to glucocorticoid sensitivity, meaning that higher values indicate that immune cells are less sensitive to cortisol's anti-inflammatory signals. To correct for extreme skewness, these data were log-transformed prior to analysis.

Confounders

Personality tendencies vary across demographic categories (Donnellan & Lucas, 2008; Goldberg, Sweeney, Merenda, & Hughes, 1998; Hart, Atkins, & Matsuba, 2008), as does exposure to stress (Hatch & Dohrenwend, 2007). To evaluate the possibility that demographic characteristics might be contributing to any observed relationships, baseline age, ethnicity, and socioeconomic status were statistically controlled for. The majority of the participants (91%) identified as being of either Caucasian or Asian descent, so ethnicity was dichotomously coded as 0 for Caucasian and 1 for other. Socioeconomic status (SES) was

measured as years of parental education, with the highest score of either parent included as a covariate. Additionally, because the sample was at high risk for developing mood problems, which themselves can trigger stress (Hammen, 1991), the severity of each woman's depressive symptoms at baseline was statistically controlled for. (It should be noted that analyses were run both with and without controlling for depressive symptoms, and controlling for depressive symptoms did not change the pattern of results.) Depressive symptoms were measured using the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), which showed excellent internal consistency in the present sample (Cronbach's $\alpha = .87$). Finally, when examining the reactivity hypotheses, two other potential confounders known to affect inflammation were included. These variables reflected oral contraceptive use and average body mass index (BMI) during the study. Although cigarettes are known to be pro-inflammatory, only three of the participants in the current sample endorsed regular smoking at any point during the study so the effects of this variable were not considered. Likewise, although nonsteroidal anti-inflammatory drugs (NSAIDs) serve an anti-inflammatory function, only four participants reported regular use of such medications during the study so the effects of this variable were also not modeled.

Results

Demographics

Table 1 provides a reference of participant demographics as well as descriptive information for the LSI and personality measures. At study entry the participants were an average of 17.04 ($SD = 1.39$) years old. The sample was ethnically diverse and mirrored the larger population of Vancouver, with 64 (48%) of the participants identifying as being of Caucasian descent, 57 (43%) as being of East or South Asian descent, and 12 (9%) reporting some other ethnic identity. The participants were generally from families who were well educated and mid to high in SES. Their parents had spent an average of 15.92 ($SD = 3.37$) years in school and 60% of both the mothers and fathers had completed at least a college degree. The majority of the sample ($n = 103$; 77%) completed the baseline and all five follow-up visits. Twenty-five (19%) of the participants completed four follow-up visits, and seven (5%) participants completed only three follow-up visits.

Attrition

Differences between participants who dropped out of the study prematurely and those included in the current analyses were explored. Due to highly disproportionate group sizes (typically $n = 133$ versus $n = 24$), the more conservative Welch's t -test was used to explore differences. At baseline, the groups were similar in terms of frequency of episodic stressors, chronic stress in the academic domain, and the three inflammatory outcomes. They also were similar in terms of the variables age, ethnicity, SES, BMI, oral contraceptive use, and depressive symptoms (all $ps > .05$). However, those who dropped out were slightly less conscientious ($M = 3.15$, $SD = 0.68$) than those who stayed ($M = 3.51$, $SD = 0.66$), $t(28.01) = -2.31$, $p = .03$. They also had slightly higher levels of interpersonal chronic stress ($M = 2.59$,

$SD = .41$) than those who stayed ($M = 2.35, SD = .47$), $t(34.36) = 2.50, p = .02$. Additionally, their most severe episodic stressor at study entry ($M = 1.46, SD = 0.76$) was slightly less intense than for those who stayed ($M = 1.91, SD = .83$), $t(33.60) = -2.62, p = .01$. These results suggest that the final sample used for analyses described below was more conscientious and lower in stress than the population they were taken from. This restriction of range may lead to an underestimation of the true effects of conscientiousness on stress exposure and reactivity in the population.

