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UNIVERSITY OF CALIFORNIA, IRVINE

The Lingering Effects of Stressors on Affect and Their Associations with Physical Health

DISSERTATION

To be submitted in partial satisfaction of the requirements of the degree of

DOCTOR OF PHILOSOPHY

In Psychology and Social Behavior

by

Kate A. Leger, M.A.

Dissertation Committee:
Professor Susan T. Charles, Ph.D., Chair
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2018

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First and foremost, I must thank my advisor and committee chair, Dr. Susan Charles. Throughout my time in graduate school, Susan has been a constant source of knowledge, encouragement, and support. She challenges me on a daily basis to expand my thinking and pushes me to reach new accomplishments of which I did not know I was capable. Susan's wisdom and insights both within and beyond the field are truly inspiring, and I am incredibly fortunate to have her as a mentor. Susan taught me that a crucial part of research is the story that we tell with our findings. Thank you, Susan, for showing me the importance of crafting a compelling story.

I'd like to thank my dissertation committee members Dr. Sarah Pressman and Dr. Roxane Cohen Silver, whose mentorship and guidance have allowed me to enhance my training and grow as a researcher. Thank you both for aiding in the development of my research and supporting me in my academic endeavors. You have been an instrumental part of my academic success. I am also fortunate to have learned from several talented faculty members in the department, and I must thank Drs. Karen Rook, Joanne Zinger, JoAnn Prause, Larry Jamner, Elizabeth Martin, and the rest of the PSB faculty and staff for supporting my curiosity and creating an enriching academic environment.

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I would like to thank my parents, Jim and Perry Leger, and my brother, Paul, for their constant love and support. For as long as I can remember they have nurtured my inquisitive nature, fostered my sense of curiosity, and have always encouraged me to work hard and pursue an answer to the question “how does this work, and why?” Mom and Dad, I am who I am today because of your unwavering love and encouragement. Thank you for the effort you put into me each and every day.

Lastly, I’d like to thank Chris Marshburn. Thank you for the hours you’ve spent listening to my presentations, reading my papers, and brainstorming research ideas. Thank you for providing me with all the love, encouragement, and strength I needed to finish this dissertation. As I continue on both my academic and personal journey, words cannot describe how beyond fortunate and happy I am that I get to take that journey with you. I love you.

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QUANTITATIVE SKILLS

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RESEARCH EXPERIENCE

- Present **Graduate Student Researcher, UC Irvine**
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Organize and analyze data from large existing datasets
Conduct graduate research on emotional reactions to stressful experiences and the impact on health outcomes
- 2015-2016 **Graduate Division Researcher, UC Irvine**
Analyzed data and compiled executive reports on surveys of UCI graduate student health and well-being, in addition to career development and planning. These reports were distributed to higher administration and faculty across UCI and prompted the development of action plans to aid in student mental health
- 2013-2014 **Graduate Student Researcher, UC Irvine**
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- 2008-2010 **Undergraduate Research Assistant, Carleton College**
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Analyzed the co-morbidity between substance use and anxiety disorders
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PUBLICATIONS

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- Leger, K.A.**, Charles, S.T., Turiano, N. & Almeida, D.M. (2016). Personality and stressor-related affect. *Journal of Personality and Social Psychology*, 111, 917-928
- Leger, K.A.**, Charles, S.T., Ayanian, J.Z., & Almeida, D.M. (2015). The associations of daily physical symptoms with future health. *Social Science & Medicine*, 143, 241-248.
- Charles, S.T., **Leger, K.A.**, & Urban, E.J. (2014). Emotional Experience and Health: What we

Know, and Where to go from here. In A.D. Ong & C.E. Löckenhoff (Eds.), *New Developments in Emotional Aging*.

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Abrams, K., Schlosser, L., **Leger, K.**, Donisch, D., Widmer, A., & Minkina, A. (2011). Panic-relevant cognitive processes among smokers. *Journal of Cognitive Psychotherapy, 25(1)*, 71-81.

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2016 **Graduate Student Panel, UCI**
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2014-2015 **Graduate Student Recruitment Coordinator, UCI**
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U.S. News and World Reports, *“Let It Go May Be Good Advice for Health,”* April 2018
Daily Mail, *“Why You Really Shouldn’t Sweat the Small Stuff,”* April 2018
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ABSTRACT OF THE DISSERTATION

The Lingering Effects of Stressors on Affect and Their Associations with Physical Health

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Doctor of Philosophy in Psychology and Social Behavior

University of California, Irvine, 2018

Professor Susan T. Charles, Ph.D., Chair

Affective responses to life's daily stressors shape our health and well-being. When studying an individual's affective response to stress, research has primarily focused on the effects of initial reactivity to stressful events. Researchers have further theorized that a person's ability to recover from a stressful experience is also an important contributor to health and well-being, but research supporting this claim is scarce. This dissertation examines lingering affect in response to both naturalistic and controlled laboratory-based stressors and its associations with physical health. This dissertation further examines how positive emotions influence lingering negative emotions following stress, and the relationship between lingering affective change in response to stress and sleep behavior. The first study found that next day lingering negative affect in response to a minor stressor predicted poor physical health in an assessment 10 years later (Chapter 2). The next study revealed that positive emotions play a role in how much lingering negative affect people experience. On stressor days when people experienced greater levels of positive emotions, they reported less lingering negative affect on the following day (Chapter 3). The final study used a laboratory-based design to examine the association between prolonged affective recovery from a stressor and sleep behavior. This study found that prolonged

affective, but not physiological, recovery was related to worse reports of sleep quality and efficiency (Chapter 4). Findings from this dissertation demonstrate that emotions that linger following a stressful event are important for shaping physical health. These results point to the importance of emotion regulation strategies that focus on hastening affective recovery from stressful events and managing emotions that linger in the time following a stressful event.

CHAPTER 1:

Introduction

Introduction

The belief that emotions influence the development of health and disease has existed since ancient times. In Greece, Hippocrates linked emotional experience and disease by proposing that both physical illness and temperament were caused by an imbalance of the four bodily humors: black bile was connected with sadness, phlegm with lethargy, blood with happiness, and yellow bile with anger (Kagan, Snidman, Arcus, & Reznick, 1994). In modern research, trait negative affect, or a general disposition to experience sadness, anger, irritability, and other negative emotions, has been studied extensively in relation to physical health. Research has shown that experiencing overall high levels of negative affect is associated with worse physical health and disease development (e.g. Friedman & Booth-Kewley, 1987; Hampson, 2012). Since the advent of modern medical research, the humoral theory of emotions and health has been discredited. Yet, empirical findings now link emotional experience and physical health, and a large body of research has begun to elucidate the impact of affective experience on physical health.

In addition to overall negative affect levels, researchers have demonstrated that our negative emotional responses to psychological stressors also impact our health. As opposed to trait levels of affect, which assess static levels of emotion in an individual, affective reactivity is a dynamic process that captures changes in affect in response to stressors (Almeida, Piazza, Stawski, & Klein, 2011). Changes in negative affect in response to a stressor have been shown to relate to physical and mental health outcomes. Research on the distress caused by psychological stressors and the processes through which this distress influences the development of health-related outcomes has largely focused on the effects of traumatic life events and chronic stressors. Substantial work has shown that both major life events such as divorce, job loss, or a natural

disaster and chronic stressors such as living in poverty or caring for a sick relative lead to significant distress in an individual and are associated with increases in both mortality and morbidity (Hatch & Dohrenwend, 2007; Pizarro, Silver, & Prause, 2006).

