Psychophysiological Processes in the Connection Between Perfectionism, Stress, and Emotional Distress

By

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Abstract

The perfectionism-stress connection is frequently studied, yet research in this area often overlooks the role of physiological processes. This research helps address this gap by testing two psychophysiological models of perfectionism, stress, and emotional dysfunction in daily life. Study 1 tested the impact of perfectionism on diurnal cortisol levels through stress generation, stress reactivity, and depressive symptoms. A sample of undergraduates (N = 127) completed questionnaires and provided samples of salivary cortisol twice daily over three days. Results suggested self-critical perfectionism influences diurnal cortisol through multiple pathways. People high in self-critical perfectionism are vulnerable to depressive symptoms, especially during periods of high stress, and depressed symptoms showed a blunting effect on diurnal cortisol intercept (i.e., waking cortisol). People high in self-critical perfectionism also demonstrated elevated cortisol intercept, relative to people lower on this trait, during periods of low stress. These findings suggest self-critical perfectionists find themselves vulnerable to HPA-axis dysregulation directly through stress reactivity and indirectly through depressive symptoms. Study 2 expanded on Study 1 by disentangling the unique effects of neuroticism, perfectionistic strivings, and self-critical perfectionism on emotional distress, fatigue, vigor, and heart rate variability through stress generation and event-focused rumination. I used a multi-method experience sampling design in a sample of 100 working professionals over a 7-day period. Multilevel path analysis showed neuroticism uniquely predicted stress-reactive rumination and emotional distress, whereas self-critical perfectionism uniquely predicted daily stressors. Perfectionistic strivings showed no unique effects beyond other personality traits. Within-person results showed daily stressors uniquely predicted emotional distress and fatigue, while stress-reactive rumination uniquely predicted emotional distress, decreased vigor, and increased heart rate variability. Between-person results showed stress-reactive rumination predicted emotional distress, fatigue, and decreased heart rate variability. Results suggest neuroticism and self-critical perfectionism function uniquely and synergistically to produce negative stress sequelae through stress generation and event-focused rumination. Together, these studies support stress generation and stress reactivity as key processes in the relation between perfectionism and psychophysiological stress. This research highlights the benefit of studying day-to-day processes and elucidates the importance of psycho-physiological measurement in understanding the effects of personality on stress processes. Theoretical and practical implications are discussed.

List of Abbreviations and Symbols Used

α	Cronbach's alpha
ACTH	adrenocorticotropic hormone
AIC	Akaike information criterion
ANN	Average distance between NN intervals
β	Standardized regression coefficient (Beta)
CAR	Cortisol awakening response
CES-D	Centre for Epidemiological Studies depression scale
CFI	Comparative fit index
CFS	Chronic fatigue syndrome
CI	Confidence interval
CRF	Corticotropin-releasing factor
CV%	coefficient of variation
df	Degrees of freedom
DFA	Detrended fluctuation analysis
e.g.	Abbreviation for the Latin "exempli gratia," meaning "for example"
ECG	Electrocardiogram
EDI	Eating Disorders Inventory
ELISA	Enzyme-linked immunosorbent assay
et al.	Abbreviation for the Latin "et alii," meaning "and others"
F	F statistic
FIML	Full information maximum likelihood
FMPS	Frost Multidimensional Perfectionism Scale
HF	High frequency power domain (.15 – .40 Hz);
HFMPS	Hewitt and Flett Multidimensional Perfectionism Scale
HPA	Hypothalamic-pituitary-adrenal
HRV	Heart rate variability
i.e.	Abbreviation for the Latin "id est," meaning "that is"
ICC	Intra-class correlation
LF	Low-frequency power domain (.04–.15 Hz)
LF/HF	Ratio of LF to HF
M	Mean
MEMS	Medication event monitoring system
N	Number of participants / Sample size
NN	Normal to normal cardiac intervals
NN50	Number of adjacent NN intervals less than 50 ms
p	p-value for determining statistical significance
pNN50	Ratio of NN50 to total number of NN intervals
POMS-15	15-item Profile of Mood States
r	Pearson Product-Moment Correlation Statistic
R_{1F}	Between-person reliability on a fixed day for all participants
R_C	Within-person reliability of change
RDEQ	Reconstructed Depressive Experiences Questionnaire

R_{KF}	Between-person reliability across the study period
RMSEA	Root mean square error of approximation
RMSSD	Root mean square of successive differences
RSA	Respiratory sinus arrhythmia
SAM	Sympathoadrenal mudullary
SCP	Self-critical perfectionism
SD	Standard deviation
SD_n	Standard deviation of points from the line of identity on a Poincaré plot
SDANN	Standard deviation of 5-minute averages in NN intervals
SDNN	Standard deviation of NN intervals
SDSD	Standard deviation of successive differences in NN intervals
SRMR	Standardized root mean square residual
t	t statistic
τ_n	Time scores reflecting individually varying times of observation
TLI	Tucker Lewis index
TSST	Trier social stress test
VLF	Very low frequency power domain (.0033 – .04 Hz)
µg/dL	ultragram per deciliter
χ^2	Chi-square statistic
χ^2/df	Chi-square divided by degrees of freedom
z	Z statistic

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Chapter 1: Introduction

Stress is ubiquitous, costly, and impactful on mental health and adjustment. Statistics Canada estimates 27% of working Canadians are highly stressed (Crompton, 2011), and the impact of stress on mental health is estimated to cost Canadians up to $35 billion annually in healthcare use and lost productivity (Brun & Lamarche, 2006; Tangri, 2003). The personal impact of stress is also substantial, as it increases vulnerability to physical disease (Cohen, Janicki-Deverts, & Miller, 2007) and psychological symptoms (Lee, Joo, & Choi, 2013). The impact of stress on depression is also notable, as research suggests stress and depression reciprocally influence each other to maintain disability and erode social functioning over time (Hammen, 1991, 2006).

Not everyone responds to the vicissitudes of everyday life in the same way. Whereas some people demonstrate resilience to stressors and can "bounce back" following adverse experiences, others show increased vulnerability to stressful events and seemingly suffer more than others in comparable contexts (Avey, Luthans, & Jensen, 2009). Personality differences uniquely contribute to stress vulnerability beyond other factors, such as maladaptive cognitions and work demands (Conrad & Matthews, 2008). Perfectionism is rapidly gaining support as an important contributor to stress vulnerability that adds to our understanding of stress and emotional distress beyond personality disorders (Shahar, Henrich, Blatt, Rayn, & Little, 2003) and other broad personality domains, such as neuroticism (Smith et al., 2016).

Perfectionism and its relation to stress may have far-reaching consequences. Two longitudinal studies have shown perfectionistic older adults are at greater risk of mortality compared to their less perfectionistic peers (Fry & Debats, 2009, 2011). The authors

suggest perfectionism increases mortality and negative health outcomes through increased susceptibility to stress, which increases vulnerability to emotional distress and interferes with immune function (Fry & Debats, 2009). These results are compelling and illustrative of the long-term perils of perfectionism; however, the mechanisms that link perfectionism and stress to long-term outcomes remains poorly understood and infrequently studied. Most perfectionism research focuses on psychological and social features of stress, whereas physiological processes are often overlooked. Outside of the perfectionism literature, physiological processes are frequently described as risk factors for poor psychological adjustment and negative health outcomes (e.g., Adam et al., 2017; Ancelin et al., 2017; Brosschot, Gerin, & Thayer, 2006). Thus, understanding the effects of perfectionism on physiological stress processes may help provide a missing link in the literature on perfectionism and stress. My dissertation sought to address this gap by testing psychophysiological models of perfectionism and stress in the context of day-to-day life.

This chapter provides (1) an overview of perfectionism, including its historical roots and contemporary measurement models, (2) an overview of psychological and biological stress systems, (3) a description of existing theoretical models that explain the interrelation between perfectionism and stress, (4) a review of extant research testing physiological conceptualizations of stress in perfectionism research, and (5) a discussion of the possible role of perseverative cognition in physiological stress processes. At the end of the chapter, I identify the specific objectives of this dissertation and provide an overview of subsequent chapters.

1.1 Perfectionism: Historical Roots, Multidimensionality, and Contemporary Models

Perfectionism is considered a dispositional tendency characterized by striving for flawlessness, setting unrealistically high standards for oneself, and harshly evaluating oneself for perceived shortcomings (Stoeber, 2018). As a dispositional tendency, perfectionism involves characteristic patterns of affective experience, cognitive processes, and behavioural tendencies (Stoeber, 2018), which overlap with basic personality traits (e.g., the Big Five model of personality; Costa & McCrae, 1995) that describe stable inter-individual differences that persist across the lifespan (McCrae & Costa, 1990) and arise, in part, from underlying biological differences (e.g., Ormel et al., 2013). Research supports perfectionism as a distinct personality construct that is uniquely important in predicting outcomes of interest beyond neuroticism (i.e., a proneness toward negative emotions and associated cognitions and behaviours) and conscientiousness (i.e., individual differences in organization and achievement; Dunkley, Blankstein, & Berg, 2012; Dunkley, Mandel, & Ma, 2014; Smith et al., 2016). Although the consensus definition of perfectionism is seemingly straightforward, it arose from a complex history of competing conceptualizations.

1.1.1 Historical Foundations for Perfectionism

Perfectionism as a pattern of compulsive striving has been documented and described by psychodynamic theorists for decades (e.g., Blatt, 1995; Hamachek, 1978; Hollander, 1965; Horney, 1950; Pacht, 1984; Sorotzkin, 1985), yet empirical models were lacking during this period. The Burns' Perfectionism Scale (1980) provided the first published measurement model of perfectionism, which included a single dimension

capturing the tendency to relentlessly and compulsively strive toward perfection, consistent with Hamachek's (1978) description of *neurotic perfectionism*.

Perfectionism rapidly evolved into a multidimensional construct with the publication of two distinct, but identically named, Multidimensional Perfectionism Scales (Frost, Marten, Lahart, & Rosenblate, 1990; Hewitt & Flett, 1991). In Frost et al.'s (1990) model, perfectionistic people have characteristic cognitive and interpersonal experiences, such as setting and maintaining high standards for performance (personal standards), doubting their performance capabilities (doubts about actions), being pre-occupied with imperfect performance (concern over mistakes), needing to maintain order (organization), perceiving their parents as holding high expectations for them (parental expectations), and experiencing harsh evaluation from their parents (parental criticism). In contrast, Hewitt and Flett's (1991) model considered perfectionism primarily from an interpersonal lens and emphasized the object and source of perfectionistic expectations, with three resulting dimensions. In this model, people can hold lofty and unrealistic expectations for performance for themselves (self-oriented perfectionism) or for others (other-oriented perfectionism). People can also feel subjected to other people's perfectionistic expectations for them (socially prescribed perfectionism). These models capture unique but overlapping features of perfectionism and have formed the foundation of modern perfectionism research.

The advent of multidimensional perfectionism sparked new interest in this area and led to a proliferation of new models and conceptualizations of perfectionism. Scales were developed to offer alternative conceptualizations of perfectionism, including the Almost Perfect Scale (Slaney, Rice, Mobley, Trippi, & Ashby, 2001), the Perfectionism

Inventory (Hill et al., 2004), the Clinical Perfectionism Scale (Shafran, Cooper, & Fairburn, 2002), and the Positive and Negative Perfectionism Scale (Terry-Short, Glynn Owens, Slade, & Dewey, 1995). Debate about the relative merits and pitfalls of these conceptualizations and measures has been, at times, acrimonious (Dunkley, Blankstein, Masheb, & Grilo, 2006; Hewitt, Flett, Besser, Sherry, & McGee, 2003; Shafran, Cooper, & Fairburn, 2003), and continues to be a source of vigorous debate (e.g., Blasberg, Hewitt, Flett, Sherry, & Chen, 2016; Stoeber, 2018). Other, perhaps less controversial, measures have also been proposed to capture ancillary phenomena related to perfectionism, such as perfectionistic cognitions (i.e., automatic thoughts pertaining to the need for perfection; Flett, Hewitt, Whelan, & Martin, 2007) and perfectionistic self-presentation (i.e., concerns about presenting oneself as perfect; Hewitt et al., 2003), with these measures frequently predicting outcomes above and beyond dispositional perfectionism (Cowie, Nealis, Sherry, Hewitt, & Flett, 2018; Hewitt et al., 2003; Mackinnon, Battista, Sherry, & Stewart, 2014).

1.1.2 Contemporary Models of Perfectionism

As conceptual models of perfectionism became ever more nuanced, researchers began to seek theoretical integration of various perfectionism measures to create higher-order perfectionism constructs. Two broad dimensions emerged from this work: *perfectionistic strivings* and *perfectionistic concerns* (Blankstein & Dunkley, 2002). Perfectionistic strivings involves setting stringent, and often unrealistic, standards for one's own performance and rigidly strivings for these perfectionistic ideals. In contrast, perfectionistic concerns (sometimes referred to as evaluative concerns) involves concerns about negative evaluation by others, doubts about performance abilities, and a perception

of being held to unrealistically high, and perhaps unobtainable, standards by others. Measures of self-criticism were later integrated with perfectionistic concerns to create self-critical perfectionism (Dunkley & Blankstein, 2000). The specific composition of each composite differs somewhat between researchers and across study, with no widely agreed consensus about measurement. The recently developed Big Three Perfectionism Scale (Smith, Saklofske, Stoeber, & Sherry, 2016) was meant to standardize measurement of these phenomena, although this scale is not yet in widespread use.

Perfectionistic concerns and self-critical perfectionism show robust associations with maladaptive outcomes (Blankstein & Dunkley, 2002; Smith, Sherry, et al., 2016), while perfectionistic strivings is described as neutral or adaptive (Bieling, Israeli, & Antony, 2004; Stoeber & Otto, 2006). This perspective is equivocal, however, as perfectionistic strivings has shown maladaptive qualities in some research (Smith, Sherry, et al., 2016). Perfectionistic strivings and self-critical perfectionism are strongly correlated (e.g., $r = .74$; McGrath et al., 2012), and researchers have relied on statistically "partialling out" this overlap to capture the unique effect of each form of perfectionism. This approach has not been without critics, with some researchers expressing concerns that these traits co-occur within people, and statistically isolating them may be producing theoretically interesting results while failing to capture perfectionism as it manifests in real people (Hill et al., 2014). Others have countered this view and staunchly defended the practice of partialling (Stoeber & Gaudreau, 2017). Current recommendations seemingly reflect a middle ground, such that researchers are encouraged to test hypotheses with and without statistical partialling to better understand how perfectionism domains exert unique and shared effects on outcomes of interest (Stoeber, 2018).

1.2 Stress as a Dynamic Process: Theoretical Roots and Physiological Processes

Stress is a manifold phenomenon involving complex psychological, biological, and social processes. Over half a century of research has informed our modern understanding of stress; however, it was only at the dawn of the new millennium that leaders in the field claimed the literature had finally reached maturity, albeit with important gaps left to fill (Lazarus, 2000).

The stress process, broadly speaking, refers to the presence of an internal or external demand (i.e., a "stressor") that places strain on the organism and elicits a pattern of physiological, emotional, and behavioural responses (i.e., the stress response) to adapt to that demand. This understanding originated largely with Hans Selye (1950), who noted environmental stressors triggered physiological resource mobilization and short-term positive adaptation in laboratory animals, albeit with long-term costs if stressors persisted over time. This triggered vigorous research on the nature of human stressors, their impact on physical and psychological adjustment, and the factors that mediate them.

Research to understand and quantify stressors in humans initially focused on major life events (both positive and negative) and the physical and mental responses needed to re-adjust following these events (Holmes & Rahe, 1967). Over several decades of research, the emphasis shifted to focus less on discrete events and more on day-to-day experiences (Thoits, 1995). Chronic stressors (ongoing and open-ended demands) and daily hassles (minor events arising from day-to-day living) have shown stronger associations with adjustment than major life events (Kanner, Coyne, Schaefer, & Lazarus, 1981; Monroe, Slavih, Torres, & Gotlib, 2007), with both chronic stressors and

daily hassles representing distinct experiences that mutually influence each other and contribute to adjustment over time (Serido, Almeida, & Wethington, 2004).

Theoretical developments suggest stressors do not directly lead to a stress response, but are rather mediated by cognitive processes. *Transactional stress theory* (e.g., Lazarus & Folkman, 1984) describes two forms of appraisal that influence the perceived stressfulness of an event. After exposure to a stressor, people first engage in primary appraisal, which involves an evaluation of whether the event represents a *challenge* that will require mobilization of resources to successfully address, or a *threat* that has a high likelihood of leading to harm or loss. Secondary appraisal follows, which involves an evaluation of available coping resources and whether those resources are adequate to cope with the stressor. Thus, a stressor would lead to a relatively mild stress response if little was at stake and the person had adequate resources available to successfully resolve the situation. Conversely, the same stressor would lead to a more pronounced stress response if it posed a significant threat of harm and if insufficient coping resources were available to prevent that harm from occurring. Thus, cognitive processes serve an important function in triggering the stress response.

1.3 Models of Perfectionism and Stress: Theoretical and Empirical Formulations

The understanding of how perfectionism relates to stress has evolved over time and involves several theoretical perspectives. Initial formulations focused on a diathesis-stress model of psychopathology, such that perfectionism functioned as a pre-existing vulnerability factor for people who, when exposed to significant stressors, were at increased risk of emotional distress. This perspective was substantiated empirically, with evidence showing perfectionism interacted with life events, or perceived stress, to predict

myriad negative outcomes including anxiety and self-harm (O'Connor, Rasmussen & Hawton, 2010), hopelessness (Chang & Rand, 2000), depression (Flett, Hewitt, Blankstein, & Mosher, 1995), and suicide risk (Hewitt, Caelian, Chen, & Flett, 2014). Diathesis-stress effects have been demonstrated for both self-oriented perfectionism (Flett et al., 1995; O'Connor et al., 2010) and socially prescribed perfectionism (Chang & Rand, 2000; O'Connor et al., 2010).

Expanding on the diathesis-stress model, researchers proposed each form of perfectionism (e.g., self-oriented and socially-prescribed perfectionism) would interact only with specific forms of stress to produce vulnerability to distress. In the specific vulnerability hypothesis, first described by Hewitt and Flett (1993), self-oriented perfectionism was thought to increase risk of distress specifically in response to performance-based stress, whereas socially-prescribed perfectionism was thought to increase risk of distress specifically in response to interpersonal stress. This hypothesis has received inconsistent empirical support. Several studies have shown self-oriented perfectionism interacts with achievement stress to predict depressed mood (Hewitt & Flett, 1993; Hewitt, Flett, & Ediger, 1996), or non-remission of depressive symptoms over time (Enns & Cox, 2005), whereas other research has shown little support for specific vulnerability effects (e.g., Joiner & Schmidt, 1995). Support for the specific vulnerability hypothesis in socially prescribed perfectionism has likewise been demonstrated (La Rocque, Lee, & Harkness, 2016), but with inconsistent results. Some studies have demonstrated interactions with both achievement and interpersonal stress predicting depressive symptoms (Hewitt & Flett, 1993), whereas other studies have shown no interactive effects (Enns & Cox, 2005; Hewitt et al.,1996). Further research has

done little to clarify these ambiguous results, and more recent work in this area has largely replaced tests of specific vulnerability with alternative conceptualizations of the perfectionism-stress link.

Other theoretical accounts provide a different perspective on the perfectionism-stress link. In response to a gap in theory regarding the role of personality traits in stress processes, Bolger and Zuckerman (1995) proposed a model in which personality traits (e.g., neuroticism) can relate to stress through two processes: stress generation and stress reactivity. In stress generation, personality vulnerabilities predispose people to experiencing more frequent stress, perhaps by selecting more stressful environments and being more likely to interpret daily events as stressful. In stress reactivity, the personality trait contributes to a stronger, and more negative, reaction to the stressful event through using less effective coping strategies or using adaptive coping strategies in ineffective ways (Bolger & Zuckerman, 1995).

Hewitt and Flett (2002) expanded and adapted this model to perfectionism by proposing four processes: stress generation, stress anticipation, stress perpetuation, and stress enhancement. The first three processes describe how perfectionists might encounter more frequent stress in their lives by creating stressful experiences (e.g., through more negative social interactions or the pursuit of more challenging careers), anticipating future events as stressful, and perpetuating that stress even after the event has passed. The last process, stress enhancement, stipulates that highly perfectionistic people experience stressors as more distressing than those who are less perfectionistic. Stress generation and reactivity models have been tested directly and received support (e.g., Hawley, Zuroff, Brozina, Ho, & Dobson, 2014; La Rocque et al., 2016). These models have also served as

a foundation for other models of perfectionism, stress, and distress that have developed over recent years.

A body of research has emerged that builds on stress generation and enhancement processes to indicate how perfectionism and perceived stress trigger psychological distress and maintain it over time through cognitive and behavioural processes. Empirical models have suggested self-critical perfectionism (and the closely-related perfectionistic concerns) contributes to stress through appraisals and maladaptive coping processes, with particular emphasis on a pattern of avoidant coping, whereas perfectionistic strivings shows no such relation (Dunkley & Blankstein, 2000; Dunkley, Zuroff, & Blankstein, 2003). These results led to the proposal of a trigger-maintenance model of perfectionism and stress (Dunkley et al., 2017; Dunkley, Ma, Lee, Preacher, & Zuroff, 2014) in which daily experiences (e.g., perceived criticism) trigger emotional distress, whereas longer-term patterns (e.g., low perceived social support) maintain that distress over time. Each of these trigger and maintenance models also involves engagement and disengagement patterns. In the engagement pattern, perceived social support contributes to increased perceived control and the positive reinterpretation of events, which support efforts to cope in an active way to solve problems. Having high personal standards increases people's tendency to engage in more problem-focused coping, which facilitates the experience of positive adjustment to stressful events. In the disengagement pattern, perceived criticism from others contributes to stress directly and indirectly through avoidant coping, with these experiences increasing negative emotions and decreasing positive emotions. This distress is maintained over time by self-critical perfectionism,

which increases people's propensity to cope with stressors through avoidance (Dunkley et al., 2017; Dunkley, Ma, et al., 2014).

Extant theory has provided a foundation for understanding the perfectionism-stress link, and nuanced empirical models have been proposed to understand the circumstances in which perfectionism relates to stress and emotional distress, as well as the factors that modify this association. The complexity of these models continues to increase, yet notable gaps remain. The physiological aspect of stress remains largely under-represented in these models despite their importance in understanding the role of individual differences in producing prolonged stress responses that contribute to physical disease progression and decreased quality of life (Fry & Debats, 2009, 2011).

1.4 Markers of Physiological Stress Processes

Stress involves physiological responses that arise from biological systems designed to help an organism adapt in a flexible way to changing environmental demands (McEwen, 2000). These systems are meant to be adaptive and maintain homeostasis, but their prolonged activation can contribute to illness and psychological syndromes (Brosschot et al., 2006). The physiological stress response is modulated in part through the autonomic nervous system, including both the sympathetic and parasympathetic nervous system, and neuroendocrine changes associated with the hypothalamic-pituitary-adrenal (HPA) axis (McEwen, 2000).

The sympathetic nervous system is a component of the autonomic nervous system that regulates homeostatic functions and enables a rapid physiological response to immediate danger (i.e., the fight-or-flight response; Mills & Ziegler, 2008). This rapid stress response functions through the sympathoadrenal mudullary (SAM) pathway, which

involves direct innervation of the adrenal medulla to release catecholamines (e.g., epinephrine and norepinephrine) into the bloodstream. Sympathetic nervous system responses can be measured more directly through serum catecholamine levels or indirectly through the effects of them, notably, cardiopulmonary changes (e.g., heart rate, blood pressure, respiratory rate), skin conductance (e.g., galvanic skin response), or the concentration of alpha-amylase in saliva (Nater & Rohleder, 2009).

The parasympathetic nervous system is complementary to the sympathetic nervous system and serves to regulate homeostatic functions at rest. Few measures of parasympathetic activity exist, and it is primarily measured using indices of heart rate variability (HRV). HRV arises through variability in cardiac rhythm resulting from the inhibitory effects of the vagus nerve on the sinoatrial node of the heart during exhalation (Thayer, Hansen, & Johnsen, 2008). Various statistical measures of HRV can be extracted from electrocardiogram trace including time-based estimates (e.g., standard deviation of successive beat-to-beat durations) and frequency-based estimates (e.g., spectral power of high-frequency power domains; see Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996, for a complete description of HRV measures and their interpretation). Rather than indicating a stress response per se, HRV is thought to provide an index of how well the organism is able to flexibly adapt to environmental demands (Appelhans & Luecken, 2006; Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012). This interpretation has been supported empirically, with data showing an association between higher HRV (i.e., stronger parasympathetic activation) and the effectiveness of coping responses to a lab-based stress induction protocol (Di Simplicio et al., 2012).

In addition to the acute stress response, stressors can also lead to longer-acting stress responses involving neuroendocrine changes associated with the hypothalamic-pituitary-adrenal (HPA) axis. In response to a stressor, the hypothalamus releases corticotropin-releasing factor (CRF), which signals the pituitary gland to release adrenocorticotropic hormone (ACTH) into the bloodstream. ACTH, in turn, signals the release of cortisol, a glucocorticoid, from the adrenal cortex. Cortisol exerts effects across numerous physiological systems to influence energy metabolism, increasing resources available for successful adaptation to environmental demands (Nicolson, 2008). In addition to increases in response to both controlled lab-based stress paradigms (Dickerson & Kemeny, 2004) and daily experiences and mood states (van Eck, Berkhof, Nicolson, & Sulon, 1996), cortisol is also subject to naturally occurring daily rhythms, such that concentrations are highest around waking and then gradually decline throughout the day until reaching the evening nadir (Nicolson, 2008). The cortisol awakening response (CAR) is superimposed on this pattern and involves a rapid increase of cortisol approximately 30-45 minutes after wakening with a return to waking levels within approximately 60 minutes (Fries, Dettenborn, & Kirschbaum, 2009). Diurnal cortisol patterns and the CAR reflect natural daily processes, although these processes can be influenced by physiological factors (e.g., age, gender, menstrual cycle, sleep, medical conditions) and psychological factors (e.g., chronic stress, burnout, psychiatric conditions; Fries et al., 2009).

1.5 Existing Research in Perfectionism and Physiological Stress

There is a paucity of research on perfectionism and stress that considers the role of physiological processes in these associations. A few existing studies measure

cardiovascular or neuroendocrine responses to stressful events, but most of these studies do so in the context of lab-based experimental paradigms.