Stress Exposure

To test the stress exposure hypotheses whether conscientiousness was related to the number or severity of stressful episodic events that participants experienced was first examined. To establish the temporal precedence of personality, these analyses were run in a completely prospective fashion. To do this, conscientiousness scores at the baseline visit were correlated with episodic stress data collected during the subsequent two-year follow-up period. Because these relationships could be confounded by differences in age, ethnicity, SES, and depression, partial correlations were used to control for the contribution of these variables (see Table 2). Conscientiousness was not related to the frequency of dependent events ($r = -.09, p = .30$) or independent events ($r = -.03, p = .75$), nor was it related to the frequency of events regardless of dependency ($r = -.08, p = .38$). It was also not related to the severity of independent events ($r = .08, p = .38$), nor was it related to the severity of events disregarding dependency status ($r = -.03, p = .75$). It was, however, related to the severity of dependent events. Participants who were higher in conscientiousness experienced less severe events that they had played a role in causing, $r(126) = -.22, p = .01$.

Hierarchical linear modeling (HLM) software (Raudenbush, Bryk, & Congdon, 2004) was then used to examine whether baseline conscientiousness was related to trajectories of chronic stress. For these analyses the interpersonal and academic domains of chronic stress were evaluated in separate equations using random effects and inferences based on robust standard errors were considered due to non-normality in the distributions of the variables. In the within-person (level 1) models, chronic stress was estimated as a function of months since the first follow-up:

$$\text{Stress} = \pi_0 + \pi_1 \text{Time} + e$$

This provided an intercept (π_0) that can be interpreted as the expected value for the chronic stress variable at the first follow-up visit, a slope (π_1) that can be interpreted as the trajectory of chronic stress over follow-up, and an error term (e). In the between-person (level 2) models these intercepts and slopes were estimated as a function of conscientiousness as well as the covariates age, ethnic identity, SES, and depressive symptoms, and a random error term. The variables indicating conscientiousness, age, socioeconomic status, and depressive symptoms were all grand mean centered. The variable indicating ethnic identity was uncentered as it is a binary variable.

$$\pi_0 = \beta_{00} + \beta_{01}\text{Age} + \beta_{02}\text{Ethnic} + \beta_{03}\text{SES} + \beta_{04}\text{BDI} + \beta_{05}\text{Conscientiousness} + r_0$$

$$\pi_1 = \beta_{10} + \beta_{11}\text{Age} + \beta_{12}\text{Ethnic} + \beta_{13}\text{SES} + \beta_{14}\text{BDI} + \beta_{15}\text{Conscientiousness} + r_1$$

To the extent that participants scored higher in conscientiousness at baseline, they tended to have less academic (upper panel of Figure 1; $\beta = -.19$, $SE = .07$, $p < .01$) and interpersonal (lower panel of Figure 1; $\beta = -.10$, $SE = .05$, $p = .04$) chronic stress six months later at the initial follow-up visit. These disparities in chronic stress persisted across the remainder of the follow-up period. In other words, individual differences in conscientiousness were not

associated with within person changes in chronic academic ($\beta < .00$, $SE < .00$, $p = .30$) or interpersonal ($\beta < .00$, $SE < .00$, $p = .88$) stress over time.

Stress Reactivity

HLM was also used to assess whether conscientiousness moderated relationships between both episodic and chronic stress and the three inflammatory measures. Separate equations were developed to evaluate each of the different immune measures (serum IL-6, IL-6 production by monocytes following a microbial challenge, and sensitivity of monocytes to glucocorticoids) paired with each of the different life stress variables (whether an episodic event had occurred within the previous six months, the most severe episodic event that had occurred within the previous six months, chronic academic stress, and chronic interpersonal stress) using random effects. Once again, only results based on robust standard errors were examined. In the within-person (level 1) models, the inflammatory process was estimated as a function of months since the first follow-up and the relevant person-centered stress index.

$$\text{Inflammatory Process} = \pi_0 + \pi_1 \text{Time} + \pi_2 \text{Stress} + e$$

This provided an intercept (π_0) that can be interpreted as the expected value for the inflammatory measure at the first follow-up visit, assuming the participant was at her average stress level, and a time slope (π_1) that can be interpreted as the trajectory of inflammation over two years, holding stress constant. Additionally, it provided a slope for the stress index (π_2) that can be interpreted as the trajectory of inflammation as the participant deviated from her average stress level, holding time constant and an error term (e). In the between-person (level 2) models, these intercepts and slopes were estimated as a function of conscientiousness and a random error term. Whether age, ethnicity, oral contraceptives use, and the participant's average BMI over the study might have confounded our analyses was also evaluated. For these analyses, the variables reflecting conscientiousness, age, and body

mass were grand mean centered. The variables indicating ethnic identity and oral contraceptive use were binary and thus were uncentered.