In contrast to major life events and chronic stressors, daily stressors are minor challenges that occur on a day-to-day basis such as a work deadline, traffic jam, or spousal argument. Unlike major life events and chronic stressors, daily stressors are frequent and happen to everyone. Almost everyone experiences an increase in negative affect and decrease in positive affect in response to a stressful situation (Almeida, 2005; Bolger & Schilling, 1991). Negative emotions in response to daily stressors are adaptive and aid in our survival. However, worry or rumination over past and future events can cause negative emotions to linger and become chronic. These prolonged changes in emotion are hypothesized to lead to susceptibility to disease and poor physical health outcomes (Sapolsky, 1996).

When examining affective responses produced by daily stressors and their role in shaping future physical health, researchers have primarily focused on same day changes in affect in response to a stressful experience. Relatively little research has examined what happens when these affective changes are prolonged and whether or not these changes that stick around in the days after a stressor has passed have any bearing on physical health. Despite the fact that a dearth of research exists on these lingering affective changes, there is reason to believe that lingering affect may exert influences on physical health that are separate and distinct from initial reactivity to stressors. Research on both physiological recovery from stressors (McEwan, 1998; Panaite, Salomon, Jin, & Rottenberg, 2015) as well as prolonged negative cognition in response to stressors (Brosschot, Gerin, & Thayer, 2006; Glynn, Christenfeld, & Gerin, 2002) has demonstrated that when people respond to a stressful experience, it may in fact be how people

recover in addition to how people react that has important implications for physical health and well-being. It has long been recognized that reactivity and recovery from stressors are separate constructs that have their own influences on physical health (Linden, Earle, Gerin, & Christenfeld, 1997). For example, it is possible for two people to have the same initial reactivity to a stressor while having different rates of recovery or amounts of lingering affect (in this dissertation, greater amounts of lingering affect is synonymous with poor or prolonged affective recovery) (Figure 1). Yet, studies that have examined affective responses to stressors have predominantly focused on affective reactivity and have neglected to examine affective recovery from these stressors.

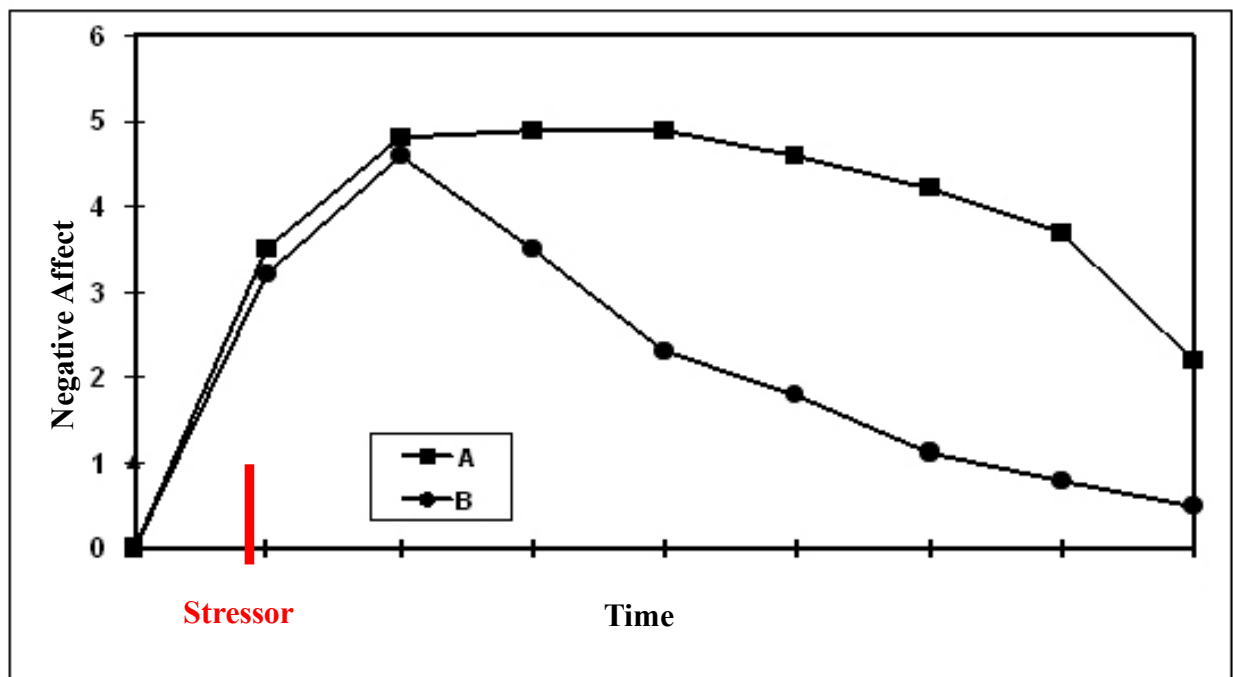


Figure 1. Two individuals with the same affective reactivity to a hypothetical stressor but with different rates of affective recovery. Person A is experiencing greater lingering negative affect or prolonged affective recovery from the stressor.

This dissertation includes three studies that examine the understudied phenomenon of lingering affective change in response to stress. The overarching purpose of these studies was to test three questions. First, does lingering affect in response to stressors influence future physical health (Chapter 2)? Second, what role do positive emotions play in the experience of lingering negative affect in response to a stressor (Chapter 3)? Third, does affective recovery from stress relate to sleep behavior, and is this relationship partially accounted for by cardiovascular functioning (Chapter 4)?

Chapter 2 of the dissertation directly assesses the relationship between next day lingering negative affect in response to daily stressors and future physical health 10 years later. Findings from this study show that next day lingering negative affect in response to a minor stressor predict increases in chronic illness and functional limitations later on in life above and beyond the influence of both same day stressor reactivity and stressor exposure. Experimental studies have examined the effects of affective reactivity and recovery from laboratory-based stressors, but the relationship between lingering negative emotions in daily life and long-term physical health has never been tested. Chapter 2 is novel in that it investigates the dynamic changes in people's affective responses to stressor as they engage in their everyday lives.

Chapter 3 shifts to an examination of the interplay between positive emotions and lingering negative affect in response to stress. Research has demonstrated that during times of stress, people experience positive affect in addition to negative affect (Folkman & Moskowitz, 2000). Researchers posit that positive emotions experienced during stress may serve to “undo” the pernicious effects of negative affect in response to a stressful situation (Fredrickson, 2001) and help facilitate quicker recovery once negative responses have occurred (Fredrickson & Levenson, 1998). However, emotional reactivity and recovery from stressors is often studied as a

trait that is relatively stable across individuals (Cohen, Manrick, Rodriguez, Feldman, Rabin, & Manuck, 2000), and less is known about how reactions to stressors fluctuate within individuals. Chapter 3 explores positive emotions as a factor that accounted for intraindividual variation in lingering negative affect in response to a stressor. Findings from this study demonstrate that people experience less lingering negative affect in response to a stressor on days when they experience higher levels of positive affect. This finding holds above and beyond trait levels of positive affect, suggesting that it is not just overall trait levels of positive affect, but also daily positive emotions that helps a person experience less lingering negative affect the next day.