Three notable perfectionism studies have tested cardiovascular reactivity to acute stressors in a lab-based setting. One study, using a sample of 200 undergraduate students, measured changes in blood pressure and heart rate in response to a stressful task completed in the lab (Besser, Flett, Hewitt, & Guez, 2008). Results showed increased blood pressure in participants high in self-oriented perfectionism when they performed poorly on a stressful task, and in participants high in socially prescribed perfectionism when they received negative feedback about their performance, but increased heart rate was evident only in the latter group (Besser et al., 2008). Another study, using a sample of 90 clinical patients, tested affective, cognitive, and physiological responses to a clinical interview (Hewitt, Habke, Lee-Baggley, Sherry, & Flett, 2008). Results suggested those who avoided disclosing their failures and were concerned about maintaining an image of perfection to others had higher heart rates and cardiovascular reactivity when discussing past mistakes during the interview. Aside from heightened reactivity, these physiological responses do not diminish over time. A study of 30 undergraduate students investigating the habituation of cardiovascular responses over repeated administration of a stressor demonstrated participants with higher levels of perfectionism showed less attenuation of stress responses across task administrations (Albert, Rice, & Caffee, 2016). Together, these studies suggest that perfectionism contributes to increased and prolonged cardiovascular stress reactivity and that the particular circumstances that elicit stress may differ between subtypes of perfectionism, which is consistent with the specific vulnerability hypothesis.

To date, only one study has investigated the effect of perfectionism and stress on parasympathetic activity. An experimental study of undergraduate students sought to test the effect of mindfulness-based meditation on HRV across a group of 21 maladaptive perfectionists (i.e., participants scoring at least one standard deviation above the mean on the Perfectionism Cognitions Inventory) and a group of 39 control participants (Azam et al., 2015). Participants were monitored for heart rate variability across a 5-minute baseline period, a 5-minute cognitive stress task, and a 10-minute recovery period. For the recovery period, participants were randomly assigned to either listen to a guided mindfulness-based meditation or to a control activity. Participants in the control group showed elevated HRV in the mindfulness condition relative to the control activity, whereas participants in the perfectionism group showed no apparent benefit from the mindfulness condition relative to the control condition (Azam et al., 2015). Results suggest people high in perfectionism may not benefit from the same stress-management strategies as other less perfectionistic people, which may contribute to the perpetuation of stress over time in people who are highly perfectionistic.

Five published studies in the perfectionism literature have tested neuroendocrine reactivity to lab-based stressors, although results have been contradictory across studies. In one study (Wirtz et al., 2007), a sample of 50 middle-aged men completed the Trier Social Stress Test (TSST), a standardized stress-induction protocol involving exposure to performance demands (e.g., completing mental arithmetic and giving a short speech) while being subject to social evaluative pressure (e.g., completing tasks in front of a panel of evaluators who maintain neutral facial expressions; Kirschbaum, Pirke, & Hellhammer, 1993). Results showed perfectionism, as measured by concern over

mistakes, uniquely predicted an elevated cortisol response to the TSST beyond stress appraisals and other personality factors, such as neuroticism (Wirtz et al., 2007). These effects, however, failed to replicate in a mixed gender sample of 84 participants (Zureck, Altstötter-Gleich, Wolf, & Brand, 2014). Another study involving 16 participants (McGirr & Turecki, 2009) failed to show cortisol reactivity to the TSST, but did show reactivity to salivary alpha-amylase, which is considered a marker of sympathetic nervous system activation (Granger, Kivlighan, El-Sheikh, Gordis, & Stroud, 2008).

Two of the studies measuring cortisol reactivity used clinical samples or used cortisol in other ways that preclude comparison with other similar research. A study of 41 female patients diagnosed with chronic fatigue syndrome (CFS) showed a blunted cortisol response to the TSST (Kempke, Luyten, Mayes, Van Houdenhove, & Claes, 2016); however, it remains uncertain whether the blunted response is typical of CFS or perfectionism per se. One other study evaluated cortisol reactivity to the TSST, but cortisol reactivity was used as a factor in cluster analysis to classify participants as adaptive or maladaptive perfectionists, but was not used as an outcome in its own right (Richardson, Rice, & Devine, 2014).

The use of physiological measures in perfectionism research studying stress processes in the context of daily life is exceptionally rare. Only two published studies to date have measured daily cortisol patterns and no studies have tested cardiovascular reactivity in this context. In their study of cortisol reactivity to lab-based stress, Wirtz et al. (2007) also measured cortisol levels over the course of a single day as participants engaged in their daily activities, but results showed no effect of perfectionism on diurnal cortisol patterns or on the CAR. A recently published study of 43 depressed patients

included a measurement of daily cortisol across a 7-day period (Mandel et al., 2018). Results of this study showed that those high in self-critical perfectionism who demonstrated elevated CAR were at increased risk for depressive symptoms at a one-year follow-up, whereas those low in self-critical perfectionism who had elevated CAR showed the lowest risk for depressive symptoms one year later. In contrast, diurnal cortisol patterns showed no significant relation to self-critical perfectionism or other processes included in the model (Mandel et al., 2018).

Together, lab-based studies provide equivocal evidence of neuroendocrine stress reactivity in perfectionistic people. Studies of cortisol in the context of daily life are even less common, and have so far shown few compelling associations with perfectionism and stress processes. Rather than casting doubt on the utility and importance of physiological measurement, the problem may arise from the unique challenges involved in the measurement of these processes. Perfectionism research using cortisol has been criticized for its poor methodological control (e.g., not including covariates of gender or hormonal contraceptive use), which likely contributes to the variability of results (Page, Hill, Kavanagh, & Jones, 2018). Existing studies have provided valuable insight into the perfectionism-stress link, yet further research is warranted to understand perfectionists' psychological and physiological vulnerability to stress.

1.6 Rumination and the Perseverative Cognition Hypothesis

Cognitive processes have been identified as possible mechanisms through which perfectionistic people become vulnerable to stress and emotional dysfunction. Much of the literature on perfectionism and emotional distress focuses on thought *content*, including automatic perfectionistic thoughts (Flett et al., 2007), discrepancies between

ideal performance and evaluated performance (Slaney et al., 2001), concerns about being perceived as imperfect by others (Hewitt, Flett, Sherry, et al., 2003), and harsh self-criticism (James, Verplanken, & Rimes, 2015). Perfectionistic thought content has shown important predictive value (e.g., Sherry et al., 2013) and increases people's propensity toward detrimental forms of cognition, including rumination, catastrophization, and self-blame (Flett, Madorsky, Hewitt & Heisel, 2002; Macedo et al., 2017; Rudolph, Flett, & Hewitt, 2007). However, the focus on thought *content* neglects the role of thought *form* in generating and maintaining distress. Theoretical work suggests thought *form* may be uniquely important in understanding the physiological effects of stress.

The perseverative cognition hypothesis (Brosschot et al., 2006) proposes that patterns of repetitive negative thought (i.e., rumination) prolong a person's natural physiological stress response in a way that amplifies the effects of day-to-day events and perpetuates that response. The resulting chronic physiological activation leads to increased physiological strain that contributes to stress vulnerability, including susceptibility to disease and psychiatric disorders (Brosschot et al., 2006).

Research on rumination in perfectionism has focused predominantly on ruminative brooding, which reflects a tendency to perseverate on one's own emotional distress (Smith & Alloy, 2009). Empirical work has shown robust support for ruminative brooding as a mediator between trait perfectionism and depressive symptoms (Harris, Pepper, & Maack, 2008; O'Connor, O'Connor, & Marshall, 2007; Olson & Kwon, 2008; Senra, Merino, & Ferreiro, 2018) and emotional distress more broadly (Blankstein & Lumley, 2008; Short & Mazmanian, 2013). However, ruminative brooding does not

necessarily reflect perseverative negative thought about stressful experiences as described in the perseverative cognition hypothesis.

Empirical investigation is beginning to reflect this distinction to elucidate how perseverative thought might relate to the perfectionism-stress connection. One study has highlighted rumination in response to distressing interpersonal events as a mediator between perfectionism and distress (Nepon, Flett, Hewitt, & Molnar, 2011). Experimental designs have reflected event-focused rumination, with several studies highlighting the role of rumination in response to perceived failure on a lab-based task (Besser, Flett, & Hewitt, 2004; van der Kaap-Deeder et al., 2016). Despite the development of scales to capture event-focused rumination (e.g., stress-reactive rumination scale; Robinson & Alloy, 2003), the use of these scales remains limited in perfectionism research despite their potential benefit for understanding psycho-physiological processes underlying perfectionism and stress vulnerability.

1.7 Summary and Objectives of the Present Research

Existing theoretical models of perfectionism and stress have provided fertile ground for research and rigorous empirical models have taken root. Knowledge in this area is advancing and increasingly sophisticated models have provided promising new directions to explore with continued research and clinical application. However, the use of physiological measures is comparatively neglected in these models, yet using such tools could provide new directions to expand our understanding of perfectionism, stress, and psychopathology. Existing research has provided an initial foray into this area, but gaps still remain. Specifically, past research has used poor methodological control in the study of cortisol and there are, as of yet, no compelling investigations of perfectionism

and cardiac functioning in the context of daily life. This dissertation thus had two broad objectives. The first objective was to advance our understanding of perfectionism and stress through the use of psychophysiological models of stress that consider emotional distress alongside its physiological sequelae. The second objective was to expand measurement of physiological stress into the realm of daily experience to capture perfectionism and stress processes as they manifest in response to everyday life.

I tested these objectives in two empirical studies using daily measurement of physiological stress indices combined with self-report measures of psychological distress and stress processes consistent with extant theoretical frameworks (e.g., Hewitt & Flett, 2002). In Study 1, I tested the effects of perfectionism on HPA-axis dysregulation, as measured by diurnal cortisol patterns, to identify possible direct and indirect effects through stress generation, stress reactivity, and depressive symptoms. In Study 2, I expanded on Study 1 to test stress generation and stress perpetuation hypotheses using intensive daily measurement of emotional adjustment and HRV over a 1-week period in a sample of working professionals. Each study has been presented as a stand-alone manuscript.

In the following chapters, I present the results of Study 1 (Chapter 2) and Study 2 (Chapter 4), along with rationale for how Study 2 expands on, and complements, Study 1 (Chapter 3). Finally, I discuss the broader empirical and clinical implications of this research, its limitations, and directions for future research (Chapter 5).

Chapter 2: Self-Critical Perfectionism, Depressive Symptoms, and HPA-Axis Dysregulation: Manifold Vulnerability Pathways Through Stress Reactivity

2.1. Introduction

Perfectionism increases people's vulnerability to depressive symptoms (Graham et al., 2010; Sherry, Mackinnon, Macneil, & Fitzpatrick, 2013), even after accounting for other personality traits, such as neuroticism (Smith, Sherry, et al., 2016). People high in perfectionism show vulnerability to depressive symptoms through psychological factors, including ineffective coping patterns (Wei, Heppner, Russell, & Young, 2006), discrepancies between ideal and evaluated performance (Sherry et al., 2013), and increased emotional sensitivity to stress (Dunkley, Mandel et al., 2014; Mandel, Dunkley, & Moroz, 2015). As a result of stress vulnerability, highly perfectionistic people remain vulnerable to depressive symptoms even after psychotherapy (Hawley et al., 2014).

Models of perfectionism, stress, and depressive symptoms have become increasingly sophisticated (Dunkley et al., 2017), yet these models have only recently begun to explore the possible role of physiological stress processes (e.g., cortisol awakening response) in depression vulnerability (Mandel et al., 2018). Research suggests physiological stress processes can become dysregulated in response to prolonged stress, which increases the risk for depressive symptoms over time (Ancelin et al., 2017; LeMoult, Ordaz, Kircanski, Singh, & Gotlib, 2015). Perfectionism may thus confer vulnerability to depressive symptoms through psychological and physiological pathways, and a better understanding of these pathways may help identify more effective ways to treat depressed and perfectionistic clients while reducing risk of relapse following treatment. The present research sought to address this gap by using measures of daily cortisol activity to understand how perfectionism might impact depressive

symptoms, as well as the physiological stress processes that may develop through overlapping and distinct pathways.

2.1.1 Perfectionistic Strivings and Self-Critical Perfectionism

Perfectionism is multidimensional and the consensus is that perfectionism is a stable personality disposition which involves striving for flawlessness, setting unrealistically high standards for oneself, and harshly evaluating oneself for perceived shortcomings (Stoeber, 2018). Two forms of perfectionism are commonly described: perfectionistic strivings and self-critical perfectionism. Perfectionistic strivings involves holding oneself to unrealistic standards for performance and striving relentlessly toward them, whereas self-critical perfectionism involves a pre-occupation with mistakes and negative evaluation from others, doubts about performance abilities, and harsh self-evaluation (Blankstein & Dunkley, 2002).

Self-critical perfectionism shows a strong, unambiguous link with depressive symptoms, whereas the association between perfectionistic strivings and depressive symptoms shows inconsistent and small unique effects (Smith, Sherry, et al., 2016). Perfectionistic strivings confers risk for depressive symptoms through relatively circumscribed mechanisms (e.g., sensitivity to academic failure; Békés et al., 2015; Hewitt & Flett, 1993), rather than shared pathways with self-critical perfectionism (Dunkley, Ma, et al., 2014; Dunkley et al., 2003). Perfectionistic strivings can also show adaptive benefits when isolated from self-critical perfectionism (Dunkley et al., 2017). Although both forms of perfectionism remain important to consider (Stoeber, 2018), self-critical perfectionism plays a far greater role in creating vulnerability to depressive symptoms relative to perfectionistic strivings (Dunkley et al., 2017).

2.1.2 Stress Generation and Reactivity

There is no single unifying framework to understand how perfectionism and stress contribute to depressive symptoms, but existing theoretical models are used to inform this area of research. Bolger and Zuckerman (1995) proposed personality traits, such as perfectionism, can lead to psychological distress (e.g., depressive symptoms) through two processes: stress generation and stress reactivity. In stress generation, people with personality vulnerabilities tend to encounter stressful situations more frequently, whether through actively creating them via maladaptive responses to the environment, or through a proclivity toward perceiving everyday events as stressful (Bolger & Zuckerman, 1995; Hewitt & Flett, 2002). In stress reactivity, people with personality vulnerabilities tend to react more strongly, and more negatively, to stressful events than others without those same traits (Bolger & Zuckerman, 1995). Hewitt and Flett (2002) adapted this framework to perfectionism by expanding stress generation to also account for stress anticipation (i.e., concern over future events) and stress perpetuation (i.e., perseveration about past events).

Perfectionistic strivings has a relatively minimal impact on stress generation or reactivity, and evidence of these processes is usually constrained to specific conditions. For example, Dunkley et al. (2003) removed perfectionistic strivings from their model because it showed no unique effects on stress, or psychological distress, beyond self-critical perfectionism. Later research specified unique processes related to perfectionistic strivings, with this form of perfectionism being associated with adaptive coping processes (e.g., problem-focused coping) that mitigate psychological distress (Dunkley et al., 2017). Other research suggests perfectionistic strivings may not be entirely adaptive.

Perfectionistic strivings demonstrates stress generation and reactivity to academic stress in particular, although these effects are only apparent when people high in perfectionistic strivings are experiencing concurrent depressive symptoms (Békés et al., 2015; La Rocque et al., 2016).

In contrast, empirical research supports stress generation and stress reactivity as noteworthy processes for people high in self-critical perfectionism. People high in self-critical perfectionism report more persistent daily hassles (Dunkley et al., 2003), with evidence suggesting they may be particularly vulnerable to interpersonal stress (Enns & Cox, 2005; La Rocque et al., 2016). Such individuals also tend to interpret daily experiences as more unpleasant, persistent, and stressful, although this tends to arise indirectly through a tendency to cope with daily experiences in avoidant ways (Dunkley et al., 2017; Dunkley et al., 2003). People high in self-critical perfectionism (and its constituent components, such as socially prescribed perfectionism) are also more vulnerable to depressive symptoms through stress reactivity, including reactivity to stressful life events (Hawley et al., 2014; Hewitt & Flett, 1993), chronic stress (Békés et al., 2015), and daily experiences (Dunkley, Ma, et al., 2014).

In perfectionism research, stress reactivity is most frequently discussed in relation to emotional vulnerability in reaction to stress (Dunkley, Mandel, et al., 2014; La Rocque et al., 2016; Mandel et al., 2015); however, physiological stress reactivity could represent a separate vulnerability. Given research suggesting physiological dysregulation can increase risk for developing depressive symptoms over time (Ancelin et al., 2017; Harris et al., 2000), stress reactivity may operate through two pathways: one representing an immediate vulnerability for depressive symptoms through psychological factors, and the

other representing a long-term vulnerability to depressive symptoms through physiological dysregulation.

2.1.3 Physiological Stress Reactivity: Gaps and Opportunities for Research

The hypothalamic-pituitary adrenal (HPA) axis assists with the mobilization of resources necessary to cope with demands from a person's environment through the eventual release of cortisol (McEwen, 2008). Cortisol levels naturally fluctuate over time based on predictable patterns (e.g., diurnal and seasonal rhythms, cortisol awakening response) and in response to stressful events (Nicolson, 2008); however, genetic vulnerability and chronic stress can result in HPA-axis dysregulation, such that cortisol responses are stronger (hyper-activation) or weaker (hypo-activation) than required to maintain optimal functioning (Miller, Chen, & Zhou, 2007). There is some inconsistency in these effects; some research shows higher cortisol levels are associated with psychological symptoms and stress (e.g., Marchand, Durand, Juster, & Lupien, 2014), while other research shows the opposite pattern (Miller et al., 2007).

HPA-axis dysregulation involving elevated diurnal cortisol increases the risk for depressive symptoms over time, (Ancelin et al., 2017; LeMoult et al., 2015).. With self-critical perfectionism implicated in chronic stress and stress reactivity (Békés et al., 2015), testing the effects of perfectionism on HPA-axis activity may provide additional insight into how perfectionism leads to vulnerability to depressive symptoms.

Extant research suggests self-critical perfectionism increases cortisol reactivity, but gaps remain. Self-critical perfectionism (and related forms of perfectionism) is related to increased cortisol reactivity to a lab-based stress induction protocol even when accounting for other personality traits, such as neuroticism (Wirtz et al., 2007). Research

using daily diary methods to test the effect of self-critical perfectionism on daily cortisol patterns showed people high in self-critical perfectionism with higher cortisol awakening responses (i.e., a surge of cortisol that occurs approximately 45 minutes after wakening) were at increased risk of depressive symptoms six months later, whereas people low in self-critical perfectionism showed the opposite pattern (Mandel et al., 2018).

Two of these studies showed no significant relation between self-critical perfectionism and diurnal cortisol patterns in daily life (Mandel et al., 2018; Wirtz et al., 2007), but each involved a notable limitation. Wirtz et al. (2007) measured diurnal cortisol over a single day, despite research showing diurnal cortisol measured on a single day has low reliability (Kraemer et al., 2006). Mandel et al. (2018) assessed diurnal cortisol on two non-consecutive days over a 7-day period, but used a mixed-gender sample without accounting for potential confounding factors, such as gender, hormonal contraceptive use, or menstrual cycle phase, which is suggested for the reliable and the valid measurement of cortisol (Page et al., 2018). Additionally, both studies used relatively small sample sizes ($N = 60$ and $N = 43$, respectively). These studies provided novel insights into the physiological processes underlying the perfectionism-stress connection, yet additional tests of perfectionism in relation to diurnal cortisol are needed to account for these methodological limitations.

2.1.4 Objectives and Hypotheses

My primary objective was to test the influence of perfectionism domains (self-critical perfectionism and perfectionistic strivings) on HPA-axis functioning while addressing methodological limitations of previous research (e.g., low sample sizes and not accounting for hormonal confounds) and potential indirect effects through depressive

symptoms and stress generation effects. My secondary objective was to test whether the effect of stress reactivity on HPA-axis functioning was distinct, or overlapped with, the effect of stress reactivity on HPA-axis activity through a shared association with depressive symptoms.

In this study, I conceptualized personality traits as stable individual differences, whereas experiences of stress and depressive symptoms were conceptualized as transient experiences that fluctuate over time. My research design includes measurement of self-report questionnaires (perfectionism, daily stress, and depressive symptoms) during a single lab-based session, followed by three days of salivary cortisol sampling to provide an estimate of HPA-axis activity. Diurnal cortisol patterns were modeled as a linear trajectory (including an intercept and slope) reflecting cortisol activity during a typical day during the sampling period. Diurnal cortisol and slope are strongly and negatively related in naturalistic research (r = -.96), with these two indices likely reflecting complementary, rather than distinct, aspects of diurnal cortisol (Adam & Gunnar, 2001). The hypothesized model accounts for the overlap between self-critical perfectionism and perfectionistic strivings, as shown in past research (Blankstein & Dunkley, 2002); however, perfectionistic strivings was not a primary focus of the present research and was included primarily to test the unique effects of self-critical perfectionism. All hypotheses relevant to cortisol were made using participant sex and menstrual cycle phase as covariates. All other pathways in the model were considered exploratory and no specific hypotheses were made.

Hypothesis 1.1. Previous research has not supported self-critical perfectionism as a direct predictor of diurnal cortisol patterns (Mandel et al., 2018; Wirtz et al., 2007), but

these studies involved relatively small sample sizes and did not account for confounding factors (e.g., sex and hormone cycle). If self-critical perfectionism increases sensitivity to HPA-axis dysregulation directly (specifically via hyper-activation of diurnal cortisol), I expected self-critical perfectionism to predict increased diurnal cortisol intercept and decreased diurnal cortisol slope (i.e., steeper negative trajectory) after controlling for the effects of depressive symptoms, recent daily hassles, sex, and hormone cycle.

Hypothesis 1.2. Because perfectionistic strivings is often associated with adaptive coping processes when isolated from self-critical perfectionism (Dunkley et al., 2017), I hypothesized (a) perfectionistic strivings would be negatively associated with depressive symptoms and (b) perfectionistic strivings would indirectly predict diurnal cortisol through its influence on depressive symptoms (see Hypothesis 1.4b).

Hypothesis 1.3. Although self-critical perfectionism is associated with higher daily stress (Dunkley et al., 2003), research suggests daily hassles do not directly predict HPA-axis activity (Herane-Vives et al., 2018). I hypothesized (a) self-critical perfectionism would be positively associated with recent daily hassles, (b) if a stress generation effect exists for diurnal cortisol, then recent daily stress should predict increased diurnal cortisol intercept and slope, and (c) the indirect effect of self-critical perfectionism on diurnal cortisol intercept and slope through recent daily hassles would be significant if a stress generation effect is present.

Hypothesis 1.4. Research supports self-critical perfectionism as a robust predictor of depressive symptoms (Smith, Sherry, et al., 2016), and recent research suggests depressive symptoms are associated with increased morning cortisol levels and decreased evening cortisol levels (Knorr, Vinberg, Kessing, & Weterslev, 2010). I hypothesized (a)

self-critical perfectionism would uniquely predict depressive symptoms after accounting for the effect of recent daily hassles and perfectionistic strivings, (b) that depressive symptoms would predict increased diurnal cortisol intercept and steeper diurnal cortisol slope over the three-day sampling period, and therefore (c) there would be an indirect effect of self-critical perfectionism on diurnal cortisol intercept and slope through depressive symptoms.

Hypothesis 1.5. Research has supported diathesis-stress models of perfectionism and depressive symptoms, such that perfectionistic people are more vulnerable to depressive symptoms in the context of increased stress (Chang & Rand, 2000; O'Connor et al., 2010). I hypothesized (a) the interaction between self-critical perfectionism and recent daily hassles would predict depressive symptoms, such that depressive symptoms would be highest for people high in self-critical perfectionism who reported high levels of recent daily hassles. Given Hypothesis 2b, I also expected (b) an indirect effect of this interaction on diurnal cortisol patterns through depressive symptoms.

Hypothesis 1.6. Research supports stress reactivity as a key factor in the vulnerability of self-critical perfectionists to depressive symptoms (Hawley et al., 2014; Mandel et al., 2018; Mandel et al., 2015). Self-critical perfectionism may similarly contribute to HPA-axis dysregulation through a similar mechanism, thus contributing to separate psychological and physiological vulnerability given the unique predictive utility of HPA-axis dysregulation in predicting depressive symptoms (Ancelin et al., 2017; Harris et al., 2000). If self-critical perfectionism confers vulnerability to HPA-axis dysregulation through stress reactivity, I hypothesized the interaction between self-critical perfectionism and recent daily hassles would uniquely predict increased diurnal

cortisol intercept and decreased slope, even after controlling for direct effects of self-critical perfectionism, depressive symptoms, and recent daily hassles.

2.2 Method

2.2.1 Procedure

A research ethics board approved my study, which involved an initial lab-based session and cortisol sampling at home over the following three-day period. In the first part, participants attended a research lab at Dalhousie University where they provided informed consent, and completed self-report questionnaires of personality, recent daily stress, depressive symptoms, and other measures not used in the current study. Participants also received instructions regarding the saliva sampling protocol and were assigned cortisol sampling materials at this time. Lab-based sessions occurred between March 2016 and December 2016, excluding the summer semester (May 2016 to September 2016). Between one and three participants attended each lab-based session, although each participant completed questionnaires in a separate room.

During the cortisol sampling period, participants were asked to complete two saliva samples each day (morning and evening) for three consecutive days. Research suggests this sampling protocol yields estimates of baseline cortisol and diurnal slope that correlate highly (r = .92) with more frequent measurement, and that at least three days of sampling are recommended to reliably assess diurnal cortisol intercept and slope (Kraemer et al., 2006). Participants were instructed to complete the morning sample within 15 minutes of waking to avoid capturing the cortisol awakening response and to complete the evening sample 12 hours after the morning sample to capture the diurnal nadir (Kraemer et al., 2006). Before completing samples, participants were instructed to

avoid eating or drinking anything other than water within one hour prior to a sample, brushing their teeth within 30 minutes of a sample, engaging in vigorous exercise within one hour of completing a sample, and drinking alcohol within 12 hours of completing a sample. These instructions were provided according to published guidelines reflecting prior research and best practices for salivary cortisol collection (Nicolson, 2008).

Participants were instructed in how to provide saliva samples and completed a practice sample during the session to ensure participants completed samples as required. The collection protocol for Salivettes™ was based on recommendations from the manufacturer (Sarstedt, n.d.). Participants were instructed to store their samples in the provided containers and to keep the containers in the freezer until samples were returned to the lab. They were discouraged from opening the storage bottles unless necessary and were not told about the tracking capabilities of the MEMS caps. Participants were also provided with a tracking sheet to record self-reported time of awakening each morning, time each sample was completed, and the duration of each sample collection (i.e., length of time the cotton roll was in their mouth), and any deviations from protocol (e.g., consumption of alcohol prior to the sample). Detailed printed instructions for completing samples were also provided to participants.

After the three-day saliva sampling period was complete, participants returned their saliva samples to the lab. Participants were encouraged to keep samples cold during transit using the ice pack provided. Participants were then debriefed about the study and received their compensation for participating (2.5 credits and $5 cash or $30 cash). Samples were promptly labeled and transferred to a laboratory freezer for storage at -20˚C until analysis.