$$\pi_0 = \beta_{00} + \beta_{01}\text{Age} + \beta_{02}\text{Ethnic} + \beta_{03}\text{Contraceptive} + \beta_{04}\text{BMI} + \beta_{05}\text{Conscientiousness} + r_0$$

$$\pi_1 = \beta_{10} + \beta_{11}\text{Age} + \beta_{12}\text{Ethnic} + \beta_{13}\text{Contraceptive} + \beta_{14}\text{BMI} + \beta_{15}\text{Conscientiousness} + r_1$$

$$\pi_2 = \beta_{20} + \beta_{21}\text{Age} + \beta_{22}\text{Ethnic} + \beta_{23}\text{Contraceptive} + \beta_{24}\text{BMI} + \beta_{25}\text{Conscientiousness} + r_2$$

The key coefficient for the stress reactivity hypothesis was the cross-level interaction between conscientiousness and life stress (β_{25}). A significant cross-level interaction for these variables indicates that conscientiousness moderated the impact of stress on the inflammatory outcome being considered. In other words, it answers the question: At a visit when an individual who was higher versus lower in conscientiousness was above or below her typical level of stress, was there a change in the inflammatory outcomes?

Results indicated that conscientiousness did not act as a moderator of the associations between stressful episodic events and inflammatory outcomes (see Tables 4 and 5).

Specifically, conscientiousness did not interact with the variable reflecting whether any severe stressful episodic event had occurred in the past six months. This was true for all three inflammatory outcomes considered: Serum levels of IL-6 ($\beta = .10$, $SE = .17$, $p = .54$), monocyte production of IL-6 when challenged with LPS ($\beta = -950.42$, $SE = 1940.40$, $p = .63$), or glucocorticoid sensitivity ($\beta = .06$, $SE = .04$, $p = .13$). Likewise, conscientiousness did not interact with the variable reflecting the most severe episodic event that had occurred at each visit. This was true for serum levels of IL-6 ($\beta = .17$, $SE = .12$, $p = .14$), monocyte production of IL-6 when challenged with LPS ($\beta = 623.40$, $SE = 1152.67$, $p = .59$), and glucocorticoid sensitivity ($\beta = .01$, $SE = .05$, $p = .88$). Similarly, conscientiousness did not moderate the association of chronic stress with serum levels of IL-6 or IL-6 production following LPS challenge (Tables 6 and 7). Specifically, conscientiousness did not shape

associations between chronic academic stress and serum levels of IL-6 ($\beta = -.03$, $SE = .08$, $p = .72$), monocyte production of IL-6 when challenged with LPS ($\beta = 1962.89$, $SE = 1192.08$, $p = .10$), or glucocorticoid sensitivity ($\beta = .02$, $SE = .02$, $p = .46$). It also did not interact with interpersonal chronic stress to affect serum levels of IL-6 ($\beta = .04$, $SE = .31$, $p = .91$), or monocyte production of IL-6 when challenged with LPS ($\beta = -848.51$, $SE = 1896.83$, $p = .66$).

However, in models of glucocorticoid sensitivity, conscientiousness was significantly associated with the slope for chronic interpersonal stress ($\beta = .09$, $SE = .04$, $p = .02$). Simple slopes for this interaction were tested using techniques described by Preacher, Curran, and Bauer (2006). As Figure 2 shows, interpersonal stress was not related to glucocorticoid sensitivity among participants who were at or one standard deviation below the mean of the sample distribution of conscientiousness (both $ps > .50$). But among participants who were one standard deviation above the mean of conscientiousness, increasing levels of interpersonal stress were associated with more resistance to glucocorticoid inhibition ($\beta = .12$, $SE = .06$, $p = .04$). This pattern indicates that at visits when these participants had lower than their mean levels of stress, their cells were more sensitive to glucocorticoid inhibition than anyone else in the sample. This changed dramatically at visits when they had higher than typical chronic interpersonal stress. At these times they were less glucocorticoid sensitive than others in the sample.