In Chapter 4, a laboratory study examines both positive and negative affective recovery from a psychosocial stressor and their relationship with sleep, a health behavior known to influence health outcomes (Ayas, White, Manson, Stampfer, Speizer, Malhotra, & Hu, 2003; Kripke, Garfinkel, Wingard, Klauber, & Marler, 2002). One factor that may link affective recovery and sleep is cardiovascular arousal. This study further examines whether cardiovascular recovery from the stress task is related to the associations between affective recovery and sleep. This study finds that positive and negative affective recovery after a Trier Social Stress Task are related to different aspects of sleep. Prolonged negative affective recovery is associated with worse sleep quality and prolonged positive affect recovery is associated with worse sleep efficiency. Cardiovascular recovery is not related to affective recovery from the stress task nor to either measure of sleep. These findings suggest that the role of sleep is particularly important when examining the link between lingering affect and health.

This dissertation further adds to the literature on emotional responses to stress and health by examining this understudied concept of lingering affective change through the use of both laboratory-based and daily diary designs. The use of both study designs allows for an

examination of lingering affective change in response to daily stressors and its impact on future health-related outcomes to be juxtaposed with lingering affect to a laboratory-based stress task and how it is related to sleep behavior. The use of both study designs has unique methodological benefits. Studying a contrived psychosocial stressor in a laboratory setting allows for a carefully controlled environment and captures the emotional response to a specific stressor. Use of daily diary methodology allows for the study of how people respond to a variety of stressors in a natural environment away from the contrived nature of the laboratory. Thus, the use of these two designs examines the phenomenon of lingering affective change and affective recovery with two different types of stressors: a controlled lab-based stressor and naturally occurring daily stressors. The studies presented in Chapters 2-4 offer an in depth look into the phenomenon of lingering affective change (or prolonged affective recovery) including its ability to predict future physical health, how positive emotions relate to the experience of lingering affect in daily life, and the relationship between prolonged affective recovery from stress and sleep behavior. Implications of these findings are discussed in Chapter 5.

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CHAPTER 2:

Let it Go: Lingering Negative Affect in Response to Daily Stressors is Associated with Physical Health Years Later

Abstract

The way we respond to life's daily stressors has strong implications for our physical health. Researchers have documented the detrimental effects of initial emotional reactivity to daily stressors on future physical health outcomes, but have yet to examine the effects of emotions that linger after a stressor occurs. The current study investigates how negative affect that lingers the day after a minor stressor occurs is associated with health-related outcomes. Participants ($N=1,155$) in a community-based, nationwide study answered questions about daily stressors and affect across 8 consecutive days, and their physical health almost 10 years later. Multi-level models indicate that people experience heightened levels of negative affect the day after a stressor occurs. Furthermore, higher levels of lingering negative affect are associated with greater numbers of chronic conditions and worse functional limitations 10 years later. Findings suggest that affective recovery from daily stressors has unique importance for long-term physical health.

Let it Go: Lingering Negative Affect in Response to Daily Stressors is Associated with Physical Health Years Later

When sharing the frustrations we feel after having an argument with a friend or learning of an unexpected work deadline, people often will tell us to “just let it go.” Yet, surprisingly few studies have tested the utility of this advice. A growing number of studies have examined the effects of everyday stressors on well-being, linking negative affect reactivity, defined as increases in negative affect on the day a stressor occurs, to outcomes including mental disorders, physical illness, and even mortality (Mroczek et al., 2015; Piazza, Charles, Sliwinski, Mogle, & Almeida, 2013; Cacioppo, 1998; Charles, Piazza, Mogle, Sliwinski, & Almeida, 2013). Researchers have also recognized that rumination, or the tendency to mentally rehearse past events, prolongs negative affect after a stressor and is related to worse health outcomes (Brosschot, Gerin, & Thayer, 2006). Yet, studies have not examined the relationship between actual lingering negative affect, or the continued heightened negative affect on the day following a stressor, on long-term health and well-being. The current study investigates the role of lingering negative affect that results from daily stressor events in changes in long-term physical health outcomes.

Affective Reactivity and Recovery

A growing literature has documented associations between same-day affective reactivity to daily stressful events to both current and future physical health. On days when individuals experience stressors, they report more physical health complaints and lower subjective well-being compared to stressor-free days. (Zohar, 1999; Charles & Almeida, 2006). Heightened negative affective reactivity to these stressors is also associated with the development of future health-related problems, such as higher disease susceptibility (Piazza et al., 2013; Cacioppo,

1998), higher levels of subsequent depression, (Cohen, Gunthert, Butler, O'Neill, & Tolpin, 2005) and risk of developing an affective disorder (Charles et al., 2013).

When it comes to affective responses to stressors, researchers have mainly focused on affective reactivity, and not affective recovery from stressors. Yet, researchers have long posited that failure to recover from these stressful experiences is also a risk factor for poorer health. Studies that have assessed recovery from stressors have mainly taken place in laboratory settings (Waugh, Panage, Berry Mendes, & Gotlib, 2010; Panaite, Salomon, Jin, & Rottenberg, 2015). Laboratory studies that have looked at physiological recovery, defined as the return to baseline from a previous activation level, find that prolonged physiological recovery from stressful events is linked to poorer physical health, including increased risk for cardiovascular disease and mortality (Panaite, Salomon, Jin, & Rottenberg, 2015). Therefore, it is imperative to study both reactivity and recovery from a naturally occurring stressful event as each of these constructs may uniquely influence physical health.

In studies that have examined stress-related effects that continue past initial reactivity, researchers have often focused on the role of appraisals such as rumination. The tendency to ruminate on past events is linked with worse physical health (Brosschot, Gerin, & Thayer, 2006). A common assumption is that the link between rumination and physical health is in part due to the negative affect that lingers as a consequence of rumination (Brosschot, Gerin, & Thayer, 2006). Yet, studies that examine the effects of rumination often do not directly examine the emotions themselves. Research has yet to examine what happens when negative affect is prolonged the day following a minor stressor, and whether or not this lingering negative affect has any association with physical health.

Current Study

In the current study, we extended experimental work on recovery from laboratory-based stressors by investigating whether lingering negative affect in everyday life (defined as negative affect related to a stressor that had occurred the day before) is associated with physical health outcomes nearly 10 years later. We hypothesized that next day lingering negative affect would independently predict three self-reports of physical health: chronic conditions, activities of daily living (ADLs), and instrumental activities of daily living (IADLs). We chose to examine both chronic conditions and functional limitations given the encompassing nature of these constructs. The more chronic conditions and functional limitations a person has is indicative of underlying features of physical health. Physicians and researchers use the presence of multiple chronic conditions to predict health needs, costs, hospitalization, and future increases in morbidity as well as mortality (Lehnert et al., 2011). Moreover, studies have confirmed that self-reports of chronic conditions and levels of functional impairment each correlate strongly with a physician diagnosis of illness (Henderson et al., 2009).

The current study is novel in that it investigates the dynamic changes in people's affective responses to stressors as they engage in their everyday lives and daily routines. Additionally, this study is the first to examine how lingering negative affect in response to daily stressors is related to future physical health across an almost ten-year period. By adjusting for both same day affective reactivity and average number of stressors in addition to baseline levels of the same health-reported outcomes, this study is able to isolate the unique effects of lingering negative affect on physical health independently of affective reactivity and amount of stressor exposure.