2.2.2 Participants

Participants were recruited using the online psychology participant pool and flyers posted around Dalhousie University. Interested students contacted the lab and completed an online screening questionnaire to determine their eligibility for the study. To be eligible for the study, students needed to indicate they had access to a freezer for sample storage and were excluded if they indicated any of the following: diagnosis of chronic or acute medical or psychiatric conditions, use of psychoactive medication or regular recreational drug use, use of estradiol-based oral contraceptives, or the use of other hormonal treatments. Exclusion criteria were based on recommendations for studies assessing cortisol (Nicolson, 2008, Page et al., 2018). Of those who completed the screening (N = 314), 53.8% were eligible to participate and were invited to schedule their lab-based session to provide informed consent, complete self-report measures, and receive instructions for collecting saliva samples. Oral contraceptive use was the most frequent reason for ineligibility (33.8% of screenings completed). To minimize effects of menstrual cycle variability in my sample, female participants were asked to participate during a time when estrogen levels would be relatively stable (within one week of beginning menses).

A total of 129 students attended the lab-based session. Two students were not included in analyses because saliva samples were not returned to the lab or waking times were not provided during the sampling period. My final sample included 127 undergraduates (72.4% women) with a mean age of 21.0 years (SD = 4.7 years). Participants were primarily Caucasian (51.2%), Asian (15.7%), Middle Eastern (11.0%), Black (9.4%), or mixed/other ethnicity (12.6%). Most were full-time students (96.9%)

and were not employed in addition to their studies (59.8%). The sample included students from first year (30.7%), second year (29.1%), third year (25.2%), and fourth year and above (13.4%). Students were primarily majoring in psychology (22.0%), neuroscience (17.3%), other sciences (26.8%), or were undeclared (21.3%). Women reported being primarily in the follicular phase of their menstrual cycle (80.7%). None of the women indicated being pregnant or nursing.

2.2.3 Measures and Materials

Self-critical perfectionism. Consistent with past research (Clara, Cox, & Enns, 2007; Dunkley et al., 2003; Sherry et al., 2013), I measured self-critical perfectionism as a composite of socially prescribed perfectionism, concern over mistakes, doubts about actions, and self-criticism. All scales measured asked participants to respond based on general tendencies over the past several years. I measured socially prescribed perfectionism using the 5-item short-form of Hewitt and Flett's Multidimensional Perfectionism Scale (HFMPS; Hewitt & Flett, 1991; Hewitt et al., 2008). Each item (e.g., "People expect nothing less than perfection from me") was rated on a 7-point scale from 1 (*strongly disagree*) to 7 (*strongly agree*). In this study, internal reliability of this scale was $\alpha = .78$, 95% CI [.71, .83].

I measured concerns over mistakes (e.g., "If I fail partly, it is as bad as being a complete failure") using the 5-item short-form of Frost et al.'s (1990) Multidimensional Perfectionism Scale (FMPS-SF; Cox, Enns, & Clara, 2002) and I measured doubts about actions (e.g., "Even when I do something very carefully, I often feel that it is not quite right") using the original 4-item subscale from Frost et al.'s (1990) Multidimensional Perfectionism scale. Research demonstrates superior psychometric properties for the

original 4-item doubts about actions subscale compared to the 3-item short-form of this scale (Cox et al.., 2002). Both concern over mistakes and doubts about actions were rated on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). In this study, internal reliability of the concern over mistakes scale was α =.82, 95% CI [.77, .87], and internal reliability of the doubts about actions subscale was α = .83, 95% CI [.78, .87].

I measured self-criticism using a 5-item short form of the self-criticism subscale of the Reconstructed Depressive Experiences Questionnaire (RDEQ-SC; Bagby, Parker, Joffe, & Buis, 1994; Blatt, D'Afflitti, & Quinlan, 1976). Each item (e.g., "I often find that I don't live up to my own standards or ideals") was rated on a 7-point scale from 1 (*strongly disagree*) to 7 (*strongly agree*). Four items from the original RDEQ-SC do not directly reflect self-criticism (e.g., "I never really feel secure in a close relationship") and were removed. The 5-item version of this scale shows similar internal reliability to the original 9-item scale (α = .89 vs. .87), with a high correlation between scale versions (r = .92; Nealis & Sherry, 2017). In this study, internal reliability of the 5-item version of this scale was α = .83, 95% CI [.78, .87].

Research supports the reliability and the validity of each scale (Bagby et al., 1994, Cox et al., 2002; Hewitt et al., 2008). Subscales were standardized, summed, and re-standardized to create the composite. Evidence supports the validity and the reliability for this composite as a whole (Clara et al., 2007), with internal reliability of α = .89, 95% CI [.86, .91] in this study.

Perfectionistic strivings. Consistent with past research, I measured perfectionistic strivings as a composite of three subscales reflecting self-oriented perfectionism and high standards for performance (McGrath et al., 2012). All scales measured asked participants

to respond based on general tendencies over the past several years. I measured self-oriented perfectionism using the 5-item short-form of the HFMPS (Hewitt & Flett, 1991; Hewitt et al., 2008). Each item (e.g., "One of my goals is to be perfect in everything I do") was rated on a 7-point scale from 1 (*strongly disagree*) to 7 (*strongly agree*). In this study, internal reliability of this scale was α = .86, 95% CI [.81, .89].

I measured high standards for performance using the 5-item short form of the personal standards subscale from the FMPS (Cox et al., 2002; Frost et al., 1990). Each item (e.g., "I set higher goals than most people") was rated on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). In this study, internal reliability of this scale was α = 83, 95% CI [.78, .88].

I also used the 4-item self-oriented perfectionism subscale from the Eating Disorders Inventory (EDI; Garner, Olmstead, & Polivy, 1983). Each item (e.g., "I feel that I must do things perfectly or not do them at all") was rated on a 6-point scale from 1 (*never*) to 6 (*always*). In this study, internal reliability of this scale was α = .81, 95% CI [.75, .86].

Research supports the reliability and the validity of each scale (Cox et al., 2002; Hewitt et al., 2008; McGrath et al., 2012). Subscales were standardized, summed, and re-standardized to create the composite. Evidence supports the validity and the reliability of this composite scale as a whole (McGrath et al., 2012). In this study, internal reliability of this composite was α = .91, 95% CI [.89, .94].

Depressive symptoms. I measured depressive symptoms with the 10-item (e.g., "I felt that I could not shake off the blues even with the help from friends or family") short form of the Center for Epidemiological Studies Depression scale (CES-D-SF; Cole,

Rabin, Smith, & Kaufman, 2004). Each item was rated on a 4-point scale from 0 (*rarely or none of the time*) to 3 (*most or all of the time*) based on how often participants felt during the previous two weeks. Research shows the 10-item short form demonstrates similar reliability as the full 20-item version, demonstrates acceptable factor structure, and is correlated highly (r = .75) with other measures of depressive symptoms (e.g., Beck Depression Inventory; see Cole et al. 2004). In this study, internal reliability of this scale was α = .77, 95% CI [.70, .83].

Daily hassles. I measured recent stressful events using the Inventory of College Student's Recent Life Experiences (ICSRLE; Kohn, Lafreniere, & Gurevich, 1990). The 49 items reflected various domains of life stress, including academic (e.g., "finding courses too demanding"), interpersonal (e.g., "conflicts with your family"), and other life stress (e.g., "difficulties with transportation"). Participants responded to each item based on the intensity of their experiences over the past two weeks using a 4-point scale from 1 (*not at all part of my life*) to 4 (*very much part of my life*). All items were summed to provide a total daily hassles score with an internal reliability of α = .90, 95% CI [.88, .93].

Diurnal cortisol. Diurnal cortisol patterns were estimated as a linear function using data from all six saliva samples completed during the three-day sampling period. Saliva samples were obtained using Salivettes™ (Sarstedt, Germany), which are commonly used in the collection of salivary cortisol (Nicolson, 2008). Participants stored completed samples in opaque plastic bottles fitted with Medication Event Monitoring System (MEMS®) caps to electronically log each time participants opened the bottles, which provided electronically verified sample completion time. The MEMS system is

regarded as best practice for measuring protocol adherence for daily cortisol sampling (Kudielka, Broderick, & Kirschbaum, 2003). Bottles were sufficiently large to store three to four Salivettes, and each participant received two containers for sample storage. Participants received a reusable ice pack to keep samples cold when returning them to the lab after the sampling period.

Salivary cortisol concentrations were measured from saliva samples using enzyme-linked immunosorbent assay (ELISA) kits (high sensitivity salivary cortisol ELISA, no. 1-3002; Salimetrics™, USA). Assay kits used a competitive binding technique and have a published sensitivity of <0.007 µg/dL. Samples were analyzed in duplicate and showed low intra-assay variability (CV% < 6). Standard curves using 4-parameter non-linear regression curve fit showed high reliability (r > .99). Assays were performed according to the protocol provided by the manufacturer. Values reflect cortisol concentrations in µg/dL unless stated otherwise. Cortisol concentration values were used in latent growth modeling (see Section 2.2.4 for details) to provide a latent diurnal cortisol intercept (i.e., average waking cortisol concentration across the three-day sampling period) and a latent diurnal cortisol slope (i.e., average within-day rate of change in cortisol concentration during the three-day sampling period). These latent variables were modeled in relation to other study variables in the hypothesized model (see Figure 2.1).

2.2.4 Data Analytic Plan

I tested hypotheses using path analysis with latent growth modeling to estimate diurnal cortisol intercept and slope (see Figure 2.1). To estimate cortisol trajectories, I combined all available cortisol samples across the three-day sampling period when

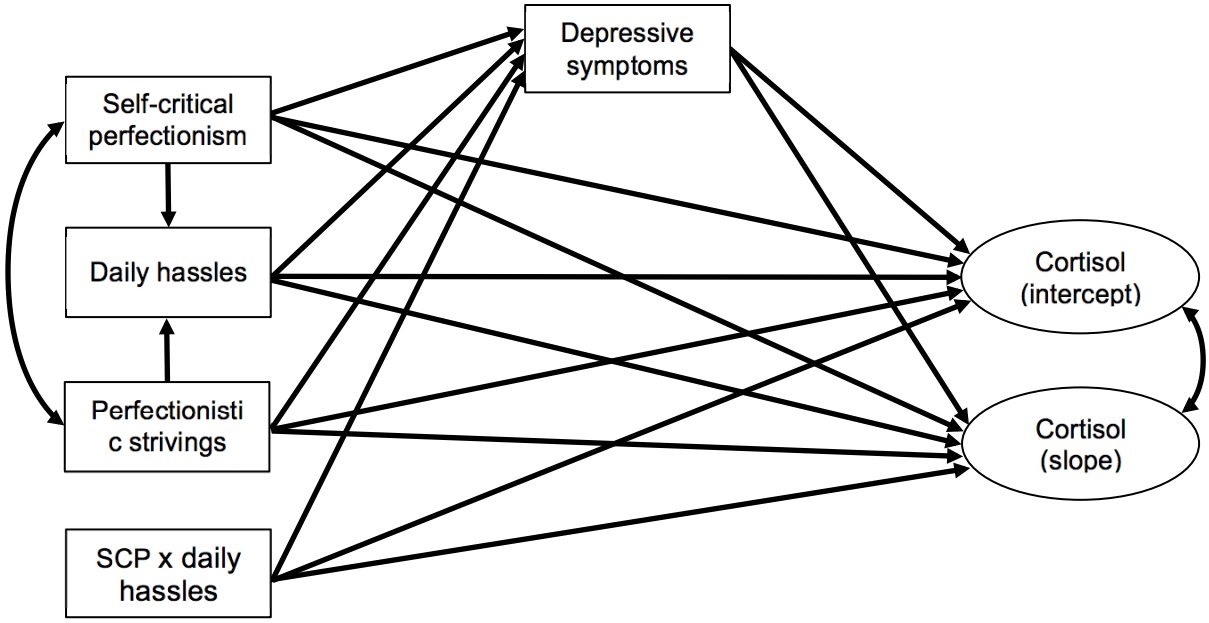

Figure 2.1: The hypothesized path model. Rectangles represent manifest variables and ovals represent latent variables. Single-headed arrows indicate regression paths and double-headed arrows indicate covariance. SCP = Self-critical perfectionism.

modeling latent growth curves to reflect a single aggregated diurnal cortisol pattern during the sampling period, rather than modeling day-specific cortisol trajectories. This method of modeling diurnal cortisol has been used in past research in naturalistic settings (Adam, 2006; Adam & Gunnar, 2001). In contrast to other approaches, such as calculating area under the curve with respect to ground (AUCg; Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003), latent growth modeling allows use of all available cortisol samples rather than requiring complete data on each sampling day. To account for variable sampling times, I modeled latent growth curves with individually varying times of observation. Time scores (τ_n) reflected the MEMS-reported sampling time

relative to self-reported waking time that day (in hours). I specified correlated errors between cortisol samples taken on the same day (see Figure 2.1) to account for day-specific variance (Adam, 2006). Problems with model convergence arising from modeling random slopes with very low variance values were addressed by multiplying cortisol concentrations by a factor of 100 prior to inclusion in the growth model. I included gender and menstrual cycle phase as covariates based on published recommendations (Page et al., 2018). I used self-reported time (in days) since the start of the last menstrual cycle to classify women into follicular phase (≤ 14 days) or luteal phase (> 14 days). Predictors and mediators were standardized.

Indirect effects were tested using a Monte Carlo technique (Preacher, Zyphur, & Zhang, 2010) with 20,000 samples. One-tailed confidence intervals (90%) not including zero indicate a significant indirect effect (Efron & Tibshirani, 1985). Analyses were conducted in Mplus 7.0 (Muthén & Muthén, 2012) using robust maximum likelihood estimation. Simple intercepts and simple slopes were calculated for significant interactions with high versus low groups defined using conditional values of ±1 standard deviation from the mean (Preacher, Curran, & Bauer, 2006). I used Cohen's (1992) criteria to evaluate effect sizes, with correlations and path coefficients of .10 to .30 indicating small effect sizes, correlations of .30 to .50 indicating medium effect sizes, and correlations greater than .50 indicating large effect sizes.

Power analyses indicate a sample of 127 participants will provide accurate and unbiased regression coefficients, variance estimates, and standard errors in planned analyses (Maas & Hox, 2005), with greater than 80% power to detect moderation effects assuming medium effect sizes ($\beta \geq .30$) and an alpha of 0.05 (Shieh, 2009). Medium

effect sizes are expected based on previous research (e.g., Dunkley et al., 2014; Mandel et al., 2018).

2.3 Results

2.3.1 Missing Data and Protocol Compliance

No item-level or scale-level data were missing on self-report questionnaires. Participants provided a total of 729 saliva samples (95.7% compliance), with 95.3% of participants (n = 121) providing complete samples at all six sampling times. One sample did not contain sufficient saliva for analysis. The cortisol awakening response (CAR) peaks between 30 to 45 minutes post waking and reflects a distinct physiological process from diurnal cortisol patterns (Fries et al., 2009). Based on MEMS-reported sampling time, samples provided between 15 and 60 minutes after self-reported waking time (n = 82) were considered to reflect the CAR and were removed from analysis. I used multiple regression to test the potential impact of food and alcohol consumption, brushing teeth, and vigorous exercise prior to sampling. After controlling for the time of sampling (i.e., morning or evening), these factors did not significantly affect cortisol concentration, $F(4, 727) = .39$, $p = .82$, and were retained for analysis. Time of sampling could not be determined for 27 samples (3.8%) because MEMS data indicated failure to follow protocol (e.g., no samples completed within the expected time period). Complete MEMS data were available for a majority of participants (n = 117; 92.1%). Final analyses included 619 cortisol samples (84.9% of provided samples), with an average of 5.3 samples (SD = 0.9) per person. Path analysis used full information maximum likelihood in Mplus (Muthén & Muthén, 2012) to address missing data. This method provides less biased estimates than other methods (e.g., listwise deletion) when all available data are

included in analysis (Acock, 2005).

2.3.2. Comparison of Self- and MEMS-Reported Sampling Time

Self-reported sampling time and MEMS sampling time data were highly correlated (r = .97). MEMS sampling times (n = 689) were within 15 minutes of self-report times for 75.3% of samples and within 30 minutes for 82.1% of samples. To verify whether MEMS-reported sampling time provided superior model fit compared to self-reported sampling time, I conducted latent growth curve analyses (without covariates in the model) using time scores from each method. I compared model fit using Akaike Information Criterion (AIC) values, with smaller values indicating better fit. MEMS-reported sampling time showed superior fit (AIC = -829.51) compared to self-report (AIC = -808.60). Mean intercept and slope were comparable between models and showed strong correlations (rs = .99 and .97, respectively). The latent growth model for diurnal cortisol thus used time scores based on MEMS-reported sampling time.

2.3.3 Path Analysis

Table 2.1 shows descriptive statistics and bivariate correlations and Figure 2.2 shows results of the path model. Menstrual cycle phase and gender were included as covariates in the path model, but were omitted from Figure 2.1 to maintain clarity of presentation. Menstrual cycle phase did not show a significant relation with diurnal cortisol intercept (β = 7.94, p = .05) or slope (β = -0.36, p = .24), although the former trended toward significance. Gender did not show unique significant effects on diurnal cortisol intercept (β = -0.13, p = .98) or slope (β = 0.48, p = .15).

Hypothesis 1.1. Contrary to hypotheses, self-critical perfectionism did not significantly predict diurnal cortisol intercept (β = .29, *p* = .15) or slope (β = -.25, *p* = .24) when accounting for covariates and all other effects in the model.

Hypothesis 1.2. As hypothesized, perfectionistic strivings was significantly and negatively associated with depressive symptoms (β = -.17, *p* = .03) when accounting for the overlap between perfectionistic strivings and self-critical perfectionism (Hypothesis 1.2a). The demonstrated effect size was small. There was a significant indirect effect of perfectionistic strivings on diurnal cortisol intercept (CI 90% [0.03, 1.35]) and slope (CI 90% [-0.100, -0.004]), indicating perfectionistic strivings was associated with a higher diurnal cortisol intercept and more shallow diurnal cortisol slope (Hypothesis 1.2c).

Hypothesis 1.3. As hypothesized, self-critical perfectionism was positively and significantly associated with recent daily hassles (β = .59, *p* < .001) but recent daily hassles did not significantly predict diurnal cortisol intercept (β = .03, *p* = .85) or slope (β = .05, *p* = .76). The association between self-critical perfectionism and recent daily hassles showed a large effect size. The indirect effect of self-critical perfectionism on diurnal cortisol intercept (CI 90% [-1.53, 1.98]) and slope (CI 90% [-0.11, 0.15]) was not significant.

Hypothesis 1.4. As hypothesized, self-critical perfectionism was positively associated with recent depressive symptoms (β = .53, *p* < .001) with a large effect size (Hypothesis 1.4a). Predictions about the relation between depressive symptoms and diurnal cortisol patterns (Hypothesis 1.4b) were mixed. Results showed recent depressive symptoms significantly predicted diurnal cortisol intercept (β = -.32, *p* = .04) and slope (β = .33, *p* = .03) over the three-day sampling period (medium effect sizes), but higher

Table 2.1

Bivariate Correlations and Descriptive Statistics for Self-report Measures and Cortisol Growth Factor Scores

Scale	1	2	3	4	5	6
1. Self-critical perfectionism	–	.61*	.62*	.57*	.17	-.12
2. Perfectionistic strivings		–	.42*	.22*	.13	-.10
3. Daily hassles			–	.53*	.07	-.04
4. Depressive symptoms				–	-.03	.04
5. Cortisol intercept (μg/dL)					–	-.98*
6. Cortisol slope (μg/dL/hr)						–
Mean	–	–	95.16	8.14	0.35	-0.02
Standard deviation	–	–	18.77	4.68	0.11	0.01
Possible range	–	–	49 – 196	0 – 30	–	–
Minimum	–	–	53.0	0.0	0.13	-.05
Maximum	–	–	138.0	22.0	0.74	-.01

Note. Cortisol growth factors were calculated using latent growth analysis with individually varying times of observation; menstrual cycle phase and gender were included as covariates. * = $p < .05$.

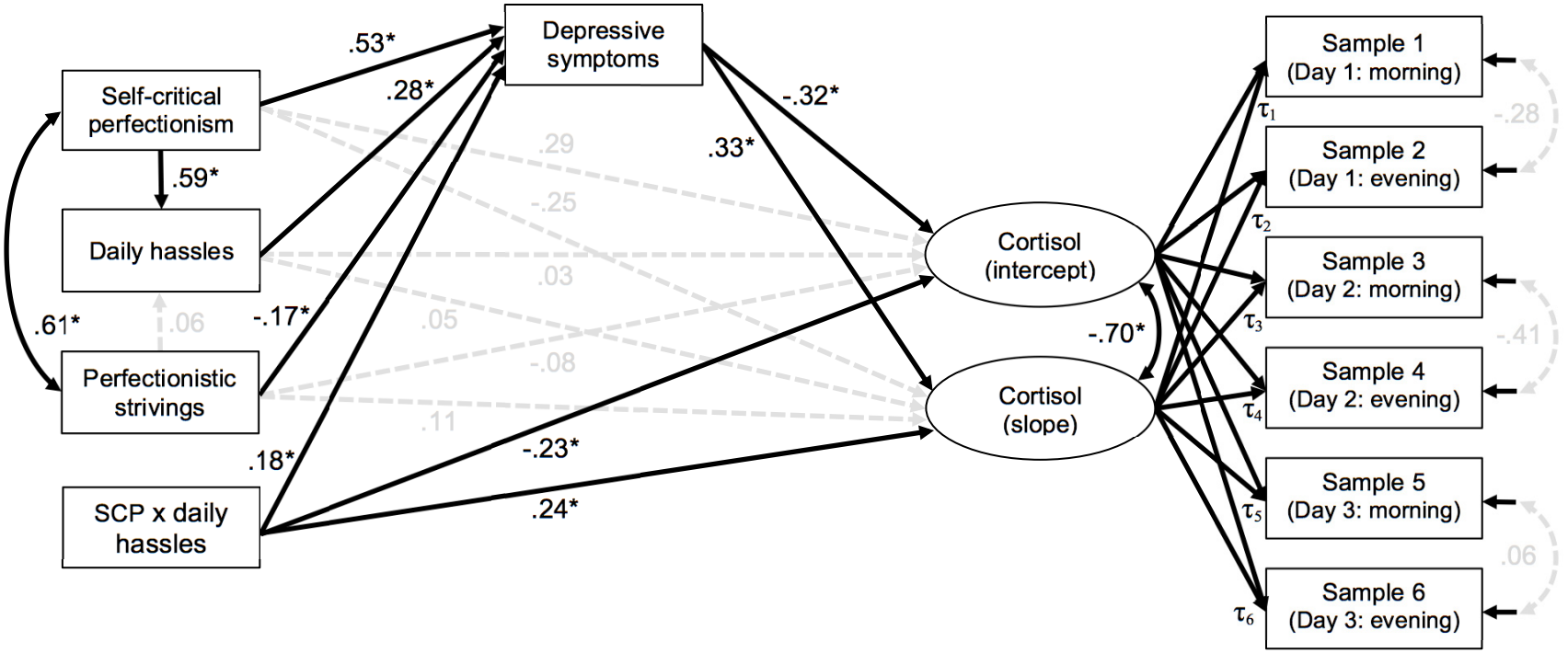

Figure 2.2: Path analysis with diurnal cortisol patterns (intercept and slope) modeled using latent growth modeling. The latent growth model used individually varying times of observation based on MEMS-reported sampling time relative to self-reported waking time on that day, with time scores indicated by τ_n. Correlated error terms between cortisol samples account for day-specific variance. Covariates (i.e., menstrual cycle phase and gender) were included in analysis but are not shown to maintain model clarity. Rectangles represent manifest variables and ovals represent latent variables. Single-headed arrows indicate regression paths and double-headed arrows indicate covariance. Grey dashed lines indicate non-significant paths. Parameter estimates are standardized. SCP = Self-critical perfectionism. * = $p < .05$.

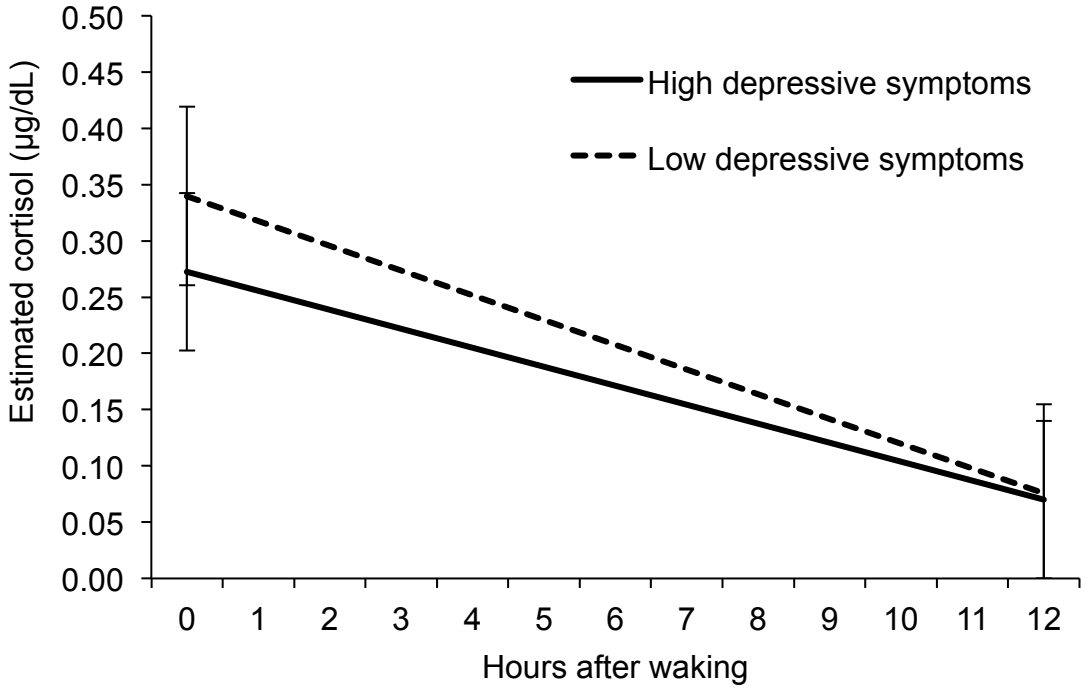

Figure 2.3 Interaction of depressive symptoms (high vs. low) by time (hours after waking) on estimated diurnal cortisol trajectories. Cortisol trajectories were calculated using latent diurnal intercept and latent diurnal slope derived from latent growth analysis (see Figure 2.1). Conditional values for depressive symptoms were defined as ±1 standard deviation from the mean and conditional values of time on the x-axis were chosen to reflect cortisol concentrations at waking and 12 hours post waking (i.e., evening). Error bars are 95% confidence intervals.

depressive symptoms predicted lower diurnal intercept and higher slope, rather than the opposite pattern as hypothesized. There was a significant indirect effect of self-critical perfectionism on diurnal cortisol intercept (CI 90% [-3.55, -0.30]) and diurnal cortisol slope (CI 90% [0.03, 0.27]) through depressive symptoms (Hypothesis 1.4c), indicating self-critical perfectionism was associated with a lower diurnal cortisol intercept and more shallow diurnal cortisol slope through its association with depressive symptoms.