Conclusion

Conscientiousness and Stress Exposure

This paper provides some preliminary support for the hypothesis that conscientiousness is related to stress exposure. Conscientiousness was unrelated to the number of dependent stressful episodic events that participants experienced. However, when events did occur, they tended to be less severe for the more conscientious participants. Furthermore, conscientiousness was associated with less chronic interpersonal and academic stress throughout the study. These findings make sense conceptually. Conscientiousness is characterized by being able to control impulses through careful thought and planning, and by setting goals and prioritizing actions (John et al., 2008). Thinking before acting may allow individuals to anticipate the results of their actions, and thus help them avoid situations that are likely to cause more stress. Of course, this argument suggests that conscientious individuals in the present sample should have experienced fewer dependent stressful episodic events over the study, and they did not. As such, what this pattern may suggest is that conscientious behavior does not prevent stressful events from occurring in the first place, but instead decreases the chances they will cascade into more severe and enduring difficulties.

Alternatively, the null findings presented above for total dependent stressful episodic events may reflect the relatively low frequency of such events in the current sample. Indeed, the current findings are somewhat contrary to evidence coming out of other laboratories. Specifically, O'Connor et al. (2009) reported that conscientious individuals experienced fewer general daily hassles over the course of a four week study. Along similar lines, Vollrath (2000) found that more conscientious college students encountered prospectively fewer daily school related hassles. In both of these studies, less severe day-to-day sorts of

stressful events were the outcome variables of interest. These targets differ from the present study which only focused on episodic events recalled during a six month window that were more severe in nature. As such, it is possible that the sort of careful planning typical of conscientious individuals allows them to organize their lives in such a way as to reduce the likelihood of encountering more predictable and mundane forms of stress, which may be what previous research has tapped into. Combining these two lines of evidence, conscientious individuals may both experience less daily forms of stress, and when larger stressful events occur, they may act in ways to reduce the severity of the event. However, in order to better elucidate this theory, future studies will need to examine both daily hassles as they occur as well as more severe and persistent forms of episodic stress.

Conscientiousness and Stress Reactivity

The current study also found some support for the notion that conscientiousness influences the degree of inflammatory reactivity to stress. Conscientiousness did not emerge as a moderator in analyses relating life stress to levels of IL-6 in serum or white blood cell responses to a bacterial challenge. However, there was evidence that it played a role in shaping how chronic interpersonal stress affected the glucocorticoid sensitivity of participants' leukocytes. To the extent that they were highly conscientious, participants became more resistant to glucocorticoid inhibition of pro-inflammatory cytokine production by monocytes when their level of interpersonal chronic stress rose beyond their "normal" levels. This finding supports the hypothesis that highly conscientious individuals may not respond well to more severe stress that is at least partially outside of their control when it occurs. This pattern is also conceptually consistent with a recent longitudinal study which found that highly conscientious individuals who became unemployed during the course of

follow-up experienced a much larger decrease in life satisfaction compared to their less conscientious counterparts (Boyce, Wood, & Brown, 2010). The authors concluded that higher conscientiousness could be harmful when a person is faced with failure. Interpersonal stress can be viewed to some degree as a form of failure, in that it arises when something within a relationship breaks down.

As previously discussed, when faced with stress, conscientious individuals tend to use active, problem-focused coping methods (Connor-Smith & Flachsbart, 2007; Watson & Hubbard, 1996). This form of coping is characterized by developing a goal to deal with the problem, allocating resources toward achieving that goal, and persisting until the goal is met and the problem has been solved. However, interpersonal relationships are defined by interacting with other people. Therefore, resolving a stressful interpersonal situation often requires action from another person. Thus, compared to other forms of more individually focused stress (e.g., academic problems), difficulties within one's social life may not always be solvable through active coping, making the strategies that the conscientious individual uses for dealing with the stress ineffective. When faced with the inability to overcome such problems, maintaining persistence has been shown to be associated with high distress and elevated levels of systemic inflammation (Miller & Wrosch, 2007; Wrosch, Miller, Scheier, & de Pontet, 2007). Taken together, these findings suggest there may be certain types of stressful situations where being highly conscientiousness is not beneficial for health and wellbeing.