Method

Sample and Design

Participants completed the second Midlife in the United States Survey (MIDUS II), a national sample of U.S. adults. A subset of the MIDUS II participants ($N=2022$) completed the National Study of Daily Experiences (NSDE II), a daily diary study where participants completed telephone interviews about their daily experiences over eight consecutive days (Almeida, McGonagle and King, 2009). Participants also completed the MIDUS III questionnaire approximately 10 years later. To assess lingering negative affect in response to a daily stressor, participants had to experience at least one stressor during the diary portion of the study to be included in analyses ($N=1637$). Of these participants, 1373 also had MIDUS III data. Of this sample, 1,155 participants had complete data on all variables of interest. Based on this sample size, there is adequate power ($>.90$) for detecting small effects ($r=.10$) of lingering affective change on physical health-related outcomes. Participants were predominantly white (90%), ranged from 30-84 years old at the first wave of data collection ($M=55$), and were fairly well educated (74% of participants reported having at least some college education). 57% were female. Compared to participants who completed the MIDUS III survey, non-respondents were more likely to be older ($M= 61$) and had higher levels of chronic conditions, ADLs, IADLs, and a higher average number of stressors assessed in MIDUS II. The NSDE protocol was approved by the institutional review boards of the University of Wisconsin and the Pennsylvania State University, respectively, and participants provided informed consent.

Measures Assessed in NSDE II

Daily negative affect. Over each of 8 days, participants were asked how much of the time over the past 24 hours they felt nervous, worthless, hopeless, lonely, afraid, jittery, irritable,

ashamed, upset, angry, frustrated, restless or fidgety, that everything was an effort, and so sad nothing could cheer you up (Chronbach's alpha for each day ranged between .83 and .86).

Participants rated their response on a five-point scale ranging from 0 (none of the time) to 4 (all of the time). Scores were then summed across the 13 items for each day ($M=.19$, $SD=.33$).

Daily stressors. Daily stressors were measured using the semi-structured Daily Inventory of Stressful Events (Almeida, Wethington & Kessler, 2002). This measure included 7 stem questions that asked if certain stressors had occurred (1= yes; 0 = no) in the past 24 hours. These included having an argument with someone, almost having an argument but avoiding it, a stressful event at work or school, a stressful event at home, experiencing race, gender, or age discrimination, having something bad happen to a close friend or relative, and having had anything else bad or stressful happen in the past 24 hours. The total number of stressors reported was summed to reflect the number of stressors experienced each day ($M=.53$, $SD=.67$).

Average number of stressors. The average number of stressors score was assessed by summing and averaging the total number of stressors mentioned across the eight days.

Measures assessed in MIDUS II and III

Chronic illness. Participants were asked if they have had each of 26 chronic physical conditions in the prior 12 months (Marmot, Ryff, Bumpass, Shipley, & Marks, 1997).

Participants also reported whether they had ever experienced cancer or heart disease. Chronic conditions were placed into 16 chronic condition categories to prevent multiple reports of conditions. Categories included autoimmune disorders (HIV, autoimmune diseases), cancer, cardiovascular conditions (heart disease, high blood pressure, stroke, hypertension), diabetes, digestive conditions (stomach trouble, constipation, ulcer, swallowing problems), foot trouble, hay fever, gall bladder trouble, lung conditions (asthma, tuberculosis, other lung problems),

neurological conditions, pain-related conditions (backache, joint diseases, migraines), skin trouble, thyroid disease, mouth/gum trouble, sleep problems, and urinary/bladder problems (Piazza et al., 2013). Scores of the chronic conditions were summed to form a measure of total chronic conditions. Participants were then grouped according to the number of chronic conditions they reported, from 0, 1, 2, 3, or 4 or more. People with 4 or more chronic conditions were pooled into a single group to prevent the skewed nature of the data (only 14% of participants had 5 or more chronic conditions) and in line with categories for chronic conditions proposed by previous research (Wolff, Starfield, & Anderson, 2002).

Functional limitation. MIDUS II and MIDUS III surveys asked about activities of daily living (ADLs) and instrumental activities of daily living (IADLs) to assess functional impairment (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963; Lawton & Brody, 1970). Items in the ADL category reflect an individual's ability to function at a basic level on his or her own, and include: bathing or dressing oneself, walking one block, and climbing one flight of stairs (MIDUS II $M=1.31$, $SD=.62$, MIDUS III $M=1.42$, $SD=.72$). Items in the IADL category reflect an individual's ability to engage in everyday activities, including lifting or carrying groceries, climbing several flights of stairs, bending, kneeling, or stooping, walking more than a mile, walking several blocks, vigorous activity, and moderate activity (MIDUS II $M=1.77$, $SD=.86$, MIDUS III $M=1.97$, $SD=.93$). Participants indicated the extent to which their health limited these activities on a 4-point scale ranging from 1 (not at all) to 4 (a lot), with items averaged together such that higher scores indicated greater functional impairment.

Statistical Analyses

Lingering negative affect is the degree to which the stressor-related negative affect from the day before (or affect reactivity) is still present the day after a stressor occurs. Defined by the

slope of the relationship between current day negative affect and previous day stressors, lingering negative affect is calculated using lagged associations estimated from multilevel models using SAS PROC MIXED. Multi-level models calculate levels of current day negative affect as a function of average negative affect (intercept), and the effect of a previous day stressor (slope). To ensure that the slope estimates the unique effects of a prior day stressor on current day negative affect, this model only includes days where individuals are not currently experiencing a stressor. For example, if a person reported a stressor on days 3, 4, and 7 of the eight-day period, those days would be removed from the analyses, and only days 1, 2, 5, 6, and 8 would be included.” Of the 11,090 interview days, 3,180 were removed from the analyses, resulting in 7,910 days where people were not currently experiencing a stressor. Removing these days guarantees that any changes in negative affect are not due to any current day stressor, thus making current day reactivity nonexistent. It also ensures that the previous day stressor is not ongoing and is not present as a stressor that day. In addition, this model includes variance explained by the average number of stressors experienced. In doing so, we estimate the unique effects of a prior day stressor on current negative affect, adjusting for average level of stressors and only looking at days where individuals are not currently experiencing a stressor.

These analyses are shown in the following model:

$$\text{Level 1: } NA_{ij} = \beta_{0j} + \beta_{1j}(\text{stressor}_{ij-1}) + r_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{averagestress}_j) + \mu_{0j}$$

In our Level 1 equation, NA_{ij} is the amount of negative affect on day i for person j . It is a function of daily negative affect for person j on a day when no stressors are encountered (β_{0j}) and the expected change in negative affect for person j as a result of having encountered a stressor the day before (β_{1j}). The intercept and slope were allowed to vary (calculated by the RANDOM

statement). The Level 2 equation includes the between-person covariate of average number of stressors.

To calculate the individual slopes that represent lingering negative affect, the model above was estimated, with lagged stressors as predictors of negative affect. Then, the fixed slope describing the average association between previous day stressors and current negative affect was added to each slope residual to produce an individual slope for each person (Charles et al., 2013). These individual slopes represent the degree to which an individual's emotional reaction to a stressor is still present the day after a stressor occurs on days when they experience no stressors.

To determine if these lingering negative affect slopes were associated with the development of future health conditions, we used a negative binomial regression model to predict the number of chronic conditions (count data) and OLS regression models to predict the level of ADLs and IADLs 10 years later from this slope. For each model, the lingering negative affect variable was used to predict the physical health variables while adjusting for age, sex, education, and the outcome physical health variable at baseline.

Results

Participants reported between 0 and 5 stressors on each day of the interviews ($M = .53$, $SD = .67$ across the 8 days). Across all days, participants reported 0 stressors on 61% of the days; 1 stressor on 29% of the days, and 2 or more stressors on 10% of all days (ranging from 8.07% reporting 2 stressors to .01% reporting 6). Given the skewness, stressors were coded dichotomously as either having been experienced (1) or not (0). People who experienced more stressors had a higher education level ($r = .12$, $p < .001$) and were younger ($r = -.12$, $p < .001$). Women reported significantly more stressors than men, $t(14568) = 11.16$, $p < .001$).