Path estimates from the model were used to plot the interaction between depressive symptoms and time (i.e., morning to evening) on cortisol levels and to calculate simple intercepts and slopes (see Figure 2.3). Calculations used a latent growth curve analysis framework for two-way interactions (see Preacher et al., 2006) and 95% confidence intervals indicated patterns of significance. Simple intercepts and slopes were significant, although confidence intervals indicated no significance difference in intercepts and slopes between people who reported higher levels of recent depressive symptoms (simple intercept = 0.272, 95% CI [0.202, 0.342], $Z = 7.62$, $p < .001$; simple slope = -0.017, 95% CI [-0.022, -0.011], $Z = 6.11$, $p < .001$) and people who reported low levels of recent depressive symptoms (simple intercept = 0.340, 95% CI [0.239, 0.374], $Z = 8.40$, $p < .001$; simple slope = -0.022, 95% CI [-0.028, -0.016], $Z = 7.12$, $p < .001$) when high and low groups were classified as one standard deviation above and below the mean, respectively.

Hypothesis 1.5. As hypothesized, the interaction between self-critical perfectionism and recent daily hassles was positively and significantly associated ($\beta = .18$, $p = .01$) with recent depressive symptoms (Hypothesis 1.5a). The effect size was small. There was a significant indirect effect of this interaction on diurnal cortisol intercept (CI 90% [-1.30, -0.07]) and slope (CI 90% [0.01, 0.10]) through its association with depressive symptoms (Hypothesis 1.5b), such that stress reactivity (the interaction between self-critical perfectionism and recent daily hassles) was associated with decreased diurnal cortisol intercept and more shallow diurnal cortisol slope.

Path estimates from the model were used to plot the interaction between self-critical perfectionism and recent daily hassles on depressive symptoms (see Figure 2.4)

and to calculate simple intercepts and slopes. Calculations used a multiple regression framework for two-way interactions (see Preacher et al., 2006) and 95% confidence intervals indicated patterns of significance. Results indicate significantly higher depressive symptoms for people reporting high levels of recent daily stressors (simple intercept = 0.29, 95% CI [-0.06, 0.65], $t = 1.60$, $p = .11$) compared to people who reported low levels of recent daily stressors (simple intercept = -0.27, 95% CI [-0.65, 0.12], $t = -1.35$, $p = .18$) when aggregating across level of self-critical perfectionism. For people who reported low daily hassles, depressive symptoms were significantly higher for people high in self-critical perfectionism than people lower in this trait (simple slope = 0.35, 95% CI [0.15, 0.56], $t = 3.40$, $p < .001$). As per hypothesis 1.5, people who reported high daily hassles and had high levels of self-critical perfectionism showed significantly higher depressive symptoms than people who reported high daily hassles and had low levels of self-critical perfectionism (simple slope = 0.70, 95% CI [0.40, 1.01], $t = 4.49$, $p < .001$).

Hypothesis 1.6. As hypothesized, the interaction between self-critical perfectionism and recent daily hassles significantly predicted diurnal cortisol intercept ($\beta = -.23$, $p = .04$) and slope ($\beta = .24$, $p = .04$). Both effect sizes were small. Similar to Hypothesis 1.4b, the direction of effects was opposite to what was hypothesized.

Path estimates from the model were used to plot the interaction of self-critical perfectionism, recent daily hassles, and time (i.e., morning to evening) on cortisol levels (see Figure 2.5) and to calculate simple intercepts and slopes. Calculations used a latent growth curve analysis framework for three-way interactions (see Preacher et al., 2006) and 95% confidence intervals indicated patterns of significance. Contrary to hypothesis

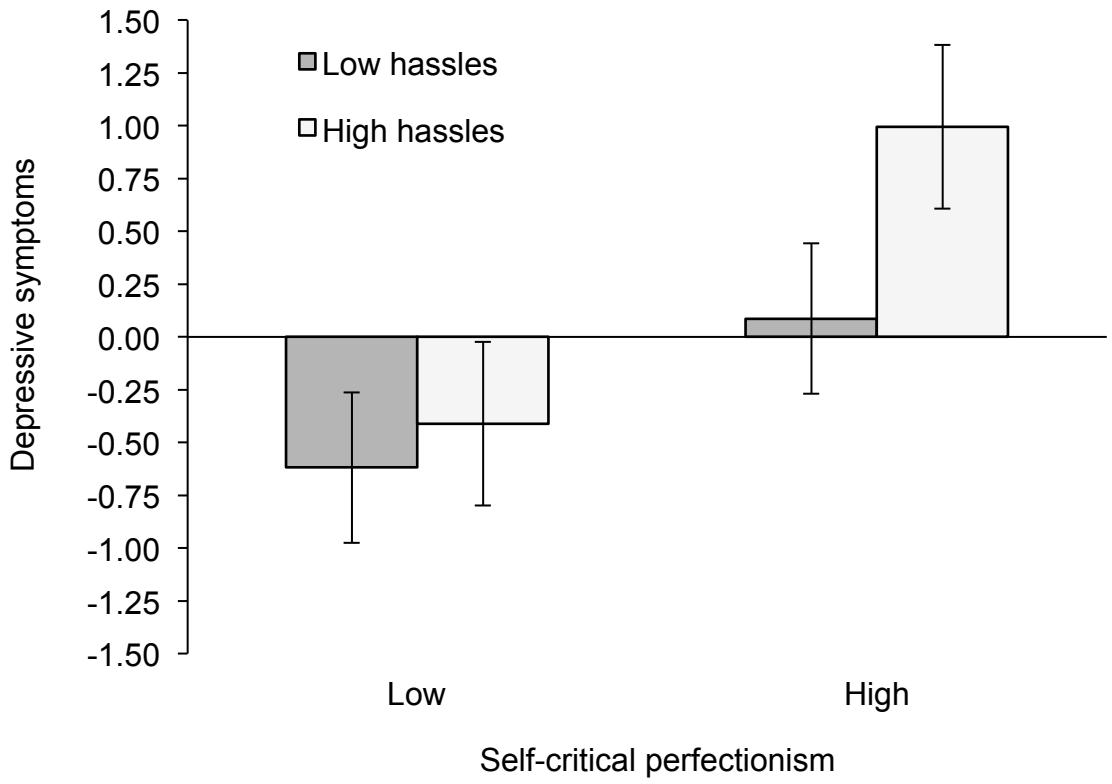

Figure 2.4 Interaction plot showing the effect of self-critical perfectionism (high vs. low) and daily hassles (high vs. low) on depressive symptoms. Depressive symptoms reflect standardized (*Z*) scores. Conditional values for self-critical perfectionism and daily hassles were defined as ±1 standard deviation from the mean. Error bars are 95% confidence intervals.

1.6, diurnal cortisol trajectories were not significantly different between people high in self-critical perfectionism (simple intercept = 0.315, 95% CI [0.242, 0.388], $z = 8.47$, $p < .001$; simple slope = -0.019, 95% CI [-0.024, -0.013], $z = 6.90$, $p < 001$) and people low in self-critical perfectionism (simple intercept = 0.304, 95% CI [0.204, 0.404], $z = 5.96$, $p < .001$; simple slope = -0.019, 95% CI [-0.027, -0.011], $z = -4.76$ $p < .001$) who also reported high recent daily hassles (see Figure 2.5b). Instead, the differences were evident for those reporting low levels of recent daily stress (see Figure 2.5a), with people high in

self-critical perfectionism showing significantly higher intercept and slope (simple intercept = 0.358, 95% CI [0.258, 0.458], $z = 7.02$, $p < .001$; simple slope = -0.024, 95% CI [-0.031, -0.016], $z = -5.52$, $p < .001$) compared to people low in self-critical perfectionism (simple intercept = 0.247, 95% CI [0.164, 0.330], $z = 5.87$, $p < .001$; simple slope = -0.016, 95% CI [-0.022, -.009], $z = -4.73$, $p < .001$).

2.4 Discussion

The goal of this research was to better understand the relation between perfectionism and HPA-axis dysregulation (i.e., atypical diurnal cortisol patterns), which is associated with increased vulnerability to depressive symptoms over time (e.g., Ancelin et al., 2017) and may represent a unique mechanism for depression vulnerability in perfectionistic people. The study had two objectives within this broad goal. The first was to conduct a rigorous test of the association between perfectionism domains (i.e.,perfectionistic strivings and self-critical perfectionism) and diurnal cortisol patterns by addressing for the methodological limitations of past research. The second objective was to test stress reactivity hypotheses in relation to HPA-axis activity to determine whether physiological stress reactivity (i.e., vulnerability to HPA-axis dysregulation) might represent a distinct vulnerability from emotional stress reactivity (i.e., vulnerability to depressive symptoms). Overall, results suggested self-critical perfectionism impacts HPA-axis activity in myriad ways that are influenced indirectly by depressive symptoms but unfold primarily through stress reactivity.

In relation to the first objective, results showed no direct effects of perfectionism domains on diurnal cortisol patterns, although indirect effects through depressive

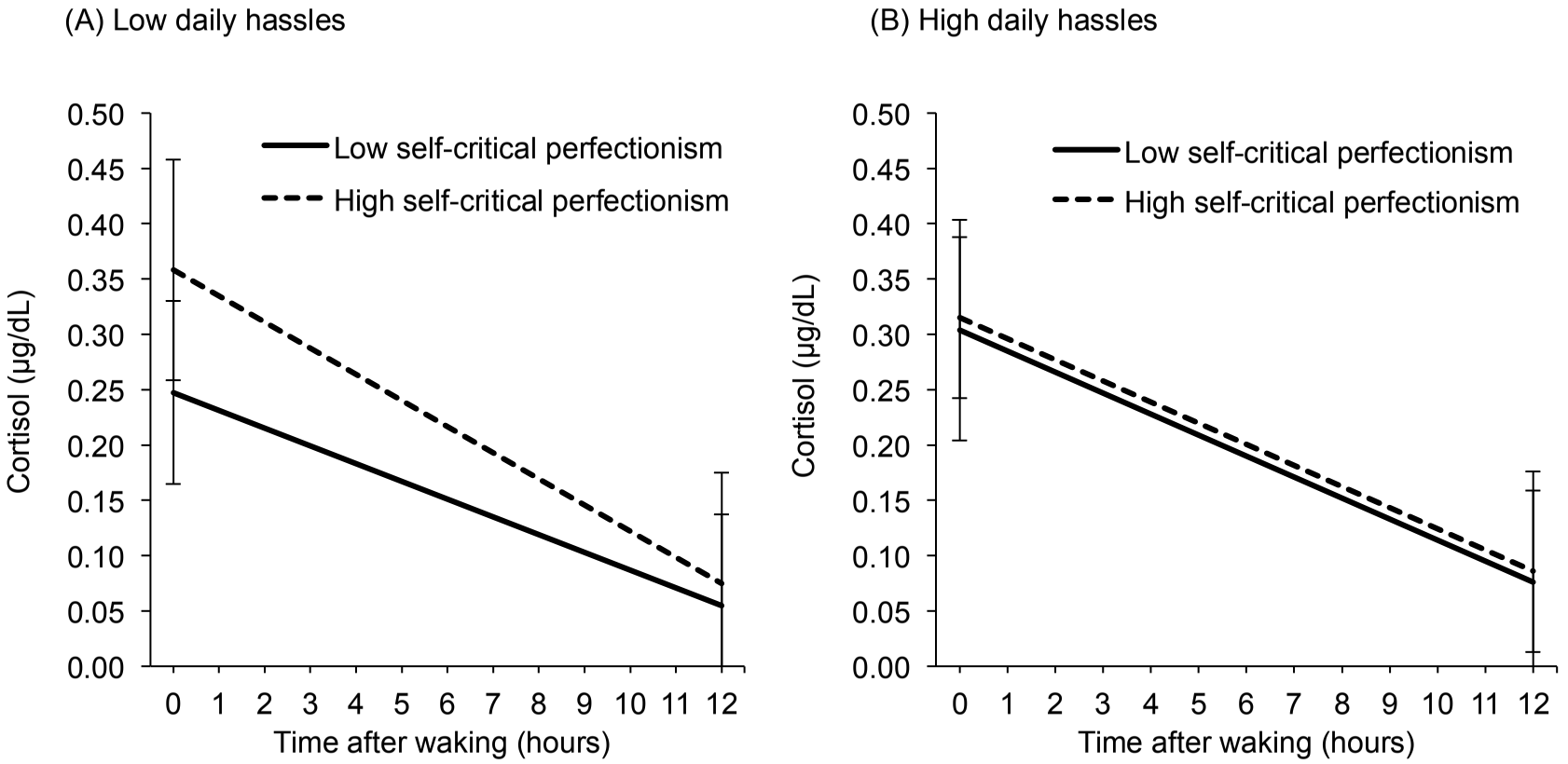

Figure 2.5 Interaction plot of self-critical perfectionism (low vs. high) by daily hassles (high vs. low) by time (hours after waking) on estimated diurnal cortisol trajectories. Cortisol trajectories were calculated using latent diurnal intercept and latent diurnal slope derived from latent growth analysis (see Figure 2.2). Conditional values for self-critical perfectionism and daily hassles were defined as ±1 standard deviation from the mean and conditional values of time on the x-axis were chosen to reflect cortisol concentrations at waking and 12 hours post waking (i.e., evening levels).. Error bars are 95% confidence intervals.

symptoms were supported. Despite a larger sample size, use of multiple sampling days, and accounting for potential confounding factors (e.g., gender, oral contraceptive use, menstrual period phase), results of this study were consistent with past research (Mandel et al., 2018; Wirtz et al., 2007) and did not demonstrate a direct association between self-critical perfectionism and diurnal cortisol as hypothesized (Hypothesis 1.1). In context of the other findings of this study and similar to Mandel et al. (2018), this was not taken to suggest self-critical perfectionism was unrelated to HPA-axis functioning, but rather that the association likely manifests under particular conditions or through intermediary processes that may not be immediately evident through direct effects alone.

As expected (Hypothesis 1.2), perfectionistic strivings showed no direct association with diurnal cortisol, while showing a small negative association with depressive symptoms after accounting for the effects of self-critical perfectionism. Through this small negative association with depressive symptoms, perfectionistic strivings demonstrated indirect protection against the HPA-axis blunting associated with depressive symptoms (see Hypothesis 1.4). Perfectionistic strivings has been associated with sensitivity to achievement-related stress under certain conditions (e.g., with concurrent depressive symptoms; La Rocque et al., 2016) and uniquely predicts depressive symptoms beyond self-critical perfectionism and neuroticism (Smith, Sherry, et al., 2016). However, it has also demonstrated uniquely adaptive qualities in stress-related research with notable associations with adaptive coping (e.g., Dunkley et al., 2017). Results from the current study thus support perfectionistic strivings as showing

modest protective qualities in relation to stress when considered alongside self-critical perfectionism.

As predicted (Hypothesis 1.3), self-critical perfectionism was positively associated with recent daily hassles consistent with stress generation theory (Bolger & Zuckerman, 1995; Hewitt & Flett, 2002) and past research (e.g., Dunkley et al., 2003). Self-critical perfectionism did not predict HPA-axis dysregulation through this association, however. This is consistent with research showing no apparent association between recent daily hassles and diurnal cortisol activity (Herane-Vives et al., 2018). Higher daily stressors would presumably result in higher overall levels of cortisol; however, coping adaptively to those demands could result in a "net zero" effect on physiological stress processes (Drake, Sladek, & Doane, 2016). Thus, only maladaptive or ineffective coping patterns, which are thought to underlie stress reactivity (Bolger & Zuckerman, 1995), would result in overall changes in diurnal cortisol patterns.

As hypothesized, self-critical perfectionism demonstrated indirect effects on diurnal cortisol intercept through depressive symptoms (Hypothesis 1.4). Rather than depressive symptoms being associated with elevated morning cortisol levels and decreased evening levels, as shown in past research (Knorr et al., 2010), the results of this study showed depressive symptoms predicted blunted morning cortisol levels. This blunting effect may be most evident at higher levels of depressive symptoms (e.g., two standard deviations above the mean), as comparisons at more moderate levels (i.e., one standard deviation above the mean versus one standard deviation below the mean) did not show a statistical difference based on simple intercepts and simple slopes analysis.

This discrepancy reflects a broader contradiction in the field; meta-analysis suggests substantial variability in effects, with some studies showing depressive symptoms are associated with higher morning cortisol, while others show the opposite (Knorr et al., 2010). This may reflect a complex relationship between stress, depressive symptoms, and HPA-axis functioning, with certain experiences of depression being associated with increased waking cortisol (e.g., social threat and shame), while other experiences are associated with decreased waking cortisol (e.g., uncontrollability and loss; Miller et al., 2007). Timing has also been suggested to explain equivocal findings, with recent distress linked to elevations in daily cortisol levels and more chronic and pervasive distress linked to decreased levels (Miller et al., 2007). Blunting effects may also be more prominent with specific manifestations of depressive symptoms, such as atypical depression marked by increased mood reactivity and interpersonal sensitivity (Herane-Vives et al., 2018). Given self-critical perfectionism is frequently associated with these characteristics (Flett, Besser, & Hewitt, 2014; Mandel et al., 2015), the possible heterogeneity of depressive symptoms in self-critical perfectionism and the impact on HPA-axis activity remains a compelling area for research.

The most notable results from this study relate to stress reactivity. Consistent with research showing stress reactivity confers vulnerability to depressive symptoms in self-critical perfectionism (e.g., Hawley et al., 2014; Mandel et al., 2015), the current study suggests people high in self-critical perfectionism are most vulnerable to depressive symptoms in the context of high daily hassles (Hypothesis 1.5). These findings reflect previously demonstrated diathesis-stress models of perfectionism (Chang & Rand, 2000; O'Connor et al., 2010). When considered together with the demonstrated blunting effects

of depressive symptoms (see Hypothesis 1.4), self-critical perfectionism may contribute to HPA-axis dysregulation, in part, though emotional stress reactivity (i.e., increased depressive symptoms in response to stress). This pathway was seemingly unique from, and independent of, the direct effect of stress reactivity on diurnal cortisol (i.e., physiological stress reactivity; see Hypothesis 1.6).

Contrary to predictions (Hypothesis 1.6), people high in self-critical perfectionism did not demonstrate increased activation of the HPA-axis in combination with high levels of recent daily hassles as would be expected with stress reactivity. Results supported the opposite—self-critical perfectionism was associated with an increase in cortisol activity, compared to people low in self-critical perfectionism, when accompanied by low daily hassles. Several possibilities could explain this pattern. First, people high in both self-critical perfectionism and recent daily hassles showed the greatest levels of depressive symptoms (Hypothesis 1.5), and depressive symptoms demonstrated a blunting effect on diurnal cortisol intercept (Hypothesis 1.4). This blunting effect may have suppressed diurnal cortisol activity when self-critical perfectionists would presumably be most prone to physiological stress.

Second, people high in self-critical perfectionism may be prone to high diurnal cortisol during periods of low stress due to a prolonged stress response (e.g., through chronic stress or rumination; Brosschot et al., 2006), such that the HPA-axis is chronically active instead of fluctuating based on life demands. Rather than self-critical perfectionists showing more stress reactivity than people low on this trait, they seemingly show less because their HPA-axis may be chronically activated. Research suggests self-critical perfectionists are vulnerable to both chronic stress (e.g., Békés et al., 2015) and

negative repetitive thinking patterns (e.g., Macedo et al., 2015; Short & Mazmanian, 2013), which could perpetuate the stress response. Chronic activation of the HPA-axis and the blunting effects of depressive symptoms during periods of high stress could thereby obscure any direct effects of self-critical perfectionism on the HPA-axis, both in past research and the current study. Thus, stress reactivity remains of critical importance for future research in this area.

Overall, the results of this study suggest self-critical perfectionists find themselves in an impossible position. Such a person tends to experience their day-to-day lives as more stressful than others, including a subjective sense of being stressed by life and a chronic activation of the HPA-axis—even when daily demands are relatively low. Self-critical perfectionists are particularly vulnerable to depressive symptoms during periods of acute stress, and depressive symptoms seemingly blunt HPA-axis activity. Rather than experiencing an increase in HPA-axis activity to deal with these demands, the self-critical perfectionist experiences little or no increase in the physiological processes meant to maintain optimal functioning during times of stress. With abnormal HPA-functioning linked to increased risk of depressive symptoms over time (e.g., Harris et al., 2000), the chronic activation of this system may predispose the self-critical perfectionist to future depressive symptoms that reinforce this pattern. These results represent merely a snapshot of these associations, however, and further research is needed to replicate these findings and understand how these processes unfold, and influence each other, over time.

2.4.1 Theoretical and Clinical Implications

These results point toward the emergence of a bio-psycho-social model of perfectionism, stress, and depressive symptoms. Extant research focuses predominantly on psychological and interpersonal factors that increase susceptibility to depressive symptoms, but the present study supports the unique importance of physiological processes in contributing to that vulnerability. Physiological measures are sometimes included solely as a means for overcoming self-report bias, yet the real strength of such measures is that they capture distinct underlying mechanisms that are uniquely and incrementally important for understanding psychological phenomena (Semmer, Grebner, & Elfering, 2004). Results also highlight the importance of thorough investigation of stress reactivity when attempting to understand the relation between perfectionism and physiological measures. Although direct effects may not be apparent, subtle and indirect effects may nevertheless yield critical new insights.

Multiple pathways of vulnerability (i.e., emotional reactivity and physiological reactivity) imply a need for multiple treatment targets. Helping perfectionistic people cope more effectively with life stress while restructuring distorted thoughts may buffer emotional stress reactivity, but other interventions may be necessary to reduce the prolonged physiological activation that may keep depression vulnerability high. Mindfulness-based strategies may help clients learn to observe and de-center from negative repetitive thoughts in a way that reduces rumination and neural reactivity to internal stimuli, which contribute to depressive symptoms (Paul, Stanton, Greeson, Smoski, & Wang, 2012). Initial randomized control trials have shown promise, with mindfulness-based interventions improving self-compassion and decreasing rumination

in perfectionistic people (James & Rimes, 2018). Whether using mindfulness-based interventions with perfectionistic clients shows efficacy in reducing vulnerability to depression over time remains to be tested.

2.4.2 Limitations and Future Directions

I focused on psychological and physiological aspects of stress and vulnerability to depressive symptoms, but interpersonal aspects were not included in this study. Research is needed to integrate these findings in other frameworks (e.g., social disconnection model; Hewitt, Flett, Sherry, & Celian, 2006). My research design involves temporal separation between self-report questionnaires and cortisol measurement, but a multi-wave longitudinal study is needed to test these pathways more rigorously. Although personality traits were conceptualized as stable factors thought to precede more recent transient experiences (depressive symptoms and daily hassles), all self-report questionnaires were completed at a single measurement occasion and temporal separation cannot be assumed. Multi-wave designs may also be needed to better differentiate between the effects of recent depressive symptoms and daily hassles versus those occurring concurrently with cortisol sampling. I used MEMS caps to record time of sampling to overcome limitations of self-report, but I relied on self-report to assess waking time and menstrual cycle phase. Future research might use objective measures of waking (e.g., actigraph watches) and assessment of hormone levels using saliva to more accurately account for menstrual phase. Though I excluded those who reported taking oral contraceptives and psychoactive medications to reduce confounds for cortisol measurement (Nicolson, 2008), this control reduces generalizability. Although research supports the cortisol sampling strategy and analytic approach used in this study (Adam, 2006; Kraemer et al., 2006), these results

should be replicated with more frequent daily measurement. Research using community and clinical samples would also be needed to demonstrate generalizability of results beyond a student sample.

2.4.3 Concluding Remarks

People who demonstrate self-critical perfectionism find themselves vulnerable to depressive symptoms through a multitude of factors spanning psychological processes (e.g., discrepancies, stress appraisals, coping), social experiences (e.g., relational discord, interpersonal stress), and physiological vulnerabilities (e.g., HPA-axis dysregulation). Although psychosocial perspectives abound in perfectionism research, physiological dimensions of stress and depression remain poorly understood in this area. In the present research, I provide novel insights into the distinct ways self-critical perfectionism confers risk for depressive symptoms and HPA-axis dysregulation through stress reactivity. Consideration of physiological mechanisms yielded important insights into depression risk, and further work in this area is needed to clearly identify assessment and treatment targets that will help clinicians treat perfectionistic clients more effectively. Researchers are encouraged to more carefully consider physiological processes to support development of a bio-psycho-social framework of perfectionism, stress, and depression.

Chapter 3: Linking Study 1 And Study 2

The results of Study 1 fill a notable gap in the literature by demonstrating how self-critical perfectionism, and associated stress reactivity, make people vulnerable to depressive symptoms directly through stress reactivity and indirectly through HPA-axis dysregulation, which puts people at risk for depressive symptoms over time (e.g., Ancelin et al., 2017). Thus, physiological stress reactivity may contribute to a feedback loop that perpetuates depressive symptoms through multiple pathways. This research is unique in demonstrating the role of perfectionism in diurnal cortisol patterns and extends previous research by highlighting the importance of stress reactivity for both emotional distress and physiological stress. Despite the important contribution of this research and its methodological strengths, the possible mechanisms through which self-critical perfectionism might impact prolonged HPA-axis activity remain uncertain and further conceptual and methodological improvements are needed to better understand what makes perfectionistic people uniquely vulnerable to stress and stress-related phenomena. This chapter describes necessary conceptual (e.g., consideration of higher-order personality traits and more diverse stress sequelea) and methodological advances (e.g., daily measurement of outcomes and the use of a more representative sample) that I address in Study 2.

3.1 Shared and Unique Effects of Perfectionism and Neuroticism

Research on personality vulnerability frequently differentiates between higher-order traits (e.g., neuroticism) and lower-order traits (e.g., perfectionism). Whereas neuroticism is thought to capture a broad and pervasive tendency to experience negative emotions and associated thoughts and behaviour, perfectionism is thought to capture

characteristic, and specific, patterns of thought and behaviour that contributes to psychological maladjustment.

Evidence suggests self-critical perfectionism can be differentiated from neuroticism by its associations with maladaptive interpersonal behaviour (e.g., defensiveness) and negative self-perception (Dunkley, Blankstein, Zuroff, Lecce, & Hui, 2006). Moreover, ample research supports perfectionism, particularly self-critical perfectionism, as a unique predictor of depressive symptoms, over and above neuroticism (Békés et al., 2015; Dunkley et al., 2012; Sherry, Gautreau, Mushquash, Sherry, & Allen, 2014; Smith, Sherry, et al, 2016). However, other research has shown no unique effects of perfectionism beyond neuroticism in tests of diathesis-stress and specific vulnerability models (Enns, Cox, & Clara, 2005), and limited unique effects in tests of stress reactivity and coping ineffectiveness (Dunkley et al., 2014). Thus, the unique importance of perfectionism cannot be dismissed or assumed, and research is needed to differentiate perfectionism and neuroticism when testing models of stress.

While the results of Study 1 support an important role of stress processes and rumination in predicting HPA-axis dysfunction and depressive symptoms, this study was not able to account for whether these effects might be specific to perfectionism, or if they reflect a higher-order vulnerability associated with neuroticism. Recent research supports the importance of moving from tests of incremental prediction to tests of specificity (e.g., Naragon-Gainey & Watson, 2018), and an emphasis on specificity in perfectionism and stress research may yield a more nuanced understanding of how perfectionism exerts shared and unique effects on stress and psychological adjustment alongside neuroticism.