Selectivity of Immune Findings

Why did conscientiousness moderate the relationship between chronic interpersonal stress and glucocorticoid sensitivity but not circulating IL-6 or IL-6 production? One

potential explanation is that changes in glucocorticoid sensitivity are an early marker of immunologic dysregulation. In young healthy women like those in the current sample, the effects of stress may first become evident in disrupted crosstalk between regulatory systems. Highly conscientious individuals in the current sample did not experience very high levels of interpersonal stress throughout the study. Indeed, individuals in the highest tier of conscientiousness only had an average interpersonal stress score of approximately 2.35 on a scale of 1 to 5 at their first follow-up visit, and this value actually declined (although not significantly) over the course of follow-up. Given that scores under 2.5 were considered “non-severe,” this makes the glucocorticoid resistance effects that were observed that much more striking. Furthermore, available evidence suggests that as levels of chronic stress increase, resistance to glucocorticoids only becomes stronger (e.g., Miller, Cohen, & Ritchey, 2002). Therefore, times of unusually high chronic stress may be particularly biologically taxing, and as individuals age and the effects of stress accumulate, this sort of dysregulation may give rise to other outcomes, like systemic inflammation or impaired IL-6 responses to bacterial stimulation. Longer-term follow-up studies will be needed to evaluate this scenario.

Limitations

This study does have a number of limitations that need to be considered. First, the sample consisted of young women enrolled because they were at high risk for depression. Alternatively, it is possible that this was a more depression resistant group of “high risk” individuals given that they had reached adolescence and had not yet experienced a depressive episode in their life at the time of study entry. Either way, due to their risk, the participants may have been more prone to experiencing life stress and may have reacted more severely when it did occur, limiting the generalizability of the findings. As such, future studies will

need to substantiate these results in more representative community samples. Second, the study was observational in nature. Although the hypotheses were tested in a prospective fashion, and some obvious confounders were controlled for statistically, it is still not possible to make causal inferences about conscientiousness. Other factors, such as early-life adversity, could account for the associations that were observed. Third, the relatively low base rate of severe dependent stressful episodic events may have limited the power to detect associations with conscientiousness. Fourth, as the LSI captured stressful events that had occurred during the previous six months, there tended to be latency between when an episodic event actually occurred and when blood was drawn from a participant to assess the three immune processes of interest. As such, it may be possible that what is being tapped into in this study is not the actual biological reactivity to the episodic events, but rather may be some combination of reactivity and recovery, depending on the time period between the stressful event and the blood draw. The body contains numerous homeostatic mechanisms that work to restore balance after a challenge has passed. Thus, these latency periods may have further limited the ability to see effects of conscientiousness on outcomes concerning episodic stress. Fifth, facets of conscientiousness were not measured and thus it was not possible to directly test whether planning specifically was responsible for the observed associations. Although there is a clear theoretical foundation suggesting that planning is an important mechanism driving the findings, future research should explicitly examine this. Finally, levels of conscientiousness may vary somewhat during young adulthood (Costa & McCrae, 2002). Thus, future studies should examine whether tendencies to experience stress during formative years shape an individual's conscientiousness trajectory over adolescence and young adulthood.

Despite these limitations, this study had several notable strengths. It had a multiwave prospective design that assessed life stress and inflammatory processes every six months over two and a half years. It also used interview methodology to assess life stress contextually, and distinguish it along important dimensions like chronicity, dependency, and severity. As a result of these strengths, it was possible to generate some preliminary insights into the role that stress exposure and reactivity might play in shaping the health benefits of conscientiousness.

Future Directions

Although this work does demonstrate that dimensions of personality shape stress processes related to health, the findings concerning the impact of conscientiousness on stress exposure and reactivity are preliminary and require both replication and extension. Additional studies will need to examine contextually how daily hassles, more severe acute events, and chronic, ongoing difficulties impact biological outcomes. As the findings discussed in this report suggest that the effects of conscientiousness are dependent on the type of stress being experienced, future studies need to utilize interview methods for measuring stress. Although these methods require more effort to utilize, they allow for assessing critical dimensions of stress such as biographical context, dependency, and chronicity. Furthermore, future studies are needed to better understand how conscientiousness impacts stress reactivity over the lifespan. Although the biological effects observed in the current study were preliminary and modest, they were nonetheless made conspicuous in that they occurred in healthy teenage women. Thus, these results may presage larger effects later in life and future studies will need to explore how exactly these processes unfold in older populations.