At MIDUS II baseline, 21% of the sample reported having no chronic conditions, 20% reported having one chronic condition, 20% reported having 2 chronic conditions, 14% had 3 chronic conditions, and 25% had 4 or more chronic conditions. At the MIDUS III follow-up ten years later, 17% of the sample reported no chronic conditions, 15% reported one chronic conditions, 18% reported 2 chronic conditions, 12% reported having 3 chronic conditions, and 38% reported 4 or more chronic conditions. For ADLs, 29% reported some amount of ADL limitation at baseline and 36% did so at follow-up. For IADLS, 77% reported some amount of IADL limitation at baseline and 80% reported some limitation at follow-up.

Participant's reported experiencing any negative affect on 55% of the days they were interviewed ($M = .19, SD = .33$). The day after an individual experienced any stressor, people reported higher negative affect ($M = .24, SD = .36$) than when they did not experience a prior stressor ($M = .10, SD = .22$) ($t(12297) = 46.69, p < .001$). Figure 1 illustrates mean levels of negative affect on all days when a person didn't experience a stressor, on days when they did experience a stressor, and then on days when they experienced a stressor the day before.

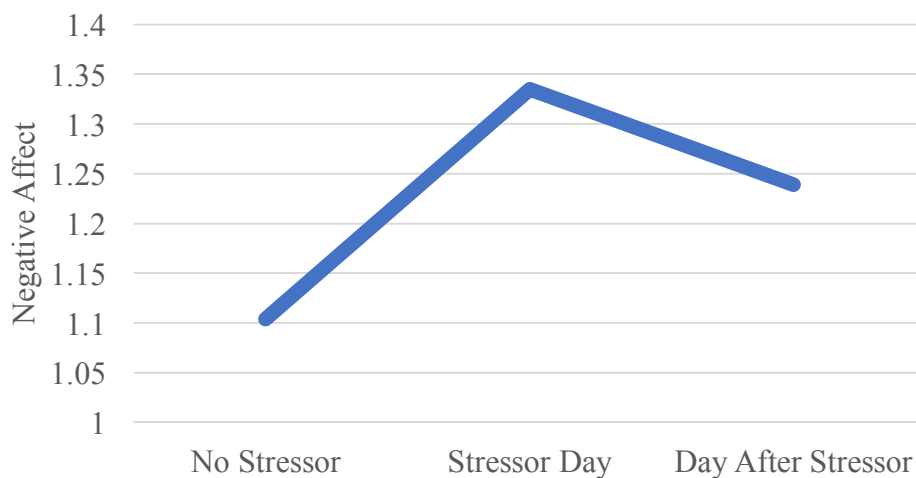


Figure 1. Mean levels of negative affect on different day types.

Multi-level model results testing the relationship between previous day stressors and current day negative affect are presented in table 1. As discussed previously, these models only included days when an individual did not report a stressor on the current day. These models indicate that on days when a person did not currently experience a stressor, negative affect was higher the day after a stressor was experienced than when they did not experience a prior stressor ($\gamma = .012, p < .01$). This finding demonstrates that people experience lingering stressor-related negative affect the day after a stressor occurs.

Table 1

Multi-level Model of Prior Day's Stressors on Current Negative Affect

Outcome: Current day affect

Fixed effects	Estimate	SE	95% CI
Intercept	0.127***	0.005	0.117, 0.138
Previous day stressor	0.012**	0.004	0.006, 0.024
Average stress	0.123***	0.012	0.100, 0.147
Random effects			
Intercept Variance	0.016***	0.001	0.013, 0.021
Previous day stressor variance	0.005***	0.001	0.004, 0.009

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

Physical Health in MIDUS III

To test whether lingering negative affect is related to increased numbers of future chronic conditions and level of functional limitation, we first computed descriptive statistics and zero-

order correlations between lingering negative affect slopes and all three health outcomes (see Table 2). Significant negative correlations between lingering negative affect and all three health outcomes suggest that people who experience prolonged negative affect in the day following a stressor have more physical health-related problems 10 years later.

Table 2

Correlations Among all Predictor Variables (MIDUS II) and Health-related Outcome Variables (MIDUS III)

Variable (Mean, SD or %)	1	2	3	4	5	6	7	8	9	10
MIDUS II										
1. Lingering Negative Affect Slopes (0.012, 0.032)	-									
2. Gender (57% female)	0.010	-								
3. Age (55.88, 12.12)	-0.005	0.003	-							
4. Education (7.20, 2.52)	-0.029	-0.107	-0.133	-						
5. Chronic conditions (21%=0)	0.127	0.179	0.159	-0.126	-					
6. ADLs (1.31, 0.62)	0.153	0.165	0.125	-0.19	0.442	-				
7. IADLs (1.77, 0.86)	0.131	0.186	0.244	-0.23	0.507	0.83	-			
MIDUS III										
8. Chronic conditions (17%=0)	0.096	0.098	0.127	-0.072	0.407	0.204	0.291	-		
9. ADLs (1.42, 0.72)	0.080	0.166	0.232	-0.255	0.382	0.578	0.571	0.291	-	
10. IADLs (1.97, 0.93)	0.080	0.177	0.351	-0.258	0.432	0.539	0.657	0.381	0.841	-

Note: Significant values are indicated in bold and are significant at the $p < .001$ level

To test our hypothesis that lingering negative affect was independently predictive of change in future physical health-related outcomes, we ran separate regression models with lingering negative affect slopes (Mean value of affect slope = .012, $SD = .032$) predicting either chronic conditions, ADLs, or IADLs. All models adjusted for age, gender, education, and the outcome health variable at baseline. Average number of stressors was not included because it was already adjusted for in the multi-level model that calculated the lingering negative affect

slopes. Results are displayed in Table 3. As hypothesized and as shown in the table, increased levels of lingering negative affect significantly predict each physical health outcome 10 years later. This finding indicates that people who experience higher levels of negative affect in response to a stressor the day after it occurs report increases in physical health problems, including more chronic conditions and functional limitations later in life. Furthermore, these associations are significant even after taking into account average number of stressors and eliminating the possibility for same day reactivity to stressors. Figure 2 contains an illustration of these findings.