3.2 Stress Sequelea Beyond Depressive Symptoms

Study 1 focused primarily on depressive symptoms and HPA-axis dysregulation as outcomes of stress, yet this overlooks the myriad ways stress can impact psychological and physiological functioning. People can feel emotionally upset and "worn down" by their daily experiences without necessarily suffering from depressive symptoms, and thus consideration of broader emotional and physiological experiences is necessary to capture the sequelea of stress. Other published models of perfectionism and stress processes have focused on a broad range of emotional experiences in assessing the impact of stress. For example, research by Dunkley and colleagues (e.g., Dunkley et al., 2017; Dunkley, Ma, et al., 2014; Dunkley et al., 2003) frequently use measures of positive and negative affect to determine psychological adjustment to daily stress experiences. Other work has added more specificity to these outcomes by considering emotional distress as a composite of sadness, anger, and anxiety (e.g., Cranford et al., 2006).

Aside from feeling upset about experiences, people can also feel worn down by them. Although fatigue is infrequently studied in stress literature, empirical evidence suggests stress and fatigue are closely related and bi-directional (Doerr et al., 2015), with prolonged fatigue increasing vulnerability to burnout, emotional maladjustment, and physical health problems (Kop & Kupper, 2016; Leone, Huibers, Knottnerus, & Kant, 2008). The cumulative effects of stress can also tax physiological systems, as reflected in previous descriptions of allostatic load, which describes the total burden on a person's physiological capacity to flexibly adapt to changing environmental demands (McEwen, 1998). Inclusion of physiological markers of allostatic load (e.g., heart rate variability;

McEwen, 2015) in models of perfectionism and stress may help explain the demonstrated links between perfectionism and long-term health problems (Fry & Debats, 2009).

3.3 Benefits of Daily Measurement

Cortisol was measured twice daily over a three-day period in Study 1 to provide a reliable estimate of diurnal cortisol activity during that time. Despite the strengths of this design for assessing daily cortisol, it was only capable of providing a snapshot of physiological processes at a single point in time. As research on the perfectionism-stress link advances, intensive measurement is increasingly becoming necessary to study day-to-day processes as they unfold over time. Study 1 provided promising new insights into the role of perfectionism, rumination, and physiological stress that requires further study with more rigorous methodology.

Daily diary research is ideally suited to study how stress, rumination, and distress unfold during day-to-day life. When combined with advanced statistical modeling techniques (e.g., multilevel path analysis), daily diary designs allow researchers to test how experiences unfold within daily experience (i.e., within-person effects) and how those experiences differ based on individual differences (i.e., between-person effects). Intensive daily measurement also reduces recall bias due to daily measurement, increases reliability due to repeated assessments, and increases ecological validity due to measurement in the context of a person's daily experience (Bolger, Davis, & Rafaeli, 2003).

While cortisol is poorly suited for daily measurement due to poor reliability of single-day estimates (Kraemer et al., 2006), other physiological stress indicators have shown promise. For example, heart rate variability (HRV) has been used effectively to

study the impact of daily worry on physiology (Brosschot, Van Dijk, & Thayer, 2007). HRV is seldom used in daily diary research, and the integration of this technique in models of perfectionism and stress would extend recent lab-based research (Azam et al., 2015).

3.4 Studying a Broader Population

Study 1 used an undergraduate sample, which is common in research on perfectionism and stress. The use of such samples is often critiqued based on concerns that undergraduate students are comprised predominantly of people who have the intellectual and economic capacity for higher education—they tend to be Caucasian with educated parents and above average household incomes (Henrich, Heine, & Norenzayan, 2010). Undergraduate students may also reflect a developmental period that does not represent the broader population.

Arnett (2000, 2007) has coined the term "emerging adulthood" to represent a developmental period characterized by prolonged identity exploration during late teens and early 20s (e.g., 18 to 25 years of age) that is less structured than adolescence, but without the fixed roles and obligations of adult life. Depressive symptoms decrease and self-esteem increases for most people across emerging adulthood, although heterogeneity may become strikingly apparent for those who struggle to navigate the transition to adult roles (Galambos, Barker, & Krahn, 2006). The association between perfectionism, stress, and psychological distress may also change as emerging adults transition into more stable adult roles and obligations.

3.5 Objectives of Study 2

Study 2 thus extends the results of Study 1 by disentangling the effects of perfectionism from neuroticism, extending outcomes to reflect the broader sequelea of stress, measuring stress processes using a rigorous daily diary design, and studying these stress processes in a broader population. Theoretical advancements will help add specificity to the perfectionism-stress link to identify how perfectionistic people might experience stress and distress in unique ways, which could improve understanding of how to assess and treat perfectionistic people in applied clinical settings. Methodological advances will allow finer-grain analysis of how stress processes unfold within days and between people, while capturing the myriad ways stress can affect psychological and physiological functioning. To study the perfectionism-stress link in a broader population, I use a community sample of working adults in Study 2. This was meant to avoid confounding developmental characteristics of emerging adults, while improving generalizability to a broader population that more closely reflects the average working Nova Scotian.

Chapter 4: Beyond David Versus Goliath: A Multi-Method Daily Diary Study Testing Differential Effects of Neuroticism and Perfectionism on Stress Generation

4.1 Introduction

The *Stress in America* survey conducted by the American Psychological Association (2008) suggests stress is increasing over time and contributes to both physical health concerns and emotional distress. Despite stress being a common experience in modern life, individual differences have a major influence on whether somebody will thrive, or suffer, in a demanding environment (Avey et al., 2009). Neuroticism is one personality trait that increases vulnerability to stress and its sequelae, with this trait being associated with emotional reactivity to stress and a propensity to perseverate over stressful events, leading to prolonged negative emotions (Suls & Martin, 2005). Despite neuroticism being the venerable juggernaut of personality vulnerability to stress and distress, perfectionism is gaining attention as a potent and notable vulnerability factor in its own right.

Researchers often pit neuroticism and perfectionism against one other in the prediction of outcomes, with perfectionism often demonstrating incremental prediction of emotional distress beyond neuroticism (e.g., Enns et al., 2005; Smith, Sherry, et al., 2016). This has established a narrative wherein perfectionism is painted as the biblical David against the Goliath of neuroticism. This approach has been useful in advancing perfectionism research, but it overlooks the key point that perfectionism and neuroticism may both contribute to stress and emotional distress in their own unique ways. Researchers are beginning to test specificity between lower- and higher-order personality traits (Naragon-Gainey & Watson, 2018), but gaps remain and further research is needed

to understand how neuroticism and perfectionism contribute to stress and its sequelae in unique and complementary ways.

4.1.1 Neuroticism and Perfectionism as Related, but Distinct

Neuroticism and perfectionism are thought to arise through root processes operating at different conceptual levels. Neuroticism is a core personality trait involving vulnerability to negative emotions (anxiety, depression, hostility, and self-consciousness) and corresponding disturbances in cognition and behavior (impulsivity and stress vulnerability; McCrae & Costa, 1990). Neuroticism is thus thought to influence fundamental cognitive, affective, and behavioural processes that contribute to distress (Hong, 2013), potentially through underlying biological factors (Ormel et al., 2013).

Perfectionism is understood as a personality disposition involving the pursuit of lofty standards for performance and a tendency to engage in harsh self-evaluation (Stoeber, 2018). In contrast to neuroticism, perfectionism is thought to affect social patterns (Nepon et al., 2011; Sherry, Law, Hewitt, Flett, & Besser, 2008) and cognitive processes (Kobori & Tanno, 2005; Yiend, Savulich, Coughtrey, & Shafran, 2011). For example, perfectionists view themselves, others, and the world in characteristic ways such that evaluative contexts are viewed as threatening (Frost & Marten, 1990) and perceived discrepancies between ideal and actual performance elicit harsh self-rebuke and negative affect (Sherry, Mackinnon, et al., 2013). Research frequently demonstrates strong associations between neuroticism and perfectionism (Smith, Sherry, et al., 2016); thus, these traits are considered empirically related but conceptually distinct.

Perfectionism is multidimensional, with research supporting two primary forms of perfectionism. *Perfectionistic strivings* represents the relentless pursuit of unrealistically

high standards for one's own performance, whereas *self-critical perfectionism* represents a pre-occupation about, and fear of, making mistakes or facing negative evaluation from others, relentless self-doubt about performance abilities, and a tendency to harshly derogate oneself in response to perceived failures (Blankstein & Dunkley, 2002). Evaluating both forms of perfectionism alongside neuroticism is important for understanding the unique contributions of neuroticism and perfectionism to outcomes of interest (Stoeber, 2018).

4.1.2 Stress Generation and Perpetuation

Stress generation and stress perpetuation are two processes suggested by theory and research that connect personality vulnerability to the negative effects of stress (Hewitt & Flett, 2002). *Stress generation* suggests people with certain personality traits think and act in ways that create stressful events that contribute to emotional distress (Bolger & Zuckerman, 1995), in part through increased propensity for depression (Hammen, 1991, 2006). Empirical tests support the notion of stress generation, with evidence showing neuroticism and self-critical perfectionism generate daily hassles and perceived stress (Bolger & Zuckerman, 1995; Dunkley et al., 2003; Enns et al., 2005).

Stress generation increases exposure to stress, while *stress perpetuation* amplifies and extends stress through rumination (i.e., repetitive negative thoughts about past events). Rather than a stressful event representing a discrete and time-limited event, rumination prolongs the subjective and physiological effects of stress that drive long-term psychological distress and physical health problems (Brosschot et al., 2006). Evidence suggests a mediating effect of rumination on the relation between neuroticism and emotional distress (Merino, Ferreiro, & Senra, 2014). Similar findings apply to

perfectionism, with rumination predicting vulnerability to achievement-related stress (Flaxman, Ménard, Bond, & Kinman, 2012) and interpersonal stress (Nepon et al., 2011). Rumination may be a driving factor in the maladaptiveness of perfectionism, with research showing rumination mediates the association between evaluative concerns perfectionism and distress (Blankstein & Lumley, 2008; O'Connor et al., 2007; Short & Mazmanian, 2013).

Research on rumination typically focuses on perseverative thinking about emotional distress (i.e., ruminative brooding) and its impact on depressed mood (Smith & Alloy, 2009). In contrast, stress-reactive rumination is event-specific and involves perseverative thinking about stressful events (Robinson & Alloy, 2003). Stress-reactive rumination is uniquely important and has predicted depressed mood beyond ruminative brooding (Rood, Roelofs, Bögels, & Meesters, 2012). Other research shows stress-reactive rumination amplifies the physiological effects of stress, including cardiovascular sequelea (Key, Campbell, Bacon, & Gerin, 2008; Ottaviani, Shapiro, & Fitzgerald, 2011). Perfectionism research usually focuses on ruminative brooding as a mediating factor in distress (Blankstein & Lumley, 2008; O'Connor et al., 2007; Short & Mazmanian, 2013), and much could be gained by testing the role of perfectionism and neuroticism in stress generation and stress perpetuation using stress-reactive rumination.

4.1.3 The Sequelae of Stress

Research commonly focuses on emotional distress (anger, sadness, and anxiety) and the attenuation of positive emotions when capturing the effects of stress (Bolger & Zuckerman, 1995; Dunkley, Ma, et al., 2014), while overlooking other outcomes. The relation between stress and fatigue is bi-directional (Doerr et al., 2015), with negative

implications for emotional and physical adjustment (Kop & Kupper, 2016). The co-occurrence of burnout symptoms and prolonged fatigue can contribute to more chronic stress-related problems over time than burnout alone (Leone et al., 2008), such that understanding vulnerability to fatigue helps advance our understanding of what puts self-critical perfectionists at risk for burnout and other stress-related difficulties (Hill & Curran, 2016). Despite these associations, fatigue is rarely included in research on personality and stress.

The broader stress literature also discusses the notion of *allostatic load*, which reflects the cumulative burden on an organism's ability to flexibly adapt to the demands of life (McEwen, 1998). Consideration of allostatic load would incrementally advance the study of personality and stress and may aid in identifying potential mechanisms for the demonstrated link between perfectionism, neuroticism, and long-term health outcomes (Fry & Debats, 2009).

Heart rate variability (HRV) is one indicator of allostatic load and is increasingly being used to supplement measures of emotional outcomes of stress. At a physiological level, HRV measures the influence of the vagal nerve on cardiac rhythm, with high HRV indicating increased predominance of the parasympathetic nervous system, which is responsible for various homeostatic functions, including rest and digestion (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). At a psychological level, it is thought to reflect a cognitive and emotional flexibility to respond adaptively to situational demands (Appelhans & Luecken, 2006), with some suggesting this acts in a state-like, rather than trait-like, way (Ode, Hilmert, Zielke, & Robinson, 2010). Research supports this view, showing HRV

increases during successful emotion regulation (Di Simplicio et al., 2012). HRV is associated with perceived stress independent of physical fitness and trait anxiety (Dishman et al., 2000).

Several studies have tested HRV in relation to personality and stress, but notable gaps remain. One study using a community sample showed a small-magnitude association between neuroticism and decreased HRV at rest and during a lab-based stressor (Čukić & Bates, 2015). Other research showed decreased state-like fluctuation of HRV across emotion regulation tasks in people high in neuroticism (Di Simplicio et al., 2012). Perfectionism is associated with emotion regulation deficits and cognitive inflexibility (Rudolph et al., 2007), and research using HRV indicates people high in perfectionism experience less cardiovascular benefit from mindfulness meditation after a lab-based stress-induction task compared to people lower in perfectionism (Azam et al., 2015). This research speaks to the potential importance of HRV in our understanding of psychological adjustment, yet rigorous tests of perfectionism and stress from a psychophysiological perspective are currently lacking.

4.1.4 Needed Conceptual and Methodological Advances

The perfectionism literature is rife with cross-sectional data, which can test association, but is poorly suited to capture the complexity of day-to-day experience. Daily measurement provides a potential solution to understand the daily experiences that contribute to myriad outcomes related to stress, while reducing recall bias, improving reliability of measurement due to multiple measurement occasions, and increasing ecological validity when measurement is conducted within a person's day-to-day life (Bolger et al., 2003). Although daily diary research using HRV is not novel (Brosschot et

al., 2007), such tests are rare and much remains to be learned about the inclusion of HRV in stress generation models. With modern statistical techniques (e.g., multi-level path analysis), daily diary designs allow tests of short-term processes as they unfold within days and between people. I advance research by using a daily diary method that integrates a multitude of emotional and physiological outcomes.

Finally, most perfectionism research uses undergraduates. Aside from concerns about the representativeness of this group (Henrich et al., 2010), undergraduates represent a relatively narrow developmental period. Students graduate and transition into new professional roles as they enter the workforce; however, researchers rarely focus on these working professionals. I advance research by studying a community sample of working professionals.

4.1.5 Objectives and Hypotheses

This research had two objectives. The first objective was to test competing perspectives regarding the relation between multidimensional perfectionism and neuroticism. The first perspective is that neuroticism and perfectionism function similarly, although distinctly, as vulnerability factors. This perspective (see Hypothesis 2.1) puts neuroticism and perfectionism in an antagonistic relationship, such that each is incrementally predicting outcomes beyond the other, consistent with many previous studies (Sherry, Mackinnon, et al., 2013; Smith, Sherry, et al., 2016). The second perspective (see Hypothesis 2.2) is that neuroticism and perfectionism are related, but function in unique ways that complement each other. The second objective was to test the indirect effects of perfectionism and neuroticism on stress sequelae through stress generation and stress perpetuation processes to better understand how neuroticism and

perfectionism may have similar, or distinct, effects on subjective distress and physiological stress in the context of day-to-day experience.

Hypothesis 2.1. Both neuroticism and self-critical perfectionism are associated with stress generation (Bolger & Zuckerman, 1995; Dunkley et al., 2003) and stress perpetuation through rumination (Merino et al., 2014; Short & Mazmanian, 2013), but have not been tested within the same model to identify unique effects. I hypothesized that if neuroticism and self-critical perfectionism function similarly, although incremental, to each other, then (a) neuroticism would incrementally predict increased stress generation and increased stress-reactive rumination beyond self-critical perfectionism and (b) self-critical perfectionism would incrementally predict these processes beyond neuroticism.

Hypothesis 2.2. Neuroticism is thought to increase people's vulnerability to negative emotions and the immediate cognitive and behavioural features associated with those emotions (Hong, 2013). In contrast, perfectionism is thought to encompass inter- and intrapersonal patterns of cognition and behaviour that, in turn, influence how a person reacts to, and shapes, their experience (Hewitt & Flett, 2002). Thus perfectionism may function more specifically through stress generation, while neuroticism may function more specifically through stress perpetuation. As an alternative to Hypothesis 2.1, I hypothesized that if neuroticism and self-critical perfectionism function uniquely from each other in predicting stress processes, then (a) self-critical perfectionism would uniquely predict daily stress over the 7-day period, but not stress-reactive rumination, and (b) neuroticism would uniquely predict stress reactive rumination over the 7-day period, but not daily stress.

Hypothesis 2.3. Research suggests perseverative thinking patterns, such as rumination, amplify and prolong the emotional and physiological responses to stressful events (Brosschot et al., 2006); thus, I hypothesized higher daily stress would predict stress sequelae indirectly through the effects of stress perpetuation when considered in aggregate over the entire 7-day period (i.e., at the between-person level). Specifically, I hypothesized (a) higher daily stress would predict higher stress-reactive rumination, and (b) higher stress-reactive rumination would predict higher fatigue, higher emotional distress, lower vigor, and lower heart rate variability at the between-person level.

Hypothesis 2.4. In contrast to Hypothesis 2.3, stressful daily events may be more likely to influence the emotional and physiological reactions within the same day (i.e., at the within-person level), rather than these reactions being driven primarily by rumination as at the between-person level. Thus, I hypothesized (a) daily stress would be associated with stress-reactive rumination at the within-person level, and (b) daily stress would be uniquely associated with higher fatigue, higher emotional distress, lower vigor, and lower heart rate variability through both direct effects and indirect effects (through stress-reactive rumination) when considered at the within-person level.

Hypothesis 2.5. As per hypothesized effects of perfectionism and neuroticism on stress processes (see Hypotheses 2.1 to 2.2) and the hypothesized effects of stress generation and stress perpetuation on stress sequelae (see Hypotheses 2.3 and 2.4), I hypothesized self-critical perfectionism and neuroticism would each show unique indirect effects on emotional distress, fatigue, vigor, and heart rate variability. These analyses were considered exploratory and no specific hypotheses were made regarding the relative

strength of effects between self-critical perfectionism and neuroticism across outcome measures.

4.2 Method

4.2.1 Procedure

A research ethics board approved this study. Participants were recruited using flyers posted on community bulletin boards, online advertisements, and social media. Interested individuals contacted the lab and were provided with an online screening questionnaire to assess eligibility. If eligible, they were invited to attend an initial lab-based session (Phase 1). All participants were instructed to refrain from drinking caffeine or exercising vigorously prior to the session. After arriving to the lab, participants provided informed consent. A research assistant took a chest circumference measurement to select an appropriately sized LifeMonitor. The participant then completed a battery of questionnaires, including demographic information and personality measures. Participants were fitted with a LifeMonitor and completed a 3-4 minute test recording to ensure proper fit. Participants were instructed on how to complete the daily online questionnaires and how to use the LifeMonitor to complete daily cardiac recordings. Participants received $15 cash for compensation and were sent home with the LifeMonitor to complete at-home recordings.

During Phase 2, participants completed daily online questionnaires and a 15-minute cardiac recording at the end of each day before bed for seven consecutive days, beginning the day after their initial session (Phase 1). Online questionnaires were administered using Opinio software hosted on university servers. A link to the online survey was sent automatically each day at 5:00 pm, with reminder emails sent at 9:00 pm

and 11:00 pm if the survey had not yet been completed. Survey links were unique each day and could only be accessed between 5:00 pm that day and 5:00 am the following day. Participants were asked to complete the survey first, followed by the cardiac recording. Participants were instructed to complete recordings lying supine on a flat surface, breathing normally, and remaining supine for the duration of the recording. Research shows seated or standing HRV underestimates parasympathetic activity due to sympathetic predominance in these postures (Dantas et al., 2010). Once the 7-day period was finished, participants returned the equipment and collected compensation for Phase 2 of the study ($35 cash). Participants were debriefed at the end of the study.

4.2.2 Participants

I recruited 102 working community members. To be eligible, participants must have indicated working full-time hours (≥30 hours per week), being 18 to 65 years of age, being fluent in English, and having home internet access with a valid email address. Participants with a history of cardiac illness (e.g., arteriosclerosis, coronary heart disease, cardiac arrhythmia, and hypertension) were not eligible to participate. Two participants indicated working less than the required number of hours during the first lab-based session and were excluded from analysis. The final sample included 100 participants (74.0% female, 23.0% male, and 3.0% other) aged 26 to 59 (M = 32.5, SD = 9.8). Participants were predominantly Caucasian (84.0%), Asian (7.0%), or mixed-ethnicity (7.0%), and the majority (80.0%) reported completing at least one university degree. Most participants were married (23.0%), cohabitating with a romantic partner (28.0%), dating (21.0%), or single (20.0%). Participants worked between 30 and 60 hours per week (M = 41.4, SD = 8.0) in a wide variety of industries, with the most frequent being

healthcare (27.0%) and education (11.0%). Median household income was $40,000 to $59,999 per year.

4.2.3 Measures and Materials

Neuroticism. I used the 8-item neuroticism subscale of the Big Five Inventory (BFI; Benet-Martinez & John, 1998). Statements (e.g., "Gets nervous easily") were rated on a 5-point scale from 1 (*disagree strongly*) to 5 (*agree strongly*) reflecting typical experiences during the past several years. This subscale has demonstrated high alpha reliability (α = .84; Benet-Martinez & John, 1998; John & Srivastava, 1999) and strong convergence (r = .90) with similar measures of Big Five personality traits (John & Srivastava, 1999). Alpha reliability was adequate in my data (α = .84 [.78 – .88]).

Self-critical perfectionism. Consistent with previous research (Dunkley et al., 2003; Clara et al., 2007), I measured self-critical perfectionism using four manifest indicators: the short-form socially prescribed perfectionism subscale from Hewitt and Flett's (1991) Multidimensional Perfectionism Scale (HFMPS; Hewitt et al., 2008), the short form of the concern over mistakes subscale and the doubts about actions subscale from Frost et al.'s (1990) Multidimensional Perfectionism Scale (FMPS; see Cox et al., 2002), and a short form of the self-criticism scale from the Reconstructed Depressive Experiences Questionnaire (RDEQ; Bagby et al., 1994; Blatt et al., 1976). This composite measure has demonstrated good factorial and predictive validity in research (Clara et al., 2007). Manifest indicators were standardized, summed, and re-standardized to create the composite scale.

The short-form socially prescribed perfectionism subscale includes five items (e.g., "People expect nothing less than perfection from me") rated on a 7-point scale from

1 (*strongly disagree*) to 7 (s*trongly agree*). Research has demonstrated the reliability and the validity of this scale (Hewitt & Flett, 1991), including a high correlation (r = .90) with the original 15-item subscale (Hewitt et al., 2008). Alpha reliability was adequate in my data (α = .82 [.76 – .87]).

The short-form concern over mistakes subscale includes five items (e.g., "If I fail partly, it is as bad as being a complete failure") rated on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). The short form of this scale demonstrated improved factorial validity compared to the original 9-item scale, showing a strong correlation (r = .96) with the original measure (Cox et al., 2002). Alpha reliability was adequate in my data (α = .84 [.79 – .89]).

The doubts about actions subscale of the FMPS included four items (e.g., "Even when I do something very carefully, I often feel that it is not quite right") rated on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Research supports the reliability and the validity of this scale (Frost et al., 1990). Alpha reliability was adequate in my data (α = .78 [.70 – .84]).

The self-criticism subscale of the RDEQ included five items (e.g., "I often find that I don't live up to my own standards or ideals") rated on a 7-point scale from 1 (*strongly disagree*) to 7 (*strongly agree*). Four items from the original measure do not reflect self-criticism (e.g., "I never really feel secure in a close relationship") and were removed. The 5-item version of this scale shows similar alpha reliability compared to the original 9-item scale (α = .89 vs. .87), with a high correlation between scale versions (r = .92; Nealis & Sherry, 2017). Alpha reliability was adequate in my data (α = .84 [.79 – .88]).

Perfectionistic strivings. Consistent with previous research (McGrath et al., 2012), perfectionistic strivings was measured as a composite of three manifest indicators: the short-form of the self-oriented perfectionism subscale of the HFMPS (Hewitt & Flett, 1991; Hewitt et al., 2008), the short-form of the personal standards subscale of the FMPS (Cox et al., 2002; Frost et al., 1990), and a modified version of the self-oriented perfectionism subscale of the Eating Disorders Inventory (EDI; Garner et al., 1983; McGrath et al., 2012).[1] This composite measure has shown high test-retest reliability (McGrath et al., 2012) and good factorial validity (Mushquash, Sherry, Sherry, & Allen, 2013). The composite measure was calculated consistent with self-critical perfectionism (see above).

The short-form self-oriented perfectionism subscale of the HFMPS included five items (e.g., "I demand nothing less than perfection of myself") rated on a 7-point scale from 1 (*strongly disagree*) to 7 (*strongly agree*). The short-form of this subscale has shown good reliability and validity in research, with a strong correlation (r = .91) with the full subscale (Hewitt et al., 2008). Internal reliability was adequate in my data (α = .89; [.85 – .92]).

The short-form personal standards subscale of the FMPS included five items (e.g., "I expect higher performance in my daily tasks than most people") rated on a 5-point

[1]Previous research (e.g., Dunkley et al., 2014) has used the personal standards subscale of the Almost Perfect Scale Revised (APS-R; Slaney, Rice, Mobley, Trippi, & Ashby, 2001) in perfectionistic strivings, although this subscale has notable limitations in measuring perfectionism (Blasberg, Hewitt, Flett, Sherry, & Chen, 2016). To address these concerns, I used the EDI-SOP as an alternative measure of perfectionistic standards.

scale from 1 (*strongly disagree*) to 5 (*strongly agree*). This subscale shows good reliability and validity, with a strong correlation (r = .97) with the original 7-item subscale (Cox et al., 2002). Internal reliability was adequate in my sample (α = .82 [.76 – .87]).

The self-oriented perfectionism subscale of the EDI included four items (e.g., "I feel that I must do things perfectly or not at all") rated on a 5-point scale from 1 (*never*) to 6 (*always*). Research supports the reliability and the validity for this scale, with good internal consistency (α = .81) and a strong correlation with the HFMPS version of self-oriented perfectionism (r = .87; Sherry, 2010). Internal reliability was adequate in my data (α = .83 [.76 – .88]).