Broader Implications

Conscientiousness has traditionally been thought of as a uniformly desirable disposition (see McCrae & John, 1992). However, the current interpretation that conscientiousness may not always be beneficial is consistent with Nettle's (2006) evolutionary based argument that being high on any personality trait is neither globally adaptive nor maladaptive. Rather, it is more likely to be associated with either costs or benefits depending on the situation. Nettle contended that something that is socially desirable is not necessarily guaranteed to improve chances of reproduction. With regards to conscientiousness, he argues that one of the hallmarks of the trait is delaying something directly desirable if it conflicts with longer-term plans. This can explain why, generally speaking, conscientious individuals show improved long term outcomes over their lower conscientious counterparts. However, when long term plans fail to work out, delayed gratifications can be translated as missed opportunities, which are not adaptive.

Further evidence in support of this theory comes from work carried out by Segerstrom et al. (2003) investigating the differential effects of optimism on immunity depending on the situation. Specifically, optimism was linked to poorer immune response during a mental stress task, and, importantly, this effect was completely explained by conscientiousness. Furthermore, in a review, Segerstrom (2005) argued that the situational context of the stressor is an important consideration in determining how optimism shapes biological outcomes. The types of coping skills employed by both optimistic and conscientious individuals are suited for dealing with some but not all forms of stress.

The current results highlight that the associations between conscientiousness, stress, and health are not clear-cut. Conscientiousness does seem to reduce people's exposure to

severe stressful episodic events and more chronic social and academic difficulties. However, when difficult interpersonal stress does arise, it may take a more powerful toll on those who are highly conscientiousness. Whether this extra toll dispels any health benefits of reduced stress exposure will be an important topic for later research. Although evidence does support that conscientiousness is generally associated with favorable health outcomes, there are numerous potential public health implications if there are indeed situations when being highly conscientiousness might be hazardous to health and wellbeing.

Tables and Figures

Table 1 Descriptive Statistics ($N = 133$)

Variable	Mean	SD
Baseline (V1 ^a) Measures		
Age (in years)	17.04	1.39
Years of parental education	15.92	3.37
Beck Depression Inventory scores (0-63)	7.01	5.99
Conscientiousness (1-5)	3.51	0.66
Inflammatory Covariates (V1 – V6)		
Body mass index	21.95	2.74
Participants who used oral contraceptives at least once during study	<i>n</i> = 65	
Life Stress Interview, Episodic Events (V2 – V6)		
Number of dependent events per six months	0.79	0.52
Number of independent events per six months	0.76	0.51
Number of events per six months	1.55	0.82
Highest severity dependent event (1-5)	2.31	0.65
Highest severity independent event (1-5)	2.56	0.87
Highest severity event (1-5)	2.72	0.83
Life Stress Interview, Chronic Stress (V2 – V6)		
Interpersonal stress (1-5)	2.42	0.47
Academic stress (1-5)	2.07	0.71
Inflammatory Measures (V2 – V6)		
Serum IL-6, pg/ml	0.89	1.39
IL-6 production, pg/ml	48,164.57	17,304.53
Cortisol resistance, log(IC50)	10 ^{-6.45}	10 ^{-0.31}

^aV = Visit

Table 2 Partial Correlations Between Baseline Conscientiousness and Episodic Stress

Measurements

		Average Dependent Events	Average Independent Events	Average Events	Most Severe Dependent Event	Most Severe Independent Event	Most Severe Event
C ^a	Partial <i>r</i>	-.09	-.03	-.08	-.22*	.08	-.03
	<i>p</i> -value	.30	.75	.38	.01	.38	.75

Note. Controlling for age and depressive symptoms at baseline, SES, and ethnicity.

^aC = Conscientiousness.