Table 3

Negative Binomial Regression (Chronic Conditions) and OLS Regression (ADLs & IADLs) Models with Lingering Negative Affect Predicting Physical Health Outcomes 10 Years Later

Variable	Chronic conditions		ADLs		IADLs	
	b	95% CI	b	95% CI	b	95% CI
Lingering negative affect	0.887*	0.052, 1.723	1.542**	0.513, 2.257	1.561**	0.887, 3.509
Time 1 health indicator	0.161***	0.140, 0.183	0.665***	0.605, 0.725	0.651***	0.600, 0.701
Gender (ref=female)	0.017	-0.068, 0.100	0.103**	0.037, 0.170	0.114**	0.035, 0.194
Age	0.014***	0.009, 0.017	0.010***	0.007, 0.013	0.017***	0.014, -.021
Education	-0.007	-0.023, 0.010	-0.037***	-0.051, -0.024	-0.033***	-0.048, -0.021
Chi ²	320.19***					
R ²			.382***		.486***	

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

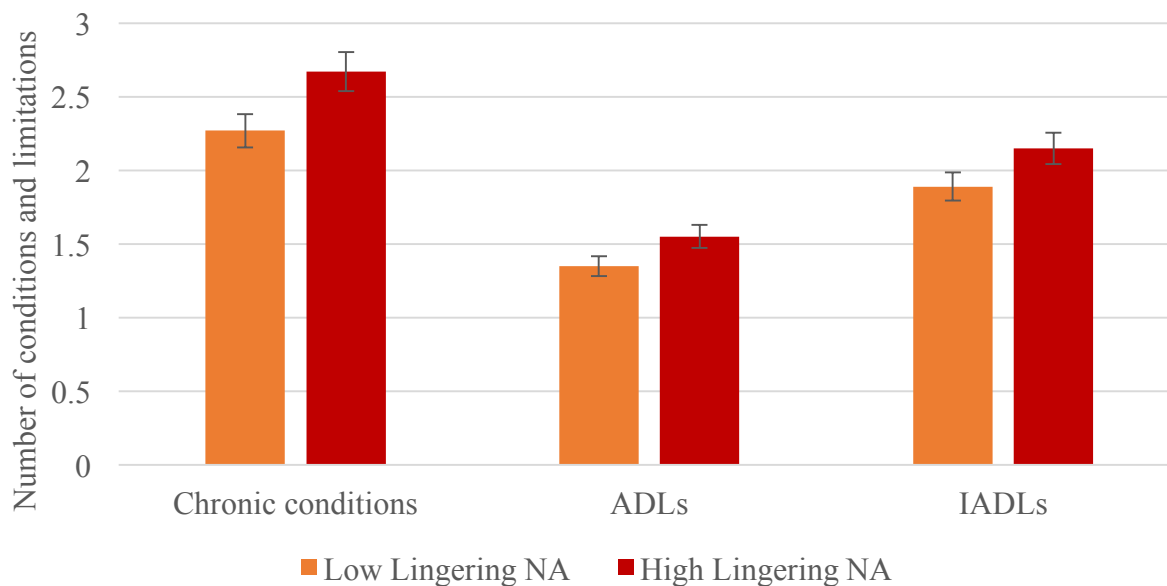


Figure 2. Differences in health outcomes by amount of lingering negative affect. For graphing purposes, a median split was conducted to create groups of people with high vs. low negative affect.

Discussion

It is not just how we react, but also how we recover from stressful experiences that matters for our physical health. Experimental studies have examined the effects of affective reactivity and recovery from laboratory-based stressors, but the relationship between lingering negative emotions in daily life and long-term physical health has never been tested. The current study examines how lingering negative affect in response to daily stressors is associated with changes in physical health across a ten-year period. We found that, on average, people experience increases in negative affect on the days following a stressful experience. Furthermore, lingering negative affect in response to a stressor was associated with an increase in chronic conditions and functional limitations nearly ten years later.

Lingering Negative Affect and Health

Several potential mechanisms may explain the relationship between lingering emotions and physical health. One such mechanism is physiological dysregulation. Emotional consequences to stressful experiences are posited to cause long-term dysregulation of physiological processes (McEwen, 2006). Similarly, lingering negative affect may influence future physical health by prolonging activation of the physiological stress response. For example, an argument with a spouse may trigger a short term physiological stress response. However, continuing to dwell on that argument after its conclusion may either prolong or reactivate that same physiological response. Research has documented that the tendency to perseverate on stressful experiences has been linked with prolonged activation of the cardiovascular system (Brosschot et al., 2006; Glynn, Christenfeld, & Gerin, 2002) and the hypothalamic- pituitary-adrenal axis (Zoccola & Dickerson, 2012). Thus, simply thinking about a negative event may be as arousing as the event itself. It is possible then, that lingering negative affect may have the same tendency to activate and prolong the physiological response.

Persistent activation of stress-related systems may, over time, leave an individual vulnerable to disease. A few studies have suggested a link between perseverative cognition and health outcomes. Prospective studies have found that rumination and worry are related to somatic complaints (Brosschot & Van Der Doef, 2006) and self-reported physical health problems (Thomsen et al., 2004). Importantly, these physiological changes may be driven by the emotional upset that results from dwelling on negative emotional experiences (Kross, Ayduk, & Mischel 2005; Gruber, Harvey, & Johnson, 2009). Yet, these studies did not directly assess the emotional responses that resulted from dwelling on these negative experiences. The results of this study are consistent with and add support for this hypothesis.

A second potential mechanism that may explain the association between lingering negative emotions and physical health is health behaviors. Negative moods have been linked to poorer health behaviors including less physical activity, higher drug use, and diets high in fat and sugar (Fulkerson, Sherwood, Perry, Neumark-Sztainer & Story, 2004). Increases in lingering negative affect may lead people to engage in poorer health behaviors, which may in turn influence physical health later in life. Additionally, lingering negative thoughts and emotions have been shown to disrupt sleep (Thomsen, Mehlsen, Christensen, & Zachariae, 2003). Sleep is a restorative health behavior that influences physical health and well-being. Therefore, sleep disruptions caused by lingering negative thoughts and emotions may also contribute to poorer physical health.

Limitations and Future Directions

One limitation of the study is the timing in which stressful events and daily negative affect were measured in NSDE II. Participants were asked about their emotions and any stressors experienced over the past 24 hours. Therefore, the calculations for affect reactivity and lingering affect were coarse, with participants being asked to recall their emotions over an entire day. Alternatively, although we assume that increases of negative affect on the day of a stressor represents stressor reactivity, the reverse association may also be true. People who experience higher levels of negative affect may be more likely to report stressors. In spite of this limitation, the significant effects of our measure of lingering negative emotions is especially noteworthy, showing that lingering negative affect an entire day later is itself predictive of future physical health outcomes.

Another limitation of the study is that the sample consisted of people who participated in both waves of data collection. Participants who completed both waves of the study were more

likely to be younger, have fewer chronic conditions and functional limitations, and experience fewer stressors. It should be noted that attrition of people who were older and in poorer health means that the longitudinal sample was selective relative to the overall baseline sample.

Finally, this study relied on self-reported measures as health-related outcomes. Because information on health-related measures, emotions, and stressors were all collected through self-report measures, it is possible that relationships between lingering negative affect and health-related outcomes are exaggerated due to response bias (Watson & Pennebaker, 1989). This concern is somewhat ameliorated, however, by previous research that has found that self-reports of chronic conditions and levels of functional impairment each correlate strongly with a physician diagnosis of illness (Henderson et al., 2009). Furthermore, the reliance on self-reports limits the causal interpretation of the data and we cannot make any definitive statements about the causal nature of affect and health. As an alternative hypothesis, the Embodied Predictive Interoception Coding Model suggests that instead of negative affect impacting health, allostatic disruptions that are not yet manifested in chronic conditions might initially cause negative thinking and emotions that then serve to maintain negative affect as well as future health conditions (Barrett & Simmons, 2015). Future work should extend these findings by examining other measures of physical health past self-report including measures of biomarkers and longevity.

As researchers continue to examine lingering negative affect as a mechanism through which daily stressors influence future physical health, it will be important to identify factors that serve as potential moderators in this relationship. Both demographic and psychosocial characteristics including socioeconomic status, levels of social support, and racial differences may serve to moderate the relationship between lingering negative affect and physical health.

Additionally, this study examined the effects of lingering negative affect on a single index of overall health comprised of a variety of chronic conditions. Future research should explore whether the effects of emotional lingering are similar on all types of health conditions or are specific to individual conditions.