Daily stress. Daily stressful events were measured using the Daily Stress Inventory (DSI; Brantley, Waggoner, Jones, & Rappaport, 1987). This measure includes a list of 58 daily hassles and stressful events (e.g., "Unable to complete a task"). Participants rated whether each event occurred over the past 24 hours (indicating an "X" if an event did not occur), and if an event did occur, the item was rated on a seven-point scale from 1 (*occurred but was not stressful*) to 7 (*caused extreme stress*). The top anchor was modified from the original version (*caused me to panic*) due to previously identified concerns conflating panic with extreme stress (Brantley, Catz, & Boudreaux, 1997). Participants also had the opportunity to list up to two additional stressful events that day and rate them according to the same scale as the other 58 items. Items were summed to represent the total daily stress impact across all endorsed items. Research supports the reliability and the validity of this scale in daily diary research (Brantley, Cocke, Jones, &

Goreczny, 1988; Brantley et al., 1987). Reliability of daily measures is shown in Table 2 and described in the results.

Daily rumination. Cognitive perseveration on daily events was measured using the Stress-Reactive Rumination Scale (Robinson & Alloy, 2003). This 9-item scale (e.g., "Thought about how terrible a stressful event is") was rated numerically, with participants providing an integer response from 0 (*never thought or did this in response to the stressful event*) to 100 (*frequently thought or did this in response to the stressful event*) reflecting how often they engaged in each behavior over the past 24-hours. Research has demonstrated reliability and validity of this scale in daily diary research (LoSavio et al., 2011).

Daily mood. Participants reported their mood using the short-form Profile Mood States (POMS-15; Cranford et al., 2006), which includes five 3-item subscales reflecting sadness (e.g., "Blue"), anxiety (e.g., "Uneasy"), anger (e.g., "Annoyed"), fatigue (e.g., "Exhausted"), and vigor (e.g., "Lively"). Each item was rated on a 5-point scale from 0 (*not at all*) to 4 (*extremely*) based on the previous 24 hours. One item from the original sadness subscale was changed (from "Discouraged" to "Blue") following recommendations (Cranford et al., 2006). This modified subscale has shown good validity and reliability in daily diary research (Cranford et al., 2006; Mackinnon et al., 2014).

Heart rate variability. Daily heart rate variability measurements were obtained at the end of each day using Equivital™ EQ02 LifeMonitor sensors, which are worn under clothing to provide electrocardiograms using a two-lead configuration (left and right side of the ribcage; 256 Hz sampling). I instructed participants to lay supine and breathe

normally for 15 minutes for each recording and to avoid caffeine and strenuous exercise for at least one hour prior to beginning. Files were processed using the Heart Rate Variability Professional Edition module in VivoSense® software (Vivonoetics, 2015). Built-in R-wave detection and artifact management tools identified measurement artifacts and ectopic beats. Recordings were also visually inspected (using ECG waveforms, R-R intervals, and Poincaré plots) for missing r-wave detections, ectopic beats, and recording artifacts to minimize bias in HRV parameters. Artifacts affecting greater than three consecutive beats were excluded from HRV calculation, while those affecting three or fewer consecutive beats were interpolated using the built-in interpolation function (Vivonoetics, 2012). Volunteer research assistants, paid research assistants, and the first author conducted data cleaning with each file double-checked for accuracy. Recordings less than five minutes in duration after cleaning were not included in analyses, and recordings longer than 20 minutes were truncated such that only the first 20 minutes were used in analyses. Files were batch-processed to yield estimates of the high-frequency band (0.15–0.40 Hz) of power spectral density to index parasympathetic activity as per Task Force (1996) guidelines. Analyzed HRV recordings were an average of 15.5 minutes long (*SD* = 3.1).

4.2.4 Data Analytic Plan

I used multilevel path analysis to account for daily measures nested within participants, which allows for simultaneous testing of multiple between-person and within-person pathways within a model. In contrast to multilevel regression, multilevel path analysis allows testing meditational analyses within a cohesive model. The between-person component tests predictive relationships between personality and trait-like

components of daily variables (i.e., daily measures aggregated across days). The within-person model tests predictive relationships between state-like daily variables that fluctuate over time. Between-person variables do not predict within-person change or vice versa (Preacher et al., 2010). Between-person relationships answer the question: "Does the trait-like component of X predict the trait-like component of Y?" and within-person relationships answer the question: "Do changes in X predict changes in Y?"

Multilevel path analyses were conducted using Mplus version 7.0 (Muthén & Muthén, 2012) using robust maximum likelihood estimation. I tested a hypothesized model (see Figure 4.1) and evaluated fit, with excellent model fit indicated by a χ^2/df below 2.00, a comparative fit index (CFI) and Tucker–Lewis Index (TLI) below .95, a root-mean-square error of approximation (RMSEA) below .06 (Hu & Bentler, 1999), and a standardized root mean square residual (SRMR) below .08 (Kline, 2011). Modification indices were used to inform post-hoc model re-specification, with any such modifications considered exploratory analyses. Boostrapping procedures were not available for multilevel models in Mplus 7.0; thus, indirect effects were calculated using the MODEL INDIRECT function in Mplus using regular standard errors. Power analyses indicate a sample of 100 participants will provide accurate and unbiased regression coefficients, variance estimates, and standard errors in planned analyses (Maas & Hox, 2005), with power estimated to be greater than .80 assuming seven measurement occasions per person and medium effect sizes (r = .30; Scherbaum & Ferreter, 2009). Medium effect sizes are expected based on previous research (e.g., Dunkley, Ma, et al., 2014).

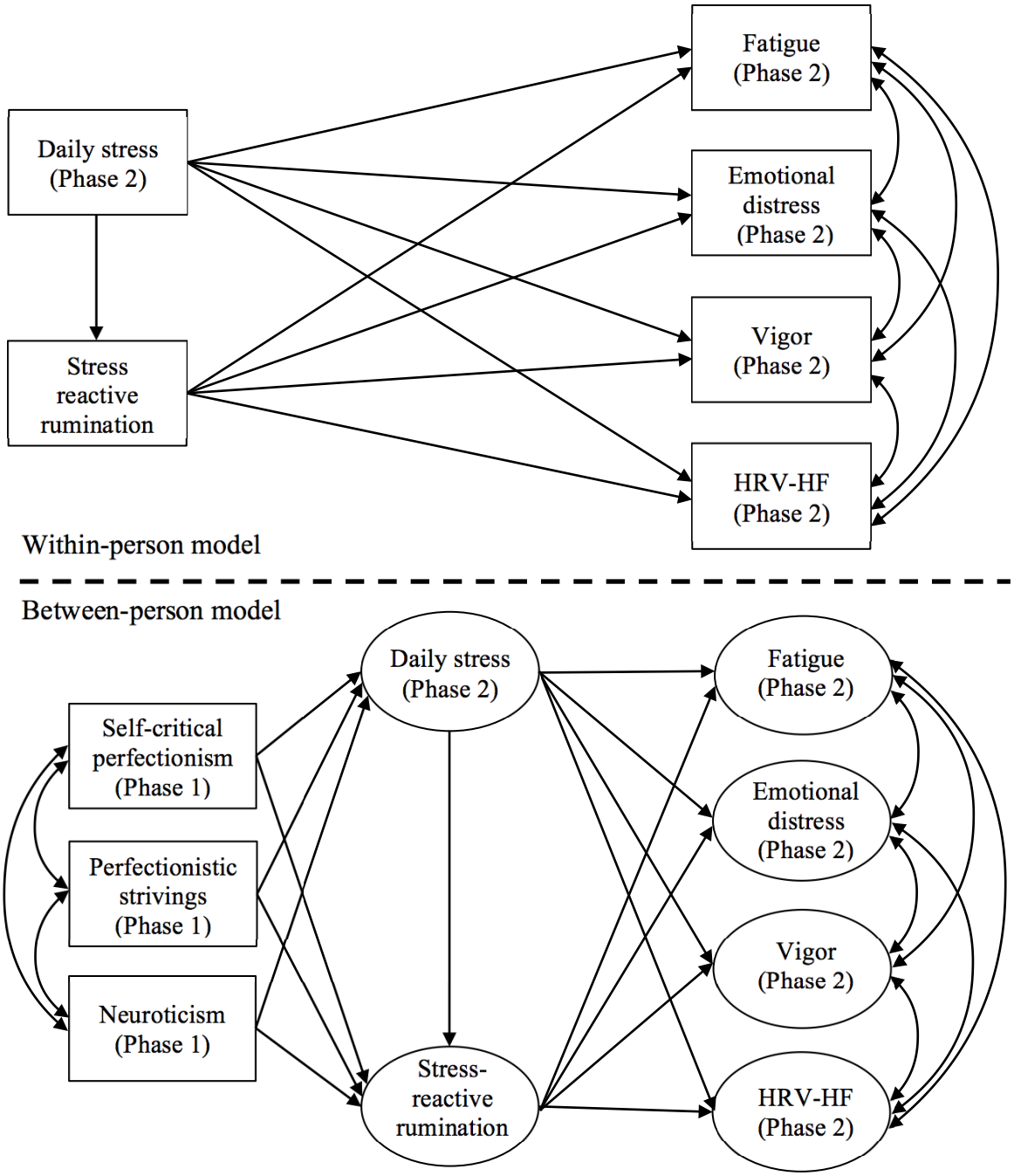

Figure 4.1 Hypothesized multilevel path model. Rectangles represent manifest indicators and ovals represent latent variables. Single-headed arrows represent regression coefficients and double-headed arrows represent covariances.

4.3 Results

4.3.1 Missing Data and Protocol Compliance

All participants completed Phase 1. No scale-level data were missing from questionnaires and < 0.01% (n = 1) of item-level data were missing. Item-level missing data were imputed using the expectation maximization algorithm in SPSS version 23, which provides unbiased estimates with < 5% missing data (Scheffer, 2002).

Only one participant did not participate in Phase 2 due to unforeseen personal circumstances. Participants provided 640 daily diaries (91.4%), with 87% of participants completing at least six of the seven daily diaries. Most daily diaries (73.8%) were completed between the hours of 9:00 PM and 2:00 AM. Completed daily diaries included 0.5% of scale level missing data, with an additional 0.4% of item-level missing data from completed scales. Ninety-eight participants provided at least one HRV recording. A total of 610 HRV recordings were provided (87.1% completion rate) with 51 (7.3%) omitted from analysis due to insufficient length of recording (< 5 minutes) or poor data quality. Analyses included data from 559 recordings (81.4% of total), with 81% of participants completing at least six of seven daily recordings. Daily HRV data were completely missing for five participants due to equipment failure (n = 3), non-compliance (n = 1), or non-participation in Phase 2 (n = 1). Item-level missing data in daily diary entries were imputed using scale proration if ≥ 50% of scale items were completed. If < 50% of scale items were completed, the scale was treated as missing. Missing scale-level data and HRV data were addressed using full-information maximum likelihood (FIML) estimation. This approach provides less biased estimates than other methods (e.g., listwise deletion) when all participants are included in the analysis (Acock, 2005).

4.3.2 Descriptive Statistics and Bivariate Correlations

Table 4.1 shows descriptive statistics of study measures and Table 4.2 shows between-person and within-person bivariate correlations.[2] Neuroticism, self-critical perfectionism, and perfectionistic strivings are between-person variables only. All other measures are both between-person variables (aggregated across days) and within-person variables (daily values). Anger, anxiety, and sadness subscales of the POMS-15 showed strong inter-correlations at a between-person level (*r*s = .67–.75) and medium inter-correlations at a within-person level (*r*s = .29–.35). These three subscales were summed to create the composite included in Table 4.2.

4.3.3 Reliability of Daily Measures and Intra-class Correlations

I calculated intra-class correlations (ICCs) and measures of internal consistency for daily measures to assess their ability to reliably measure change within a multilevel framework. ICCs range from 0 to 1.0 and indicate the proportion of variance explained at the between-person level. Values greater than .05 indicate suitability for multilevel analysis (Preacher et al., 2010). Table 4.2 shows ICCs for daily measures. Values ranged from .47 to .64 and indicate substantial variability at between and within-person levels; thus, measures are suitable for multilevel analysis.

Reliability of daily measures was calculated according to Cranford et al. (2006) and involved three estimates of reliability per scale. The first estimate (R_{1F}) describes between-person reliability on a single fixed day for all participants and represents

[2]Descriptive statistics for measures of heart rate variability beyond those used in my models are provided in Appendix K.

Table 4.1

Descriptive Statistics

	M	*SD*	Range	
			Actual	Potential
Neuroticism (Phase 1)	22.9	6.7	10.0–39.0	8–40
Self-critical perfectionism (Phase 1)				
HFMPS: Socially prescribed perfectionism	18.8	6.7	5.0–33.0	5–35
FMPS: Concern over mistakes	11.4	4.9	5.0–24.0	5–25
FMPS: Doubts about actions	9.5	3.8	4.0–19.0	4–20
RDEQ: Self-criticism	19.9	7.1	5.0–34.0	5–35
Perfectionistic strivings (Phase 1)				
HFMPS: Self-oriented perfectionism	21.5	7.2	7.0–35.0	5–35
FMPS: Personal standards	17.2	4.3	6.0–25.0	5–25
EDI: Self-oriented perfectionism	13.7	4.4	4.0–23.0	4–24
Daily Stress Inventory (Phase 2)	36.5	22.5	7.7–116.0	0–420
Stress-reactive rumination (Phase 2)	241.6	182.5	1.4–790.0	1–900
Profile of Mood States – Short form (Phase 2)				
Sadness	2.2	2.2	0.0–11.0	0–12
Anxiety	3.6	2.5	0.0–12.0	0–12
Anger	3.9	2.0	0.6–10.0	0–12
Fatigue	5.0	2.7	0.4–10.6	0–12
Vigor	4.4	2.1	0–9.0	0–12
Heart rate variability: High frequency (Phase 2)	1023.5	990.6	61.2–5089.0	–

Note. HFMPS = Hewitt and Flett's (1991) Multidimensional Perfectionism Scale; FMPS = Frost et al.'s (1990) Multidimensional Perfectionism Scale; RDEQ = Reconstructed Depressive Experiences Questionnaire (Bagby et al., 1994; Blatt et al., 1976); EDI = Eating Disorders Inventory (Garner et al., 1983; McGrath et al., 2012). Statistics for daily measures (Phase 2) represent aggregates across the 7-day diary period.

Table 4.2

Between-person and Within-person Bivariate Correlations, Intra-class Correlations for Daily Measures, and Reliability Estimates for Daily Measures

	1	2	3	4	5	6	7	8	9
1. Neuroticism	–	.60*	.19*	.32*	.47*	.48*	.62*	-.24*	-.02
2. Self-critical perfectionism	–	–	.56*	.49*	.48*	.37*	.51*	-.02	-.11
3. Perfectionistic strivings	–	–	–	.26*	.30*	.12	.27*	-.02	-.02
4. Daily stress	–	–	–	–	.74*	.47*	.71*	-.01	-.10
5. Stress-reactive rumination	–	–	–	.47*	–	.54*	.82*	-.07	-.27*
6. Fatigue (POMS)	–	–	–	.37*	.22*	–	.69*	-.19	-.09
7. Emotional distress (POMS)	–	–	–	.56*	.62*	.31*	–	-.12	-.12
8. Vigor (POMS)	–	–	–	-.12*	-.21*	-.21*	-.34*	–	.19
9. HRV-HF	–	–	–	.13	.15*	.03	.09	-.06	–
Intra-class correlations (ICC)	–	–	–	.64	.65	.46	.58	.51	.47
Cronbach's alpha (R_{1F})	–	–	–	.89	.92	.88	.83	.77	–
Between-person reliability (R_{KF})	–	–	–	.98	.99	.98	.97	.96	.97
Within-person reliability (R_C)	–	–	–	.81	.86	.89	.77	.74	.84

Note. HRV-HF = high frequency domain of heart rate variability; POMS = Profile of Mood States, short form (Cranford et al., 2006). Between-person correlations are above the diagonal and within-person (daily) correlations are below the diagonal. Self-critical perfectionism and perfectionistic strivings represent composite measures, with manifest variables standardized and summed. Between-person estimates of daily measures represent an aggregation of scores across the 7-day period. A bivariate correlation in the range of .10 signifies a small effect size; a bivariate correlation in the range of .30 signifies a medium effect size; a bivariate correlation in the range of .50 signifies a large effect size. Heart-rate variability (HRV) does not contain multiple items and thus inter-item reliability over the daily diary period (R_{1F}) is not applicable to this measure. * = $p < .05$.

a measure's average Cronbach's alpha across days. The second estimate (R_{KF}) describes between-person reliability of a measure across the study period. The third estimate (R_C) describes within-person reliability of a measure, or its reliability when estimating change over time. Table 4.2 shows reliability of daily measures. All daily measures showed adequate between- and within-person reliability.

4.3.4 Multilevel Path Analyses

I tested self-critical perfectionism and perfectionistic strivings together alongside neuroticism within a single model to test hypothesizes (see Figure 4.2).[3] Initial model fit was adequate, $\chi^2(16) = 38.69$, $p = .001$, CFI = .98, TLI = .92, RMSEA = .05, $SRMR_{within} = .002$, $SRMR_{between} = .07$, although modification indices suggested the addition of a direct path between neuroticism and emotional distress (M.I. = 10.19). The revised model showed excellent model fit, $\chi^2(11) = 19.22$, $p = .06$, CFI = .99, TLI = .96, RMSEA = .03, $SRMR_{within} = .001$, $SRMR_{between} = .05$.

With regards to the first study objective, results from the revised model supported Hypothesis 2.2 and not Hypothesis 2.1. Specifically, self-critical perfectionism uniquely predicted increased daily stress ($\beta = .49$, $p < .001$), but not stress-reactive rumination ($\beta = -.05$, $p = .69$), during the 7-day period when simultaneously accounting for the effect of

[3]I also tested this model with age as a between-person covariate (Mann, Selby, Bates, & Contrada, 2015). Age was negatively correlated with HRV ($r = -.34$, $p < .001$). The overall pattern of associations remained unchanged; however, model comparison indicated a less parsimonious model ($\Delta AIC = 727.96$). Age was thus not included in the final model shown in Figure 4.1.

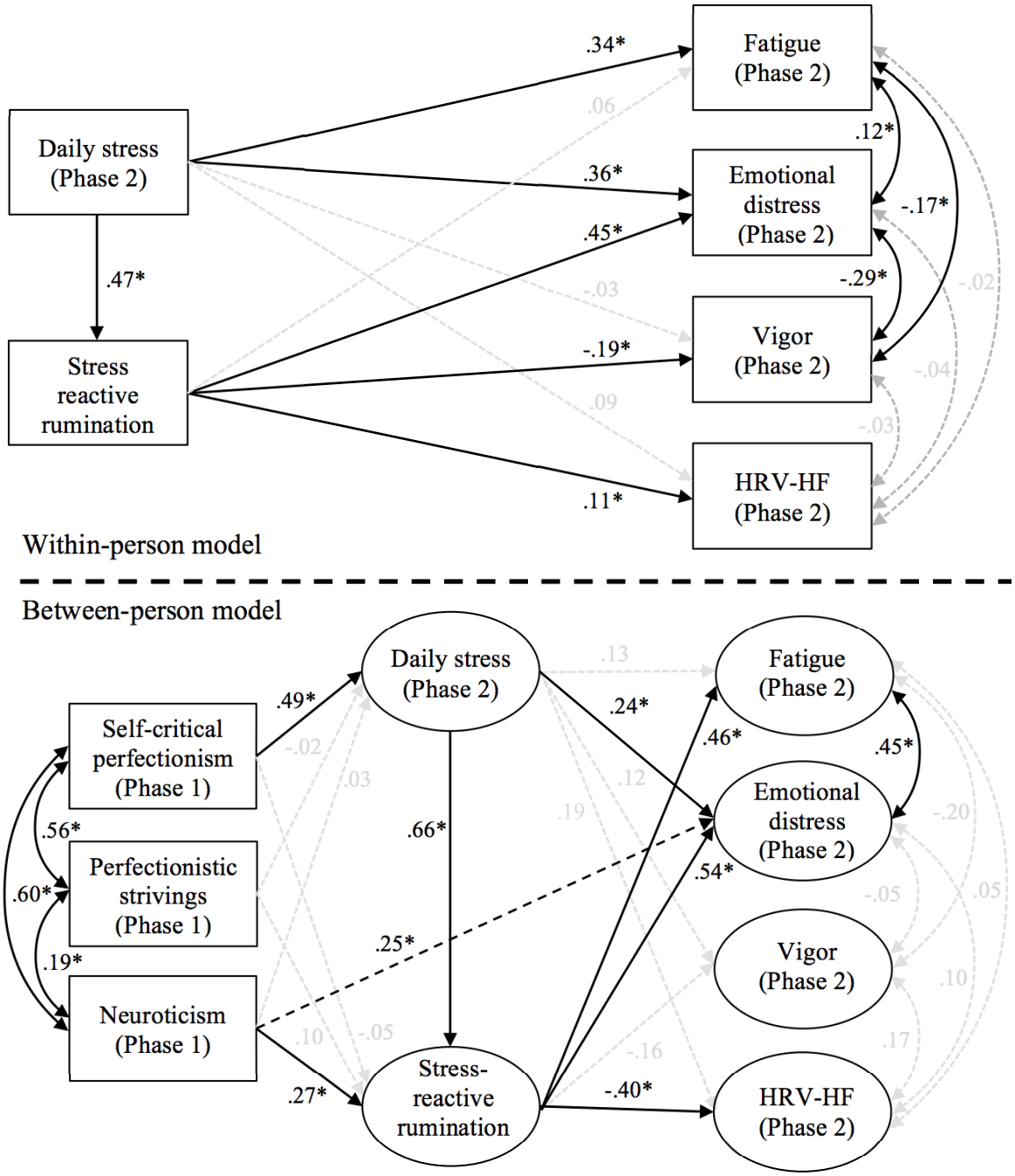

Figure 4.2 Multilevel path analysis for the revised model. Single-headed arrows represent regression coefficients and double-headed arrows represent covariances. Grey dashed lines indicate non-significant paths and grey double-headed arrows indicate non-significant covariances. All path coefficients are standardized. Black dashed lines reflect paths added to hypothesized models based on modification indices. * = $p < .05$.

neuroticism and perfectionistic strivings. Conversely, neuroticism uniquely predicted increased stress-reactive rumination (β = .27, $p < .001$), but not increased daily stress (β = .03, $p = .82$), during the 7-day period when simultaneously accounting for the effect of self-critical perfectionism and perfectionistic strivings. Exploratory analyses arising from modification indices also suggested a direct effect between neuroticism and emotional distress (β = .25, $p < .001$) at a between-person level.

With regards to the second study objective, results partially supported Hypothesis 2.3. As hypothesized at a between-person level, daily stress was associated with stress reactive rumination (β = .66, $p < .001$), and higher stress-reactive rumination was associated with increased fatigue (β = .46, $p < .01$), increased emotional distress (β = .54, $p < .001$), and decreased HRV (β = -.40, $p < .01$). Contrary to hypotheses, stress-reactive rumination was not associated with decreased vigor at the between-person level (β = -.16, $p = .39$). As hypothesized, daily stress showed significant indirect effects on fatigue (β = .30, $p = .006$), emotional distress (β = .35, $p < .001$), and HRV (β = -.26, $p = .007$) via its association with stress-reactive rumination. Contrary to hypotheses, daily stress showed no significant indirect effect on vigor at the between-person level (β = -.11, $p = .49$) and daily stress showed a direct effect on emotional distress in addition to its indirect effect through stress-reactive rumination.

Results also partially supported Hypothesis 2.4. As hypothesized, daily stress predicted stress-reactive rumination at a within-person level (β = .47, $p < .001$) and daily stress indirectly predicted increased emotional distress (β = .21, $p < .001$), decreased vigor (β = -.09, $p = .01$), and increased HRV (β = .05, $p = .02$) via stress-reactive rumination. Contrary to hypotheses, daily stress was only directly associated with fatigue

(β = .34, $p < .001$) and emotional distress (β = .35, $p < .001$), but showed no significant direct association with vigor (β = -.03, $p = .63$) or HRV (β = .08, $p = .19$) at a within-person level. The within-person indirect effect of daily stress on fatigue through stress-reactive rumination was also not significant (β = .03, $p = .29$).

As described in Hypothesis 2.5, total indirect effects between personality traits (i.e., neuroticism and self-critical perfectionism) and stress-related outcomes are shown in Table 4.3 and were considered exploratory. Neuroticism showed small total indirect effects on emotional distress and HRV. Neuroticism also showed a medium total effect on emotional distress when considering direct and indirect effects. In contrast, self-critical perfectionism showed small total indirect effects on emotional distress and fatigue, but no significant total indirect effect on HRV.

4.4 Discussion

Perfectionism and neuroticism are frequently placed in an adversarial position when predicting psychological distress, with any victory by perfectionism or related constructs hailed as a triumph against the juggernaut of neuroticism (Sherry, Mackinnon, et al., 2013; Smith, Sherry, et al., 2016). My primary objective was to test two competing hypotheses: 1) that neuroticism and perfectionism would incrementally predict stress generation and stress perpetuation beyond the other, but show no distinct effects

(Hypothesis 2.1), and 2) that neuroticism and perfectionism would uniquely and differentially predict stress generation and stress perpetuation (Hypothesis 2.2). My measurement of cognitive, affective, and physiological features of stress over a 7-day period allowed rigorous tests of the processes linked with neuroticism and perfectionism, and my use of a community sample of working professionals helped extend research

Table 4.3

Indirect Effects of Self-Critical Perfectionism and Neuroticism on Outcome Measures.

	Specific indirect effects			Total indirect effect	Total effect
	Via DSI	Via SRRS	Via DSI and SRRS		
Neuroticism					
Fatigue	< .01	.12*	.01	.13	.13
Emotional distress	.01	.14*	.01	.16*	.41*
Vigor	< .01	-.04	-.01	-.04	-.04
HRV-HF	.01	-.11*	-.01	-.11*	-.11*
Self-critical perfectionism					
Fatigue	.06	-.02	.15*	.19*	.19*
Emotional distress	.12*	-.03	.17*	.26*	.26*
Vigor	.06	.01	-.05	.02	.02
HRV-HF	.09	.02	-.13*	-.02	-.02

Note. DSI = Daily stress inventory (Brantley et al., 1987); SRRS = Stress-reactive rumination scale (Robinson & Alloy, 2003); HRV-HF = high-frequency domain of heart rate variability. Values reflect standardized estimates. All effects are at the between-person level. * $p < .05$.

beyond undergraduates to understand stress generation in people facing the day-to-day stress of being a working adult. Results supported the hypothesis that neuroticism and perfectionism would differentially predict stress generation and related processes (Hypothesis 2.2). Whereas neuroticism predicted key cognitive (stress-reactive rumination) and affective components (emotional distress), self-critical perfectionism directly and uniquely predicted daily stress. Perfectionistic strivings showed no unique relations to stress processes in my data. Based on exploratory analyses (Hypothesis 2.6), both neuroticism and self-critical perfectionism were associated with emotional distress,

but each trait also showed its own unique impacts. People high in self-critical perfectionism may be uniquely vulnerable to fatigue, while people high in neuroticism may be uniquely vulnerable to physiological effects of stress as a result of ruminative tendencies. These exploratory findings remain tentative, however, and should be tested directly in future research.