**p* < .05.

Table 3 HLM Results for Conscientiousness and Chronic Stress Exposure

		Intercept	Time Slope
Academic Stress	β	-0.187**	-0.003
	<i>SE</i>	0.068	0.003
	<i>p</i> -value	0.007	0.303
Interpersonal Stress	β	-0.098*	0.000
	<i>SE</i>	0.047	0.002
	<i>p</i> -value	0.041	0.880

Note. Controlling for age and depressive symptoms at baseline, SES, and ethnicity.

* $p < .05$. ** $p < .01$.

Table 4 HLM Results for Episodic Stress Reactivity

		Intercept	Time Slope	LSI Slope (Any Event)
Serum IL-6	β	0.057	-0.001	0.103
	<i>SE</i>	0.088	0.003	0.167
	<i>p</i> -value	0.516	0.746	0.536
Cortisol Resistance: log(IC50)	β	-0.007	0.000	0.060
	<i>SE</i>	0.021	0.001	0.039
	<i>p</i> -value	0.753	0.957	0.125
IL-6 Production	β	-361.607	-101.056	-950.416
	<i>SE</i>	1359.844	62.114	1940.400
	<i>p</i> -value	0.791	0.106	0.625

Note. For these analyses, episodic stress was coded as 0 = No Occurrence of 2.5+ Magnitude

Event and 1 = Occurrence of 2.5+ Magnitude Event

Table 5 HLM Results for Episodic Stress Reactivity Measured as Most Severe Event at Each Visit

		Intercept	Time Slope	LSI Slope (Most Severe Event)
Serum IL-6	β	0.101	-0.005	0.172
	SE	0.102	0.003	0.115
	p -value	0.322	0.173	0.138
Cortisol Resistance: log(IC50)	β	-0.009	0.001	0.007
	SE	0.019	0.002	0.048
	p -value	0.633	0.732	0.878
IL-6 Production	β	-318.354	-104.224	623.396
	SE	1350.014	60.594	1152.669
	p -value	0.814	0.087	0.589

Table 6 HLM Results for Chronic Academic Stress Reactivity

		Intercept	Time Slope	Academic Stress Slope
Serum IL-6	β	0.056	-0.002	-0.027
	SE	0.090	0.003	0.076
	p -value	0.532	0.651	0.721
Cortisol Resistance: log(IC50)	β	-0.011	0.000	0.017
	SE	0.019	0.001	0.023
	p -value	0.579	0.926	0.463
IL-6 Production	β	-787.124	-57.972	1962.886
	SE	1369.893	62.755	1192.078
	p -value	0.566	0.358	0.102

Table 7 HLM Results for Chronic Interpersonal Stress Reactivity

		Intercept	Time Slope	Interpersonal Stress Slope
Serum IL-6	β	0.051	-0.000	0.037
	SE	0.089	0.005	0.311
	p -value	0.566	0.929	0.905
Cortisol Resistance: log(IC50)	β	-0.012	0.001	0.090*
	SE	0.021	0.001	0.038
	p -value	0.563	0.665	0.019
IL-6 Production	β	-175.256	-116.890	-848.509
	SE	1363.125	64.384	1896.829
	p -value	0.898	0.071	0.655

* $p < .05$.