Conclusions

Researchers are increasingly studying how minor stressors affect our physical well-being. This study examined people's negative affective responses to stressors in their everyday lives. These findings illustrate that the negative emotions that people feel in response to everyday stressors can linger, and that they have important implications for long term physical health. Therefore, the continuing study of the dynamic process of emotional experience in response to stressful experiences, and how these processes influence our health, is vital for the enhancement of physical health and well-being.

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CHAPTER 3:

Positive Emotions Experienced During Daily Stressors Facilitate Quicker Affective Recovery

Abstract

Positive emotions help us during times of stress. They serve to replenish resources and provide relief from stressful experiences. One way that positive emotions may be particularly beneficial during times of stress is by quickening emotional recovery from stressful events. In this study, we used a daily diary design to examine how positive emotions experienced during a minor stressor impacted next day emotional recovery from daily stressful events. We combined data from the National Study of Daily Experiences II (NSDE II) and the Midlife in the United States survey (MIDUS II), resulting in 1,672 participants who answered questions about daily stressors and affect across 8 consecutive days. On days when people experienced higher positive affect, they experienced less lingering negative affect the day after a stressor. These results held above and beyond trait measures of positive affect. These results suggest that daily positive emotions experienced during times of stress have an impact on our emotions the next day by helping us recover more quickly from lingering negative emotions.

Positive Emotions Experienced During Daily Stressors Can Facilitate Quicker Affective Recovery

Positive emotions play an important role in successful adaptation to stress. Since Lazarus, Kanner, & Folkman (1980) first proposed that positive emotions help sustain coping efforts and replenish resources that have been depleted by stress, a large literature has demonstrated the benefits of trait positive emotions and having a general positive disposition on well-being and the stress process (for a review, see Pressman & Cohen, 2005). Other studies have examined fluctuations in daily positive emotions and their association with the stress response, finding that daily positive emotions are also related to shorter and less severe responses to stress (Ong, Bergeman, & Bisconti, 2004; Ong, Bergeman, Bisconti, & Wallace, 2006) as well as quicker recovery from stressful events (Ong et al., 2006; Tugade & Fredrickson, 2004). Positive emotions experienced during a stressor may help regulate negative emotional responses to stressful events and facilitate quicker emotional recovery from the negative consequences of a stressful experience. Yet little research has examined the relationship between daily positive emotions and next day negative affect. The current study assesses the effects of positive emotions experienced during a minor stressor on the lingering negative emotions that are present the day after a stressor takes place.

Daily Positive Affect and Stressors

Positive emotions influence how people respond to stressors in several ways. First, positive emotions can offset the immediate adverse consequences of stress by lessening negative affective reactivity in response to stressors. The dynamic affect model contends that under non-stressful circumstances, positive and negative affect are both beneficial and independent from one another (Zautra, Smith, Affleck, and Tennen, 2001). During non-stressful events, people

benefit from having distinct positive and negative emotions that serve to broaden their affective experience. During times of stress, however, a person's ability to have distinct positive and negative emotions lessens, and positive and negative affect become inversely correlated with each other. Hence, when an individual experiences distress, negative emotions tend to dampen positive emotions. People who experience more positive emotions during stressors, however, will experience less negative affect. Therefore, positive emotions lessen the pernicious effects of stressors by preventing negative emotional responses. Studies supporting the dynamic affect model demonstrate that positive emotions tend to lessen negative emotions in response to both chronic stressors and everyday life events (Zautra et al., 2001; Zautra, Affleck, & Tennen, 2005; Ong, Bergeman, & Bisconti, 2006; Ong & Bergeman, 2004). For example, one study found that among people with arthritis and fibromyalgia, the presence of positive affect reduced the relationship between pain episodes and negative affect (Zautra et al., 2001). These studies suggest that positive emotions are beneficial and protect against the detrimental effects of stress by dampening the increase in negative emotions associated with them.

In line with their ability to dampen negative emotions, positive emotions are also viewed as general resources that can be drawn upon to facilitate adaptation in times of stress. The Broaden and Build Theory posits that positive emotions serve adaptive functions in times of stress (Fredrickson, 1998, 2001). People who experience positive emotions during times of stress are able to draw upon these emotions as resources and use them to successfully regulate negative emotions. Multiple studies have provided support for the Broaden and Build Theory (for a review, see Vacharkulksemsuk & Fredrickson, 2013). For example, studies have found that positive affect buffers the association between depressive symptoms and stress among military spouses (Faulk, Gloria, Cance, & Steinhardt, 2012) and those caring for an ill child (Moskowitz,

Shmueli-Blumberg, Acree, & Folkman, 2012). In people experiencing chronic pain, positive emotions allow people to rebound more quickly from daily pain catastrophizing (Ong, Zautra, & Reid, 2010). Furthermore, Ong and Bergeman (2004) found that recently bereaved widows experienced less distress in response to stressors on days when they experienced more positive emotions.

In addition to buffering against negative reactions to stressful experiences, positive emotions may also aid in quicker recovery from these experiences. The Broaden and Build Theory posits that not only do positive emotions build resources that help regulate negative responses to stressful events, but that they also may facilitate quicker recovery once negative responses have occurred (Fredrickson & Levenson, 1998). This “undoing effect” hypothesizes that positive emotions undo cardiovascular and autonomic aftereffects of negative emotions by hastening recovery from stressful events. Studies testing this hypothesis find that positive emotions are linked to faster affective and cardiovascular recovery from both lab-induced stressors and stressful life events (Fredrickson & Levenson, 1998; Fredrickson, Mancuso, Branigan, & Tugade, 2000; Tugade & Fredrickson, 2004; Ong et al., 2006). Research on the undoing effects of positive emotion suggests that positive emotions offer protective benefits against the pernicious effects of stress through dampening both the initial reactions to as well as the lingering effects of stress. Therefore, it is possible that positive emotions experienced during a minor stressor may prevent people from experiencing lingering negative emotions the day after a stressor occurs.

Intraindividual Variability in Emotional Response to Stressors

Emotional responses from stressors are often considered to be a relatively stable trait characteristic (Cohen et al., 2000). Research has focused extensively on factors that influence

how people vary in their reactions to stressors including personality traits (Bolger & Schilling, 1991; Leger, Charles, Turiano, & Almeida, 2016), socioeconomic status (Gallo & Matthew, 2003), and trait affect (Pressman & Cohen, 2005). Yet, these studies do not focus on how reactions to stressors may fluctuate within individuals. Indeed, a study by Sliwinski and colleagues (2009) found that only about 27% of variability in emotional reactivity to a stressor across a 6-month period was due to stable individual differences in adults in their 70s. Instead, stress reactivity varied within individual and was greatest during times when individuals experienced high levels of overall subjective stress. This finding implies there is considerable within-person variability in how people respond to stressors and that daily changes in positive emotions may influence how people recover emotionally from daily stressors.

Current Study

The current study explored the role of positive emotions experienced during stress on next day negative affective recovery. We hypothesized that when people experienced high levels of positive affect on stressor days, they would also experience less lingering negative affect the following day. We further hypothesized that this association would hold above and beyond trait positive affect and be unique to positive emotions experienced the day of a stressor. The daily diary design, where people responded to questions about stressors and emotions across eight days, allowed us to examine these daily processes. Additionally, we adjusted for both same day negative affect reactivity and average number of stressors experienced. Adjusting for reactivity and average numbers of stressors allowed us to examine the unique effects of positive emotions specifically on next-day lingering negative affect. Doing so would show that it's not just how people react to daily stressors or the number of stressors that they are exposed to, but that

positive emotions experienced during stress specifically impact how negative people feel the following day.