For people high in neuroticism, daily life is thought to bring frequent problems along with negative emotions that are seemingly stronger, and last longer, than people who are low in this trait (Suls & Martin, 2005). Consistent with this and other research (Merino et al., 2014), my results showed people high in neuroticism are vulnerable to emotional distress directly and indirectly through a tendency to perseverate about daily events. My results advance knowledge of neuroticism by showing the "neurotic cascade" of rumination and stress reactivity described by Suls and Martin (2005) may perpetuate negative emotions and the physiological burden of stress in a way that puts people at increased risk of the long-term physical and mental health sequelea of stress (Brosschot et al., 2006).

Inconsistent with prior research (Bolger & Zuckerman, 1995; Suls & Martin, 2005), neuroticism did not uniquely predict daily stress when compared alongside self-critical perfectionism or perfectionistic strivings. My results suggest the tendency to generate problems in day-to-day life may not be unique to neuroticism and are accounted for by other personality vulnerabilities, yet it appears people high in neuroticism uniquely and characteristically respond to daily events (e.g., through rumination) in a way that makes them vulnerable to negative emotions and physiological stress.

Self-critical perfectionism stood in contrast to neuroticism and seemingly functioned in a complementary way. People high in self-critical perfectionism experienced higher daily stress over a 7-day period. Although these stress experiences were associated with rumination in their own right, people high in self-critical perfectionism did not show a direct vulnerability to rumination when compared alongside neuroticism. These results add to literature showing the stress generation effects of perfectionism, with self-critical perfectionism predicting stress beyond other forms of perfectionism, such as perfectionistic strivings (Dunkley et al., 2003). The harsh self-criticism involved in perfectionism may be a key factor in this vulnerability, as people who show this tendency seemingly act upon their environment in a way that produces friction with others (Shahar et al., 2003; Sherry et al., 2008). Together with past research, my findings suggest self-critical perfectionists act, and interact, with their world in a way that generates stressful experiences as they navigate daily life.

The question remains as to how self-critical perfectionists generate stressful experiences. Research suggests this may arise through a tendency to use avoidance to cope with daily stressors (Dunkley et al., 2003), such that minor problems are not addressed proactively and become more pressing issues. For instance, a tight deadline soon becomes nearly impossible to meet and the failure (real or perceived) to perform adequately at work quickly becomes more problematic than the work itself. Another possibility is that perfectionists generate stress through their actions toward, and interactions with, others (Hammen, 1991, 2006), including increased social negativity and lower social support (Dunkley, Sanislow, Grilo, & McGlashan, 2006; Sherry et al., 2008). With interpersonal conflict frequently discussed in relation to neuroticism (Bolger

& Zuckerman, 1995), nuanced tests of how self-critical perfectionism and neuroticism might intersect or diverge in predicting interpersonal dynamics are needed.

In addition to showing neuroticism and perfectionism as related but distinct, my results also point toward a complementary relationship between these dual vulnerability factors. Results showed neuroticism and self-critical perfectionism tend to co-occur within individuals and put such people at risk of increased stress exposure, as well as the cognitive and affective sequelea that amply the effects of stress. This may reflect Cattell's (1957) notion of a *source trait*, such that the higher-order vulnerability of neuroticism puts people at risk of developing perfectionistic and self-critical tendencies. Research has provided equivocal support for this notion (Cox, Clara, & Enns, 2009; Stoeber, Otto, & Dalbert, 2009) and further research is needed. The overlap between neuroticism and perfectionism also speaks to neurotic perfectionism (Hamachek, 1978), which has been discussed for decades, but largely forgotten since the advent of multidimensional perfectionism (Frost et al., 1990; Hewitt & Flett, 1991). Future empirical models might shed better light on how past theoretical conceptualizations of perfectionism may still be relevant and aid in the understanding of how multiple vulnerability factors might manifest within individuals rather than relying on statistical techniques to separate and test unique effects. That is, in "real" people such traits occur together and cannot be isolated statistically.

Whereas neuroticism and self-critical perfectionism showed unique roles in predicting stress generation, perfectionistic strivings showed no unique effects (Hypothesis 2.3). Consistent with hypotheses and research (Dunkley et al., 2003; Stoeber & Otto, 2006), perfectionistic strivings appeared decidedly neutral, as it failed to

uniquely predict stress generation or related processes beyond other personality traits. Other research, however, suggests perfectionistic strivings may serve as a specific vulnerability factor for distress, but only in the context of achievement stress (Enns & Cox, 2005; Hewitt & Flett, 1993). Thus, people who set high standards for their own performance may only perceive their daily lives as more stressful if performance is a regular and salient aspect of everyday life.

The second objective was to test the effects of stress generation and stress perpetuation on stress sequelae in aggregate over time (i.e., between-person effects) and on a day-to-day basis (i.e., within-person effects). Hypotheses 2.4 and 2.5 were mostly supported, although the relative contributions of stress generation and stress perpetuation depended largely on the outcome being considered. Emotional distress is perhaps the most ubiquitous outcome when studying stress vulnerability, and this research suggested it might be the most multi-factorial in origin. Results suggest stress generation and stress perpetuation have unique effects on emotional distress, which supports the notion that rumination amplifies and prolongs the effects of stress (e.g., Brosschot et al., 2006), although the events themselves still have a unique effect on emotional distress, consistent with other research (Dunkley, Ma, et al., 2014). The effects of rumination in this study also point to the importance of rumination in research on perfectionism and stress, and research in this area would benefit from increased focus on stress perpetuation.

Consistent with past research, parasympathetic activity was distinct from other measures of subjective experience (Čukić & Bates, 2015), and was associated primarily with rumination (Key et al., 2008; Ottaviani et al., 2011). My results extend other daily diary research showing a similar effect of another form of perseverative cognition on

parasympathetic activity—namely, worry (Brosschot et al., 2007). Although rumination was associated with decreased heart rate variability over the span of a week as expected (i.e., at a between-person level), the opposite pattern was true when considered within days. This pattern may arise from the dynamic balance between sympathetic and parasympathetic systems (Thayer, Yamamoto, & Brosschot, 2010), such that strong sympathetic activation during a stressful day leads to subsequent increases in the parasympathetic system at the end of the day to restore physiological balance. Despite this seemingly successful short-term adaptation, prolonged activation taxes physiological resources and leads to decreased physiological regulation over time, consistent with theory and research on allostatic load (McEwen, 1998). These short-term adaptations to stress come at a cost—the long-term wear-and-tear on people's capacity to flexibly and adaptively respond to daily life.

Positive emotions are featured prominently in other models of perfectionism and stress (e.g., Dunkley, Ma, et al., 2014) and capture the effects of more adaptive coping responses. With vigor only showing negative associations with rumination at a daily level in this research, my model reflects stress vulnerability alone, while not capturing more adaptive processes shown in other research. This is notable, as the lack of subjective distress may not be equivalent to an adaptive response. Existing models (e.g., Dunkley, Ma, et al., 2014) that more specifically feature adaptive coping responses (e.g., perceived control, positive re-interpretation, and problem-focused coping) may be better suited to account for successful adaptation to stress. Thus, future work may be warranted to more specifically address the possible relation between adaptive coping and increased parasympathetic activity.

Fatigue is infrequently studied in perfectionism literature, and yet fatigue was the one subjective experience at a daily level uniquely predicted by daily stress. Self-critical perfectionists may thus be uniquely prone to feeling exhausted and overwhelmed by their experiences on a day-to-day basis. When considered at a between-person level, fatigue and emotional distress were strongly related. Emotional distress and fatigue were seemingly parallel, but distinct, outcomes of stress processes. This may reflect the bi-directional relationship between stress and fatigue (Doerr et al., 2015). Together with research showing the interactive effects of prolonged fatigue and burnout symptoms in producing chronic burnout (Leone et al., 2008), these findings may provide new understanding of the daily processes underlying the vulnerability of perfectionistic people to burnout (Hill & Curran, 2016). This highlights the importance of multi-method research, as multiple facets of subjective experience and physiological dysregulation may link stress perpetuation to long-term health outcomes (Fry & Debats, 2009).

4.4.1 Limitations and Future Directions

I used a once-a-day end-of-day reporting schedule, which minimizes participant burden, but makes inter-related daily processes more difficult to disentangle. For example, retrospective evaluation of the perceived stressfulness of an event may be inflated by rumination about that event. Research using more frequent reporting or random sampling would be helpful to disentangle within-day associations. Similarly, participants completed HRV recordings after the daily questionnaire. Reflecting upon daily events prior to HRV recordings could have inflated the relation between rumination and parasympathetic activity. Experimental studies could test the degree to which order effects might influence daily diary research.

My sample of working professionals helps situate stress processes within a broader population rather than focusing on undergraduate students. However, my sample was primarily Caucasian, educated, and married, which this limits generalizability. Unemployed people, part-time workers, and stay-at-home parents remain unrepresented. Such groups may experience stress in qualitatively and quantitatively different ways than my sample of working professionals, and future research could test these possible differences empirically. My sample was relatively small, and lacked sufficient power to detect small between-person effects. Replications with larger sample sizes are needed. Finally, I tested the contribution of neuroticism and perfectionism as global personality domains, but further research is needed to test how specific facets of each may uniquely contribute to stress generation processes.

4.4.2 Concluding Remarks

This research supports the notion that neuroticism and perfectionism operate in more-or-less distinct ways. Both neuroticism and perfectionism are considered vulnerability factors for stress and depression (Enns et al., 2005; Smith, Sherry, et al., 2016), but the present study suggests these two forms of personality can be considered together to better understand cognitive-affective vulnerability factors that contribute to the generation of stress on a day-to-day basis. Self-critical perfectionists seemingly act, and interact, with their world in a way that generates stressful experiences, whereas the core of neuroticism may be a reactivity to those day-to-day events through rumination and mood reactivity. Rather than competitors, neuroticism and perfectionism may be complementary and I hope this research spurs interest in how these related personality constructs might work in complementary and synergistic ways.

Only a small number of perfectionism studies to date have included measures of cardiovascular functioning (Albert et al., 2016; Azam et al., 2015; Besser et al., 2008; Hewitt et al., 2008). These studies are noteworthy and important; however, they all reflect physiological responses to a lab-based scenario. My study is unique in the perfectionism literature in that it uses daily measures of physiological responses to stress (i.e., heart rate variability) alongside cognitive and affective phenomena to test stress processes as they unfold during everyday life. My findings demonstrate the utility of short-term heart rate variability recordings in daily diary research. Short-term recordings may help make these techniques more practical for researchers compared to more intensive measurement (e.g., Brosschot et al., 2007), while simultaneously reducing participant burden.

My use of a psychophysiological model of stress in personality research is also noteworthy, as it supports a growing trend toward the use of multi-method research to more rigorously test questions of interest. My study was also unique in that it brought physiological measurement into the realm of daily experience. Beyond methodological rigor, however, my psychophysiological model of stress also helps situate personality research amidst a broader stress literature. With a developing link between personality and increased risk of disease burden and morbidity (Fry & Debats, 2009), my research points toward personality vulnerabilities, and their associated processes, as important contributors to the increased emotional and physiological burden that puts people's long-term health at risk.

Chapter 5: Conclusion

Existing research on perfectionism and stress focuses predominantly on the contributions of psychological and interpersonal experiences, but frequently neglects physiological processes. The few existing studies using physiological measures to understand perfectionism and stress are often subject to notable limitations, including poor methodological control and reliance on lab-based physiological measurement. This dissertation was meant to help fill in this gap and served two primary objectives: (1) to highlight the importance of psychophysiological processes in perfectionism and stress, and (2) to address limitations of previous research by bringing physiological measurement into the realm of daily experience. These objectives served as a foundation for two empirical studies. In this chapter, I summarize key findings from this dissertation, discuss implications for research and clinical practice, identify methodological strengths and limitations of this research, and outline areas in need of further study.

5.1 Summary of Research Findings

Study 1 tested the direct and indirect effects of perfectionism on HPA-axis activity, as measured by diurnal cortisol patterns over a three-day period, and showed self-critical perfectionism influences diurnal cortisol primarily through two pathways related to stress reactivity. Whereas people low in self-critical perfectionism showed a pattern of diurnal cortisol activity that increased with stress, people high in self-critical perfectionism showed similarly elevated cortisol regardless of stress level. People high in self-critical perfectionism were also more vulnerable to depressive symptoms during periods of high stress, which showed indications of a blunting effect on diurnal cortisol levels. Together, these two unique effects suggest stress reactivity processes can

influence HPA-axis activity, and lead to dysregulation of this system, through two mechanisms. Research shows HPA-axis dysregulation creates vulnerability to depressive symptoms over time (Ancelin et al., 2017; LeMoult et al., 2015), which suggests highly perfectionistic people may be vulnerable to depressive symptoms through multiple pathways, each with unique treatment needs.

Study 2 complemented and extended Study 1 by testing the unique contributions of perfectionism and the higher-order personality trait of neuroticism, capturing a broad sequelea of stress, including heart rate variability, using a 7-day daily diary design with a sample of working community members. In contrast to research that has focused on whether perfectionism predicts outcomes beyond neuroticism (e.g., Enns et al., 2005; Smith, Sherry, et al., 2016), this study showed the contributions of neuroticism and perfectionism may be unique. Most notably, results showed neuroticism confers unique vulnerability to emotional distress and ruminative thinking, while self-critical perfectionism confers vulnerability to daily stress that serves as a focus for rumination, leading to emotional distress, fatigue, and reduced parasympathetic activity over the 7-day study period. Vulnerability to daily stress and rumination also had an impact at the daily level, with daily stress uniquely contributing to fatigue, rumination uniquely contributing to parasympathetic activity and lack of positive emotions, and both stress and rumination uniquely contributing to emotional distress.

Both studies, when considered together, point toward the unique interplay between neuroticism and self-critical perfectionism in creating both emotional and physiological vulnerability to stress. The psychological vulnerability of self-critical perfectionism demonstrated in my research is well documented in existing literature. For

example, other research points toward the role of perfectionistic discrepancies (Sherry, Mackinnon, Fossum et al., 2013; Sherry, Mackinnon, Macneil et al., 2013) and interpersonal difficulties in creating vulnerability to depressive symptoms (Dunkley, Sanislow et al., 2006; Sherry et al., 2008), the propensity for perfectionistic people to be reactive to stress (Hawley et al., 2014; Hewitt & Flett, 1993), and the contribution of ineffective coping to stress reactivity (Dunkley, Mandel et al., 2014; O'Connor & O'Connor, 2003). The present research helps clarify how perfectionism, and the higher-order trait of neuroticism, impacts physiological activity through mediating processes. Whereas Study 1 suggested self-critical perfectionism contributes to HPA-axis dysregulation through two distinct pathways involving stress reactivity, Study 2 suggested self-critical perfectionism may impact physiological stress through rumination that arises from higher order personality vulnerability, rather than perfectionism itself. This does not imply perfectionism is unimportant, however; Study 2 also suggested self-critical perfectionism serves a unique role in generating the daily experiences that "feed" rumination to increase psychological distress and decrease a person's ability to respond in a flexible and adaptive way to daily demands. In summary, perfectionistic people are likely vulnerable to the immediate and long-term effects of stress through various inter-related mechanisms, including both psychological and physiological processes. Although perfectionism is important to consider alongside other complimentary personality traits (e.g., neuroticism), the effect of perfectionism is undoubtedly unique and continued research using psychophysiological models is needed to better understand the unique role of perfectionism in stress vulnerability.

5.2 Implications for Research

5.2.1 Toward a Bio-psycho-social Model of Perfectionism and Stress

Research on perfectionism and stress is advancing, with recent models focusing mostly on psychological and social features of this relation (e.g., Dunkley et al., 2017). This dissertation helps fill a gap in this area by testing psychological and physiological factors in this association, with the intention for these models to dovetail with existing research to move toward a more integrative bio-psycho-social understanding of perfectionism and stress. Integration is not without challenges, however.

True integration within a single model would involve substantial complexity, and the use of physiological measures places notable constraints on research design. The high cost of using physiological measures places limitations on the sample sizes that are feasible with this research, and certain research designs are less compatible with these methods. For example, measurement of diurnal cortisol patterns within daily diary research is problematic due to the low reliability of single-day estimates (Bolger et al., 2003). Failure to control for confounding factors in physiological processes also makes this research vulnerable to methodological problems that obscure underlying associations (Page et al., 2018). Carefully designed research using physiological measures in longitudinal and daily diary designs are resource-intensive and may be infeasible for many research groups.

For these reasons, the expectation that physiological measures be commonly integrated into perfectionism research may be untenable and unproductive. Specialization may be particularly important in this area given the infrastructure cost in conducting this research and the need for careful research design, which may make certain research

groups more effective in conducting this research than others. The expectation that these methods be adopted widely may make the field more vulnerable to methodological problems that confound measurement in a way that does more to obscure understanding than advance it.

5.2.2 Balancing Costs and Benefits of Physiological Measures

The use of physiological measures carries significant cost and adds to research complexity. Equipment and infrastructure necessary for physiological measurement can involve significant procurement and maintenance cost, which can make physiological measures, such as daily heart rate variability, inaccessible to many research groups. Even if equipment is available, research design using these measures can be complex and require careful consideration of measurement spacing and frequency, sample storage, and how to account for (and minimize) potential confounding factors (e.g., Kraemer et al., 2006; Nicolson, 2008; Page et al., 2017). During data collection, equipment failure can result in data loss or degradation. Physiological sampling involves higher participant burden and requires additional training and support to maximize protocol compliance. Data processing, cleaning, and analysis can also be resource intensive; cleaning daily ECG data requires a significant time investment, and hormone assays for cortisol or other salivary biomarkers requires significant financial resources.

Are physiological measures worth the cost? Researchers may differ on this question, but the answer may depend largely on the purpose of the research. Physiological measures tap into phenomena that may be inaccessible through self-report and are, in and of themselves, noteworthy phenomena that have important implications for physical and emotional health (e.g., Adam et al., 2017). Although physiological

measures such as cortisol and heart rate variability have psychosocial correlates, they do not correspond directly to psychological or emotional phenomena (Nater & Rohleder, 2009; Thayer et al., 2012). Collection of physiological measures to provide "objective" measures of psychological phenomena are more likely to result in poor use of resources, with data often showing null results and thus giving poor return on investment (e.g., Zureck et al., 2014).

If physiological measures are used, strategies to reduce cost may be warranted if applied judiciously. Reducing measurement frequency or length of recordings may be possible under certain conditions while still providing reliable data (Kraemer et al., 2006), and the use of robust statistical techniques (e.g., latent variable modeling) can ensure all available data can be used despite missing data due to equipment failure or participant non-compliance (Acock, 2005).

5.2.3 The Relation Between Neuroticism and Perfectionism

Early conceptualizations of "neurotic perfectionism" (Hamachek, 1978) are largely a historical footnote to contemporary perfectionism research; however, the intersection between neuroticism and perfectionism may be strikingly apropos to empirical advancement. Findings from Study 2 support the overlap between neuroticism and perfectionism, consistent with a large and unequivocal body of existing research, but the present research approaches this overlap in a novel way. Rather than focusing on questions of whether perfectionism predicts outcomes incrementally beyond neuroticism, I sought to test ways in which each might show specificity of prediction to understand how each might serve as a unique vulnerability factor for different processes that contribute to psychological distress.

Neuroticism is more than a personality trait that needs to be accounted for in the study of perfectionism—rather, more work is needed to provide a theoretical and empirical understanding of how these two traits function together in overlapping and distinct ways. This may not involve the development of a new form of perfectionism, as was done for the now frequently studied self-critical perfectionism (see Dunkley & Blankstein, 2000), but may instead involve establishing a clearer understanding of how neuroticism might give rise to perfectionism, in what circumstances this might occur, and to what effect. There is little evidence to date that supports neuroticism as a so-called "source trait" for perfectionism (Stoeber et al., 2009), although this may reflect a paucity of data rather than a lack of causal association. Perhaps the data is also ambiguous because neuroticism may only contribute to the development of perfectionism under specific familial or academic conditions (Speirs-Neumeister, 2004), or in combination with other demonstrated source traits (e.g., conscientiousness; Stoeber et al., 2009). These possibilities remain largely speculative, however. Other researchers are encouraged to carefully consider how perfectionism and neuroticism may function in concert, rather than attempting to isolate them statistically without considering the theoretical and empirical implications of doing so.

5.2.4 Considering Content and Form of Perfectionistic Cognition

Much research on perfectionism and cognition focuses on the content of thoughts, whether it be discrepancies between ideal and evaluated performance (Slaney et al., 2001), perfectionistic automatic thoughts (Flett et al., 2007), or self-presentation concerns (Hewitt, Flett, Sherry, et al., 2003). Although each of these areas has led to fruitful empirical research, the present research suggests the form of cognition may also be

important. Many of the existing studies of perfectionism and ruminative thinking have focused on perseveration about one's own distress (i.e., symptom-focused rumination), rather than perseveration about negative events (i.e., event-focused rumination). For perfectionistic people, particularly those who are also high in neuroticism, repetitive negative thought about daily experiences may be uniquely important for catalyzing emotional distress in response to stressful events.

This is not to suggest form of cognition is more important than content—rather, consideration of both form *and* content may be necessary to understand the impact of cognition for perfectionistic people in distress. Content and form may interact in unique ways, such that people high in both self-critical perfectionism and neuroticism may be more likely to perseverate on perfectionistic content compared to other themes, or be more vulnerable to perfectionistic cognitions when engaged in event-focused rumination. This represents a potentially fruitful area for further research and may provide opportunities to better understand how perfectionistic people process information about their day-to-day experiences.

5.3 Practical and Clinical Implications

Aside from its empirical implications, results from this research have the potential to inform practical applications that support the well-being of people who are vulnerable to stress. Perfectionistic people may see stress as a necessary evil, or even a badge of honour, in the fulfillment of their chosen pursuits, while downplaying the long-term deleterious effects of stress and their role in generating that stress. They may also become defensive about how they manage stress, with concerns that ineffective coping implies a notable flaw. This research could support efforts to help increase public awareness about

the role of perfectionism in exacerbating stress, de-stigmatize the processes that amplify stress, and help perfectionistic people self-manage their stress more effectively. This research also has important implications for the identification of assessment and treatment targets to help clinicians treat perfectionistic people more effectively when they present for clinical services.

Several key findings from this research could help people who self-identify as perfectionists to better understand how, and under which conditions, they could be vulnerable to the negative effects of stress. Study 1 showed people high in self-critical perfectionism are vulnerable to physiological effects of stress not just during times of high stress, but also when stress seems to be comparatively low. Thus, periods of relatively low demands may represent an "eye of the storm", rather than a period of true recuperation (Flaxman et al. 2012). Similarly, results suggest emotional distress and physiological effects of stress are linked in important ways; that is, emotional distress has impacts on physical health in addition to subjective well-being. Study 2 suggests self-critical perfectionism acts primarily to increase stress levels, but it works together with other personality vulnerabilities (i.e., neuroticism) that amplify emotional and physiological distress in response to that stress. Both fatigue and emotional distress may be important indicators of increased stress that may suggest a need for perfectionistic people to take a more active coping approach, regardless of their level of neuroticism.

Perfectionistic people are particularly vulnerable to self-stigmatization, and they may see emotional difficulties as a sign of a flawed self, and thus avoid treatment despite significant distress (Shannon, Goldberg, Flett, & Hewitt, 2018). Results from both studies suggest it is not the stress itself that necessarily leads to negative sequelae, but rather the

prolonged activation through other processes (e.g., rumination linked to neuroticism). If perfectionistic people see perseveration as a result of neurophysiological differences that can manifest in both helpful (e.g., determined problem solving) and unhelpful ways (e.g., rumination), then there may be less tendency to see characteristics, like perseveration, as a deeply ingrained character flaw. If people were to see these tendencies as the result of inheriting a brain predisposed toward perfectionism (e.g., through source traits; Stoeber et al., 2009), it may generate a greater tendency to seek help in developing skills to compensate for these shortcomings. Cognitive-behavioural approaches that focus on maladaptive thinking styles and cognitive distortions (e.g., Egan, Wade, Shafran, & Antony, 2014) may do more to advance stigma than to address it. In contrast, thinking about perfectionistic processes as imperfect solutions to distressing problems (e.g., avoiding criticism and feeling a sense of self-worth; see Hewitt, Flett, & Mikail, 2017) may help reduce the stigma that inhibits perfectionistic people from seeking needed support.

If perfectionistic people are able to recognize when and how they are vulnerable to stress and see it non-defensively as a problem to address, they may be more likely to take active steps to mitigate their vulnerability. This research did not focus on the development of effective coping strategies, but it does suggest some potentially novel solutions using physiological indicators. Study 2 suggests HRV may be an objective indicator of physiological stress that could be measured and monitored at home. Self-administered bio-feedback programs for stress have shown mixed results (Horgan, Howard, & Gardiner-Hyland, 2018; Turner, 2018), although biofeedback programs using HRV showed efficacy overall in a recent meta-analysis (Goessl, Curtiss, & Hofmann,

2017) and could be useful for perfectionistic people who wish to learn more effective stress management skills without seeking clinical services. Empirical tests are needed, however, to demonstrate whether HRV-based biofeedback programs would be effective with perfectionistic people.

In employment and academic settings, those people occupying leadership positions as supervisors, mentors, or instructors are advised to build awareness of how perfectionism influences stress and well being. While perfectionistic traits can sometimes be seen as positive qualities in terms of productivity, these traits can also plan an important role in stress vulnerability that may impact work performance and overall adjustment. While mild perfectionistic traits may respond well to coaching and encouragement to reduce perseveration or concerns about evaluation, more severe presentations (e.g., those high in self-critical perfectionism) may require additional support to reduce stress generation and the perseverative thought that is most likely to drive maladjustment.

Despite the potential benefit of self-management programs, some perfectionistic people may require more intensive clinical services. The present research was not meant to validate clinical assessment measures or test intervention strategies for perfectionistic clients, yet results provide potentially valuable information about assessment targets and intervention strategies for working with people high in perfectionism that present for clinical services.

5.3.1 Clinical Assessment Targets

There are no validated normative data for heart rate variability or diurnal cortisol patterns that have been used to inform clinical assessment practices, and the possibility of

widespread use of these measures in clinical practice is unlikely unless substantial advances are made in this area. However, results from the present research suggest psychological processes that *contribute* to physiological dysregulation may serve as useful assessment targets in clinical practice.

Self-critical perfectionism is unique from perfectionistic strivings and neuroticism in its ability to generate stressful events, and thorough assessment of stress generation effects may be important in treatment planning for people high in self-critical perfectionism. Research has documented the vulnerability of perfectionistic people to self-defeating behaviours that generate emotional distress, including avoidance, binge eating, procrastination, and interpersonal conflict (Dunkley, et al., 2003; Mushquash & Sherry, 2012). Although these tendencies may provide a useful heuristic for assessment, stress generation effects may also be ideographic and unique to the individual. Behaviour chain analysis, as used in Dialectical Behaviour Therapy (DBT; Linehan, 2014), may be a useful strategy for identifying how stressful events arise, at least in part, through problematic responses to daily events. Although avoidance and other maladaptive coping strategies have been identified as problematic behaviours in perfectionism (Dunkley, Mandel, et al., 2014), stress generation and related research (e.g., La Rocque et al., 2016) suggests a focus on interpersonal experiences may be particularly relevant for understanding how depressive symptoms are maintained in perfectionistic clients.