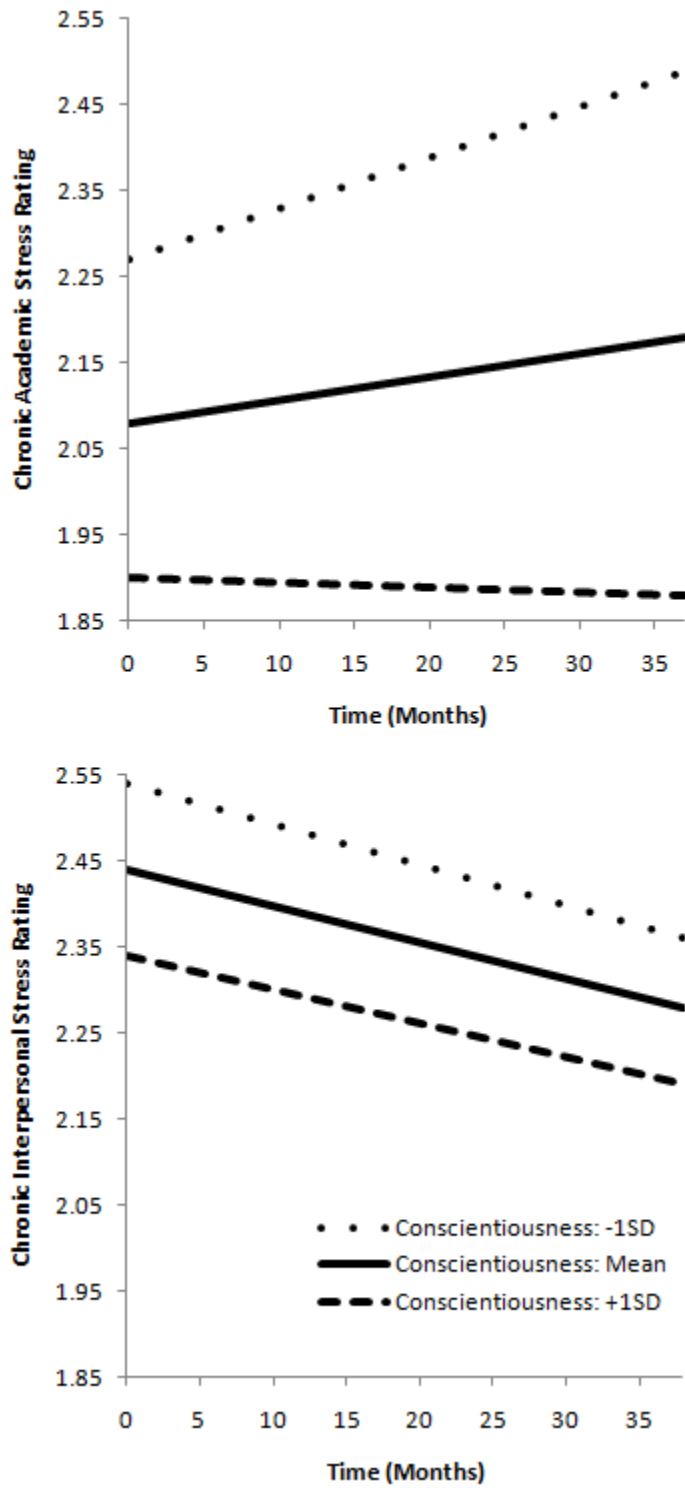


Figure 1 Chronic academic and interpersonal stress differences at V2 based on level of conscientiousness at V1.

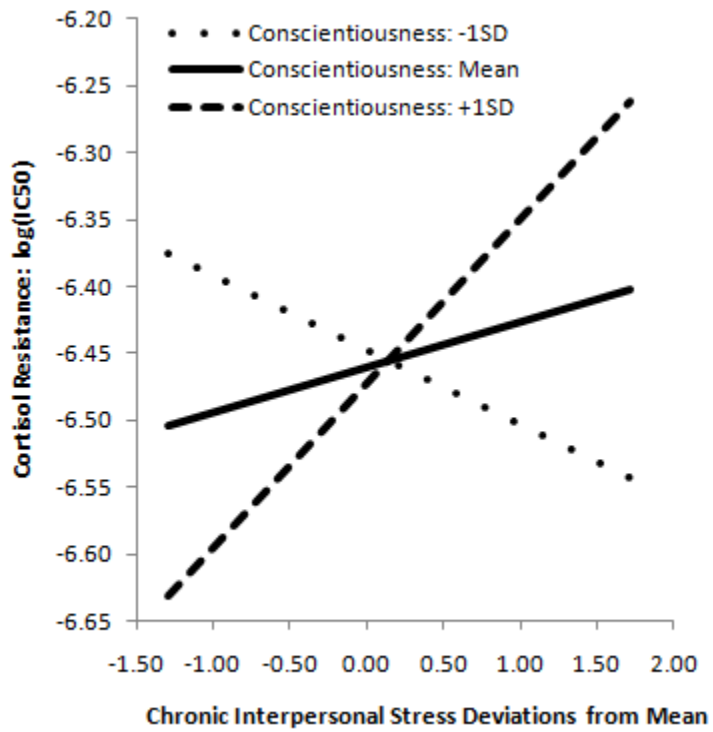


Figure 2 Changes in cortisol resistance associated with deviations from average chronic interpersonal stress. Values on the y-axis should be read as 10^y .

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