For those clients who present with self-critical perfectionism and neuroticism, the events arising from stress generation are also likely to be catalyzed by perseverative thinking that contributes to the emotional and physiological sequelea of stress. Symptom-focused rumination (i.e., perseveration about having symptoms) is commonly discussed

in relation to depressive symptoms, yet event-focused rumination (i.e., perseveration about negative experiences) may be similarly relevant (see Smith & Alloy, 2009). Assessment of social anxiety commonly includes post-event processing (i.e., prolonged cognitive rumination about negative aspects of behaviour following social interactions; Clark & Wells, 1995), and similar measures may be useful in understanding how perfectionistic clients might dissect their experiences, particularly interpersonal interactions, in a way that amplifies and prolongs their distress. Although the present research focuses on rumination, perfectionistic cognitions (e.g., discrepancies, self-presentation concerns, self-criticism) are likely to arise within the context of event-focused rumination, and thus remain important to assess when conducting case formulation and treatment planning.

5.3.2 Clinical Intervention Strategies

Cognitive-behavioural (Egan et al., 2014) and interpersonal treatments (Hewitt et al., 2017) are available to address perfectionistic tendencies, which target self-defeating behaviours, perfectionistic cognitions, and interpersonal processes that contribute to, and perpetuate, distress. Rumination, however, may be a uniquely important treatment target at risk of being overlooked in these models. Challenging thought content without reducing perseveration may help ameliorate emotional distress overall, but leave people vulnerable to symptom recurrence or the persistence of residual symptoms. Research suggests mindfulness-based interventions may be helpful, at least in part, by reducing ruminative processes (James & Rimes, 2018). However, evidence suggests perfectionistic people may also find these skills more challenging to develop and use effectively (Short & Mazmanian, 2013). Thus, perfectionistic clients may have much to gain from these

skills, yet require more support than other clients to develop and use these skills effectively.

If people high in self-critical perfectionism are vulnerable to emotional distress in part due to concomitant neuroticism, residual emotional reactivity following psychotherapy may be challenging to eliminate completely. Although recent work has suggested neuroticism may be malleable and amenable to psychotherapy (Sauer-Zavala, Wilner, & Barlow, 2017), reducing the self-defeating behaviours and rumination that feed emotional vulnerability may be a more effective treatment target. Residual symptoms may very well be expected for perfectionistic clients high in neuroticism, and thus "successful" treatment may not involve a complete resolution of symptoms. Augmentation of CBT or interpersonal therapy with third-wave approaches aimed at fostering acceptance and psychological flexibility (e.g., Acceptance and Commitment Therapy, Mindfulness-based Cognitive Therapy) may be helpful for perfectionistic clients who may otherwise interpret residual symptoms as a treatment failure, which could precipitate relapse.

5.4 Methodological Strengths of this Research

This research, including the individual studies and the dissertation as a whole, involves notable methodological strengths that set it apart from existing research. The key feature of this research is the combination of intensive, multi-method measurement of short-term processes combined with advanced statistical modeling techniques, whereas many studies of perfectionism show an over-reliance on cross-sectional designs, self-report questionnaires, and undergraduate samples. Study 1 advances the literature on perfectionism and stress by measuring salivary cortisol twice daily for three days to

provide a reliable estimate of diurnal cortisol patterns, while reducing the impact of other factors (e.g., hormonal contraceptive use, menstrual cycle, gender) that other studies often overlook (Page et al., 2018). Study 2 is unique in testing daily heart rate variability in the context of perfectionism and other stress processes. The use of a 7-day daily diary design helps provide more reliable estimates of daily processes, provides increased ecological validity by measuring phenomena in the context of daily life, and helps reduce recall bias (Bolger et al., 2003). Using a sample of working community members in Study 2 also helps overcome the potential for results to reflect developmental processes specific to emerging adults (Arnett, 2000, 2007), rather than the average working Canadian.

Latent variable modeling techniques allow intensive daily measurement to be analyzed in a way that takes full advantage of available data. Missing data and participant non-adherence are typical in daily diary studies (Black, Harel, & Matthews, 2012), and yet many statistical techniques require complete data. Latent variable modeling techniques used in this dissertation allow unbiased estimates of model parameters when incomplete data are included in the model (Acock, 2005). The flexibility of these techniques also overcomes logistical complications that arise when strict control of sampling is not possible, such as when participants provide samples unsupervised in the context of their daily lives. For example, the use of latent growth modeling with individually varying times of observation (as used in Study 1) provides a robust method of analyzing diurnal cortisol patterns within a larger path model to answer novel research questions that would be challenging, if not impossible, using other methods.

5.5 Limitations and Future Directions

Despite these numerous strengths, further research is needed to replicate and extend these findings. Based on the previously discussed challenges associated with physiological measurement (see Section 5.2.2), the sample size for each study is relatively small. This was necessary given resource constraints, yet larger samples may be needed to provide more powerful and rigorous tests of these models and allow for greater statistical complexity. Despite the use of a community sample of full-time working professionals in Study 2, both samples remained relatively homogenous in terms of cultural background and socio-economic status. The perfectionism-stress connection may manifest differently when considered within a broader population that also includes, for example, people who did not study at a university, people who are unemployed, and people engaged full-time in other activities (e.g., stay-at-home parents and retirees). The use of a more diverse population would aid in supporting generalizability of these results. Similarly, studying these processes in clinical populations (e.g., patients with treatment refractory depression) may help provide a more rigorous test of the possible physiological pathways involved in depression vulnerability, as suggested in Study 1.

The present research highlights the importance of rumination in psychological and physiological outcomes. However, perfectionistic cognitive processes (e.g., perfectionistic cognitions, discrepancies, perfectionistic self-presentation, self-criticism) were not included in these models, and thus it cannot be determined whether rumination functions independently from perfectionistic thought content. Research is needed to understand how event-focused rumination occurs in perfectionistic people, including to

what degree perfectionistic thought content might contribute to the malignancy of this process.

Psychological experiences in this research are measured using self-report questionnaires. While this method is straightforward and convenient, it may result in oversimplification of otherwise complex phenomena. This may be especially true for the measurement of stress, which involves objective events and a subjective interpretation of those events . As such, it is unclear to what degree these measures represent a true reflection of environmental demand versus stress perception. Other methods, such as structured interviews or observational protocols, could provide a more nuanced understanding of stress processes when used in conjunction with physiological measures.

The use of physiological measures in daily research is a significant advance, yet more work in this area is needed. The present research was not able to test how physiological dysregulation might uniquely predict outcomes longitudinally. Intensive multi-wave research designs may be needed, particularly for studying research questions related to diurnal cortisol to understand how the processes identified in this research might unfold over time. For example, Study 1 was not able to differentiate between the effects of acute transient stressors and more chronic stressors on HPA-axis functioning.

Further tests are needed to understand how psychological and physiological factors manifest in more nuanced ways. For example, it remains unclear whether physiological changes might persist following successful treatment to reduce ruminative tendencies (i.e., scar effects), whether physiological dysregulation might reinforce ruminative tendencies (i.e., complication effects), or whether physiological dysregulation might alter how perfectionism and associated stress processes produce symptoms of

distress (i.e., pathoplastic effects). Addressing these questions would help improve understanding of the psychophysiological connections and could indicate whether physiological biomarkers may be relevant for clinical practice.

Each study used a single physiological indicator, which may provide an incomplete picture of physiological stress processes. Research using multiple physiological measures would be desirable to better understand how stress affects multiple physiological systems in similar or distinct ways. Similarly, cortisol and heart rate variability do not capture the wide gamut of available physiological research methods and many more possibilities are available for use in future studies.

5.6 Concluding Remarks

Physiology is highly relevant to stress processes, yet this area is infrequently studied in the perfectionism literature. Research methods capitalizing on physiological processes can be powerful and may open new areas for inquiry, but such methods are not easy to implement outside of lab-based environments. Despite these challenges, advances in the area of perfectionism and stress require more careful consideration of how biological factors function alongside psychological and social experiences to influence emotional adjustment and psychopathology. Single studies incorporating these broad domains may be exceedingly complex, but focused research using psychophysiological models, such as the present research, helps fill this blind spot. The work is not done, however, and more research is needed in this area to move toward a more integrated understanding of perfectionism and stress. Caution is also warranted; poor methodology in psychophysiological research may do more harm than good if associations are

obscured by confounding factors and it is assumed that the absence of evidence implies evidence of absence.

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Appendix A: Hewitt and Flett's Multidimensional Perfectionism Scale

INSTRUCTIONS: Listed below are a number of statements concerning personal characteristics and traits. Read each item and decide whether you agree or disagree and to what extent. If you ***strongly agree***, circle 7; if you ***strongly disagree***, circle 1; if you feel somewhere in between, circle any one of the numbers between 1 and 7. If you feel neutral or undecided the midpoint is 4. These questions are about the kind of person you generally are, that is, how you usually have felt or behaved over the past several years.

		Strongly Disagree						Strongly Agree
1.	One of my goals is to be perfect in everything I do	1	2	3	4	5	6	7
2.	I strive to be as perfect as I can be	1	2	3	4	5	6	7
3.	It is very important that I am perfect in everything I attempt	1	2	3	4	5	6	7
4.	I demand nothing less than perfection of myself	1	2	3	4	5	6	7
5.	I must work to my full potential at all times	1	2	3	4	5	6	7
6.	Success means that I must work even harder to please others	1	2	3	4	5	6	7
7.	The better I do, the better I am expected to do	1	2	3	4	5	6	7
8.	My family expects me to be perfect	1	2	3	4	5	6	7
9.	People expect nothing less than perfection from me	1	2	3	4	5	6	7
10.	People expect more from me than I am capable of giving	1	2	3	4	5	6	7

Note: items 1-5 comprise the self-oriented perfectionism subscale; items 6-10 comprise the socially prescribed perfectionism subscale.

Appendix B: Frost's Multidimensional Perfectionism Inventory

INSTRUCTIONS: Listed below are a number of statements concerning personal characteristics and traits. Read each item and decide whether you agree or disagree and to what extent. If you ***strongly agree***, circle 5; if you ***strongly disagree***, circle 1; if you feel somewhere in between, circle any one of the numbers between 1 and 5. If you feel neutral or undecided the midpoint is 3. These questions are about the kind of person you generally are, that is, how you usually have felt or behaved over the past several years.

	Strongly Disagree				Strongly Agree
1. If I fail at work/school, I am a failure as a person	1	2	3	4	5
2. If someone does a task at work/school better than I, then I feel like I failed the whole task	1	2	3	4	5
3. If I fail partly, it is as bad as being a complete failure	1	2	3	4	5
4. If I do not do as well as other people, it means I am an inferior human being	1	2	3	4	5
5. The fewer mistakes I make, the more people will like me	1	2	3	4	5
6. Even when I do something very carefully, I often feel that it is not quite right	1	2	3	4	5
7. I usually have doubts about the simple everyday things I do	1	2	3	4	5
8. I tend to get behind in my work because I repeat things over and over	1	2	3	4	5
9. It takes me a long time to do something "right."	1	2	3	4	5
10. It is important to me that I am thoroughly competent in everything I do	1	2	3	4	5
11. I set higher goals than most people	1	2	3	4	5
12. I have extremely high goals	1	2	3	4	5
13. Other people seem to accept lower standards than I do	1	2	3	4	5
14. I expect higher performance in my daily tasks than most people	1	2	3	4	5

Note: items 1-5 comprise the concern over mistakes subscale; items 6-9 comprise the doubts about actions subscale; items 10-14 comprise the personal standards subscale.

Appendix C: Eating Disorder Inventory – Self-Oriented Perfectionism Subscale

INSTRUCTIONS: This is a scale which measures a variety of attitudes, feelings and behaviors. There are no right or wrong answers so try very hard to be completely honest in your answers. Select the response which best describes your feelings, thoughts, behaviors, etc. **over the past several years**.

NEVER = 1 RARELY = 2 SOMETIMES = 3 OFTEN = 4 USUALLY = 5 ALWAYS = 6

	NEVER					ALWAYS
1. I expect excellence of myself	1	2	3	4	5	6
2. I feel that I must do things perfectly or not do them at all	1	2	3	4	5	6
3. I have extremely high goals	1	2	3	4	5	6

Appendix D: Reconstructed Depressive Experiences Questionnaire – Self-Criticism Subscale

INSTRUCTIONS: Listed below are a number of statements concerning personal characteristics and traits. Read each item and decide whether you agree or disagree and to what extent. If you ***strongly agree***, circle 7; if you ***strongly disagree***, circle 1; if you feel somewhere in between, circle any one of the numbers between 1 and 7. If you feel neutral or undecided the midpoint is 4.

These questions are about the kind of person you generally are, that is, how you usually have felt or behaved over the past several years.

	Strongly Disagree						Strongly Agree
1. I often find that I don't live up to my own standards or ideals	1	2	3	4	5	6	7
2. There is a considerable difference between how I am now and how I would like to be	1	2	3	4	5	6	7
3. I tend not to be satisfied with what I have	1	2	3	4	5	6	7
4. Often, I feel that I have disappointed others	1	2	3	4	5	6	7
5. I am not very satisfied with myself and my accomplishments	1	2	3	4	5	6	7

Appendix E: Big Five Inventory – Neuroticism Subscale

INSTRUCTIONS: Here are a number of characteristics that may or may not apply to you. For example, do you agree that you are someone who *likes to spend time with others*? Please choose a number for each statement to indicate the extent to which you agree or disagree with that statement.

These questions are about the kind of person you generally are, that is, how you usually have felt or behaved over the past several years.

Disagree strongly = 1
Disagree a little = 2
Neither agree nor disagree = 3
Agree a little = 4
Agree strongly = 5

I see myself as someone who…

____ 1. is emotionally stable, not easily upset
____ 2 is relaxed, handles stress well
____ 3. can be tense
____ 4. gets nervous easily
____ 5. worries a lot
____ 6. is depressed, blue
____ 7. can be moody
____ 8. remains calm in tense situations

Please check: Did you write a number in front of each statement?

Appendix F: Centre for Epidemiological Studies – Depression Subscale (Short-Form)

INSTRUCTIONS: Below is a list of the ways you might have felt or behaved. Please indicate how often you have felt this way **DURING THE PAST TWO WEEKS**. Place a check mark (✓) in the column that describes your experience.

	Rarely or None of the Time (Less than 1 day)	Some or a Little of the Time (1-4 Days)	Occasionally or a Moderate Amount of Time (5-8 Days)	Most or All of the Time (9-14 Days)
	***DURING THE PAST TWO WEEKS*:**			
1. I was bothered by things that usually don't bother me.				
2. I felt that I could not shake off the blues even with help from my friends or family.				
3. I felt that I was just as good as other people.				
4. I had trouble keeping my mind on what I was doing.				
5. I felt that everything I did was an effort.				
6. I felt hopeful about the future.				
7. I felt my life had been a failure.				
8. I felt fearful.				
9. I felt lonely.				
10. People were unfriendly.				

Appendix G: Inventory of College Students' Recent Life Events

INSTRUCTIONS: Following is a list of experiences which many students have some time or other. Please indicate for each experience how much it has been a part of your life over the past month. Put a "1" in the space provided next to an experience if it was *not at all part of your life* over the past month (e.g., "trouble with mother in law- 1"); "2" for an experience which was *only slightly part of your life* over that time; "3" for an experience which was *distinctly part of your life*; and "4" for an experience which was *very much part of your life* over the **past two weeks**.

Intensity of Experience over Past Two Weeks

1 = not at all part of my life
2 = only slightly part of my life
3 = distinctly part of my life
4 = very much part of my life

1. Conflicts with boyfriend's/girlfriend's/spouse's family _____
2. Being let down or disappointed by friends _____
3. Conflict with professor(s) _____
4. Social rejection _____
5. Too many things to do at once _____
6. Being taken for granted _____
7. Financial conflicts with family members _____
8. Having your trust betrayed by a friend _____
9. Separation from people you care about _____
10. Having your contributions overlooked _____
11. Struggling to meet your own academic standards _____
12. Being taken advantage of _____
13. Not enough leisure time _____
14. Struggling to meet the academic standards of others _____
15. A lot of responsibilities _____
16. Dissatisfaction with school _____
17. Decisions about intimate relationship(s) _____
18. Not enough time to meet your obligations _____
19. Dissatisfaction with your mathematical ability _____
20. Important decisions about your future career _____

21. Financial burdens _____
22. Dissatisfaction with your reading ability _____
23. Important decisions about your education _____
24. Loneliness _____
25. Lower grades than you hoped for _____
26. Conflict with teaching assistant(s) _____
27. Not enough time for sleep _____
28. Conflicts with your family _____
29. Heavy demands from extracurricular activities _____
30. Finding courses too demanding _____
31. Conflicts with friends _____
32. Hard effort to get ahead _____
33. Poor health of a friend _____
34. Disliking your studies _____
35. Getting "ripped off" or cheated in the purchase of services _____
36. Social conflicts over smoking _____
37. Difficulties with transportation _____
38. Disliking fellow student(s) _____
39. Conflicts with boyfriend/girlfriend/spouse _____
40. Dissatisfaction with your ability at written expression _____
41. Interruptions of your school work _____
42. Social isolation _____
43. Long waits to get service (e.g., at banks, stores, etc.) _____
44. Being ignored _____
45. Dissatisfaction with your physical appearance _____
46. Finding course(s) uninteresting _____
47. Gossip concerning someone you care about _____
48. Failing to get expected job _____
49. Dissatisfaction with your athletic skills _____

Appendix H: Daily Stress Inventory

Instructions: Below are listed a variety of events that may be viewed as stressful or unpleasant. Read each item carefully and decide whether or not that event occurred within the past 24 hours. If the event did not occur, place an "X" in the space next to that item. If the event did occur, indicate the amount of stress that it caused you by placing a number from 1 to 7 in the space next to that item (see numbers below). Please answer as honestly as you can so that we may obtain accurate information.

X = did not occur (past 24 hours)
1 = occurred but was not stressful
2 = caused very little stress
3 = caused a little stress
4 = caused some stress
5 = caused very much stress
6 = caused extreme stress

1. Performed poorly at task _____
2. Performed poorly due to others _____
3. Thought about unfinished work _____
4. Hurried to meet deadline _____
5. Interrupted during task/activity _____
6. Was stared at _____
7. Did not hear from someone you expected to hear from _____
8. Experienced unwanted physical contact (crowded, pushed) _____
9. Was misunderstood _____
10. Was embarrassed _____
11. Had your sleep disturbed _____
12. Forgot something _____
13. Feared illness/pregnancy _____
14. Experienced illness/physical discomfort _____
15. Someone borrowed something without your permission _____

16. Your property was damaged _____

17. Someone spoiled your completed task _____

18. Did something you are un- skilled at _____

19. Unable to complete a task _____

20. Was unorganized _____

21. Criticized or verbally attacked _____

22. Ignored by others _____

23. Spoke or performed in public _____

24. Dealt with rude waiter/waitress/salesperson _____

25. Interrupted while talking _____

26. Was forced to socialize _____

27. Someone broke a promise/appointment _____

28. Competed with someone _____

29. Had minor accident (broke something, tore clothing) _____

30. Thought about the future _____

31. Ran out of food/personal article _____

32. Argued with spouse/boyfriend/girlfriend _____

33. Argued with another person _____

34. Waited longer than you wanted _____

35. Interrupted while thinking/relaxing _____

36. Someone "cut" ahead of you in a line _____

37. Performed poorly at sport/game _____

38. Did something that you did not want to do _____

39. Unable to complete all plans for today _____

40. Had car trouble _____

41. Had difficulty in traffic _____

42. Money problems _____

43. Store lacked a desired item _____

44. Misplaced something _____

45. Bad weather _____

46. Unexpected expenses (fines, traffic ticket, etc.) _____

47. Had confrontation with an authority figure _____

48. Heard some bad news _____

49. Concerned over personal appearance _____

50. Exposed to feared situation or object _____

51. Exposed to upsetting TV show, movie, book _____

52. "Pet peeve" violated (someone fails to knock, etc.) _____

53. Failed to understand something _____

54. Worried about another's problems _____

55. Experienced narrow escape from danger. _____

56. Stopped unwanted personal habit (overeating, smoking, nailbiting) _____

57. Had problem with kid(s) _____

58. Was late for work/appointment _____

Any stressors that we missed? List below:

59. _____ _____

60. _____ _____

Appendix I: Stress-Reactive Rumination Scale

Instructions: People think and do many different things when they experience stressful events. Please read each of the items below and indicate how much of the time you did this following the stressful event you just described. You may assign each statement any number from 0 to 100. A 0 means that you would never thought or did this in response to the stressful event. A 100 would indicate that you would frequently thought or did this in response to the stressful event. Please indicate what you **actually did**, not what you *think* you should have done.

0	10	20	30	40	50	60	70	80	90	100
Never thought or did this					Thought or did this half the time					Frequently thought or did this

1. Thought about how the stressful event was all your fault _____
2. Thought about what the occurrence of the stressor means to you _____
3. Thought about how things could have gone differently _____
4. Thought about how terrible the stressful event is _____
5. Thought about the stressful event and wish that it had gone better _____
6. Thought about how the stressful event(s) will negatively affect your life _____
7. Thought about the causes of the stressor _____
8. Thought about how important the stressful event is to you _____
9. Thought about how things like this always happen to you _____

Appendix J: Profile of Mood States – Short Form

Instructions: Please indicate the extent to which you are feeling or experiencing the following moods **during the past 24 hours**, on a scale from 0 (did not feel or experience the mood at all) to 4 (felt or experienced the mood extremely):

	Not at all				Extremely
1. Anxious	0	1	2	3	4
2. On edge	0	1	2	3	4
3. Uneasy	0	1	2	3	4
4. Sad	0	1	2	3	4
5. Hopeless	0	1	2	3	4
6. Blue	0	1	2	3	4
7. Angry	0	1	2	3	4
8. Resentful	0	1	2	3	4
9. Annoyed	0	1	2	3	4
10. Fatigued	0	1	2	3	4
11. Worn out	0	1	2	3	4
12. Exhausted	0	1	2	3	4
13. Vigorous	0	1	2	3	4
14. Cheerful	0	1	2	3	4
15. Lively	0	1	2	3	4

Note: items 1-3 correspond to the anxiety subscale; items 4-6 correspond to the depression subscale; items 7-9 correspond to the anger subscale; items 10-12 correspond to the fatigue subscale; items 13-15 correspond to the vigorous subscale.

Appendix K: Supplemental Heart Rate Variability Data

Table B

Descriptive Statistics for Aggregated Heart Rate Variability Indices

				CI 95%	
Statistic	*M*	*SD*	*ICC*	Lower	Upper
Mean heart rate	68.61	8.82	.75	66.79	70.44
Time domain					
ANN	894.91	118.07	.68	870.46	919.36
NN50	210.99	136.54	.52	182.72	239.27
pNN50	0.22	0.14	.56	0.19	0.24
SDANN	26.54	11.56	.18	24.15	28.94
SDNN	63.55	20.38	.53	59.33	67.77
SDSD	46.24	22.19	.58	41.64	50.84
RMSSD	46.21	22.18	.58	41.62	50.81
Frequency domain					
LF	1190.01	979.20	.50	987.23	1392.80
LF (normalized)	0.56	0.13	.56	0.53	0.58
HF	1023.47	990.60	.47	818.32	1228.62
HF (normalized)	0.41	0.13	.56	0.38	0.44
VLF	1175.34	757.35	.43	1018.50	1332.18
LF/HF ratio	1.86	1.32	.60	1.58	2.13
Non-linear					
RSA	32.20	17.74	.56	28.53	35.88
SD_1	32.68	15.69	.58	29.43	35.93
SD_2	83.06	25.26	.51	77.83	88.29
DFA α1	1.03	0.17	.55	1.00	1.07
DFA α2	0.90	0.10	.36	0.88	0.92
Sample entropy	1.69	0.19	.39	1.65	1.73
Correlation dimension	3.22	0.85	.32	3.04	3.39

Note. Heart rate variability (HRV) estimates are aggregated across days. Estimates of HRV are consistent with published guidelines from the European Society of Cardiology

and the North American Society of Pacing and Electrophysiology (1996). ANN = average distance between normal to normal sinus rhythm intervals (NN intervals); NN50 = number of adjacent NN intervals less than 50 ms; pNN50 = ratio of NN50 to total number of NN intervals; SDANN = standard deviation of 5-minute averages in NN intervals; SDNN = standard deviation of NN intervals; SDSD = standard deviation of successive differences in NN intervals; RMSSD = root mean square of successive differences; LF = low-frequency power domain (.04–.15 Hz); HF = high frequency power domain (.15 – .40 Hz); VLF = very low frequency power domain (.0033 – .04 Hz); RSA = respiratory sinus arrhythmia; SD1 = standard deviation of points from the line of identity on a Poincaré plot; SD2 = standard deviation of points along the line of identity on a Poincaré plot; DFA = detrended fluctuation analysis. Normalized units are expressed as a proportion of total power density. Intra-class correlations represent the proportion of total variability attributable to between-person differences. CI 95% = 95% confidence interval of the mean.

Appendix L: Student Contribution to Manuscripts

Chapter 2 was adapted from a manuscript submitted for peer-review at the *Journal of Research in Personality*. I was responsible for conceptualizing and designing this research under the supervision of Dr. Simon Sherry, overseeing data collection, completing cortisol assays under the direction of Dr. Tara Perrot, analyzing the data, writing the manuscript, and revising the manuscript based on feedback from co-authors and peer-reviewers at the *Journal of Counseling Psychology*. Adaptations to this manuscript were made based on feedback from Dr. Arla Day. The reference for this paper is as follows:

Nealis, L. J., Sherry, S. B., Perrot, T., & Rao, S. (2018). *Self-critical perfectionism, depressive symptoms, and HPA-axis dysregulation: Manifold vulnerability pathways through stress reactivity.* Manuscript submitted for publication. Dalhousie University.

Dissertation for submissionChapter 4 was adapted from a manuscript submitted for peer-review at the *Journal of Research in Personality*. I was responsible for conceptualizing and designing this research under the supervision of Dr. Simon Sherry, overseeing data collection, analyzing the data, writing the manuscript, and revising the manuscript based on feedback from co-authors and peer-reviewers at the *Journal of Personality and Social Psychology*. Adaptations to this manuscript were made based on feedback from Dr. Arla Day. The reference for this paper is as follows:

Nealis, L. J., Sherry, S. B., & Baggley, D. L. (2018). *Beyond David versus Goliath: A multi-method daily diary study testing differential effects of neuroticism and perfectionism on stress generation.* Manuscript submitted for publication. Dalhousie University.