Method

Participants and Procedure

Participants included a subset of individuals who completed the second Midlife in the United States Survey (MIDUS II), a national, community-based sample of U.S. adults. The MIDUS II consisted of a telephone interview and self-administered questionnaires designed to assess physical and psychosocial well-being. A subset of these participants (N=2022) also completed the National Study of Daily Experiences (NSDE II), a daily diary study where participants completed repeated telephone interviews across an eight-day period about their daily experiences (Almeida, McGonagle and King, 2009). Of this sample, 1,672 individuals had complete data on all variables of interest. Participants were between the ages of 33 and 84 ($M=56.2$), were fairly well educated (95% reporting at least a high school education), and were predominantly white (92%).

Measures Assessed in NSDE II

Daily negative affect. Each day, participants were asked how much of the time over the past 24 hours they felt nervous, worthless, hopeless, lonely, afraid, jittery, irritable, ashamed, upset, angry, frustrated, restless or fidgety, that everything was an effort, and so sad nothing could cheer you up. Participants rated their answers on a five-point scale ranging from 0 (none of the time) to 4 (all of the time). Scores were then averaged across the 13 items for each day ($\alpha=.86$)

Daily positive affect. Daily positive affect was measured in NSDE II through 13 items including in good spirits, cheerful, extremely happy, calm, satisfied, full of life, close to others,

like you belong, enthusiastic, attentive, proud, active, and confident. On each of the 8 days, participants were asked how much of the time over the past 24 hours they felt each affective state on a scale ranging from 0 (none of the time) to 4 (all of the time). Scores were then averaged across the 14 items for each day ($\alpha = .94$).

Daily stressors. Daily stress was measured by using the semi-structured Daily Inventory of Stressful Events, a validated instrument for assessing daily stressors (Almeida et al., 2002). The DISE asks participants about the occurrence of seven different types of daily stressors within various life domains and captures a variety of interpersonal stressors, work stressors, and network stressors (see Almeida, Wethington, & Kessler, 2002 for a detailed description of the DISE). This measure was comprised of 7 stem questions that asked if the following stressors had occurred in the past 24 hours: an argument with someone; almost having an argument but avoiding it; a stressful event at work or school; a stressful event at home; experiencing race, gender, or age discrimination; having something bad happen to a close friend or relative; and having had anything else bad or stressful happen in the past 24 hours. Stressors were then summed for each day.

Average number of stressors. The total number of stressors reported across the eight-day period were summed and averaged as an index of average stress levels.

Measures Assessed in MIDUS II

Trait positive affect. Trait positive affect was measured in MIDUS II by asking participants how much of the time over the past 30 days they felt 13 items including cheerful, in good spirits, extremely happy, calm and peaceful, satisfied, full of life, enthusiastic, attentive, proud, active, like you belong, close to others and confident. Responses ranged from 0 (none of

the time) to 4 (all of the time). Scores were averaged across items a for single positive affect score ($\alpha = .84$).

Statistical Analyses

We used multilevel modeling in SAS Proc Mixed to examine how positive emotions experienced on the same day as a stressor impacted lingering negative affect the day following that stressor. Lingering negative affect is defined as the degree to which negative affect in response to a stressor is still present the day after that stressor occurs. Because we were interested in assessing how positive emotions experienced the same day as a stressor influenced the presence of negative affect the next day, we calculated lagged variables for positive emotions and stressors. This allowed us to assess the association between previous day stressors and positive emotions on current day negative affect. In this model, current day negative affect is a function of average negative affect (intercept), as well as the occurrence of a previous day stressor (slope). Lagged daily positive emotion was included as a moderator. This model only included days when individuals did not report experiencing a stressor when current day negative affect was assessed. Of the 9104 interview days, 2133 days were removed from the analysis. Removing these days from the analyses ensures that changes in negative affect are not due to a current stressor. This model also included the variance explained by the average number of stressors experienced. Additionally, the model included trait positive affect, allowing us to conclude that any differences in daily changes in positive emotions were not simply due to underlying trait positive affect. This generated the following model:

$$\text{Level 1: } NA_{ij} = \beta_{0j} + \beta_{1j}(\text{positiveemotions}_{ij-1}) + \beta_{2j}(\text{stressor}_{ij-1} * \text{positiveemotions}_{ij-1}) + r_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{age}_j) + \gamma_{02}(\text{traitpositiveaffect}_j) + \gamma_{03}(\text{avstress}_j) + \gamma_{04}(\text{education}_j) + \gamma_{05}(\text{gender}_j) + \mu_{0j}$$

Results

Participants reported between 0 and 5 stressors on each day of the interview ($M = 0.53$, $SD = 0.48$ across the 8 days). Across all days, participants reported 0 stressors on 61% of the days, 1 stressors on 29% of the days, and 2 or more stressors on 10% of the days. Because participants reported either experiencing 0 or 1 stressors on 90% of the days, stressors were categorized as either having experienced a stressor on a given day (1) or not (0) to address the skewness of the variable. People who experienced fewer stressors were older ($r = -0.23$, $p < .001$), male ($t(14568) = 11.16$, $p < .001$), and had a lower education level ($r = 0.20$, $p < .001$).

Participants reported experiencing any negative affect on 55% of the days they were interviewed ($M = 0.19$, $SD = 0.33$). Consistent with recent findings (Leger, Charles, & Almeida, 2018), the day after participants experienced a stressor, they reported higher negative affect ($M = 0.24$, $SD = 0.36$) than when they did not experience a prior stressor ($M = 0.10$, $SD = 0.22$) ($t(12297) = 46.69$, $p < .001$). This demonstrates that participants were experiencing lingering negative affect the day after a stressor was experienced. Participant's reported experiencing positive affect on 99% of the interview days ($M = 2.74$, $SD = 0.79$). Their positive affect was lower on days when they experienced stressors ($M = 2.53$, $SD = 0.79$).

Table 1 displays descriptive statistics and bivariate correlations between the main variables of interest. People who experienced greater amounts of daily positive affect reported fewer stressors ($r = -0.28$, $p < .001$) and less negative affect ($r = -0.49$, $p < .001$). Trait positive affect was also significantly associated with fewer number of stressors ($r = -0.14$, $p < .001$), less negative affect ($r = -0.29$, $p < .001$), and greater positive affect ($r = 0.52$, $p < .001$). Age, gender, and education were significantly associated with daily stressors and were thus included in the model as covariates.

Table 1

Descriptive Statistics and Correlations Among Variables of Interest

	M	SD	1	2	3	4	5	6	7	8
1. Daily Negative Affect	0.19	0.33	-							
2. Daily Positive Affect	2.74	0.79	-0.49	-						
3. Stressor (ref=no)	0.61	0.49	0.55	-0.28	-					
4. Trait Positive Affect	2.46	0.70	-0.29	0.52	-0.14	-				
5. Age	56.24	12.20	-0.12	0.17	-0.15	0.17	-			
6. Education	2.11	0.83	0.01	-0.05	0.17	0.04	-0.12	-		
7. Gender (ref = female)	0.56	0.50	-0.05	0.00	-0.07	0.02	0.02	0.11	-	
8. Average number of stressors	0.53	0.48	0.34	-0.27	0.64	-0.20	-0.23	0.20	-0.09	-

Note: Significant values are indicated in bold and are significant at the $p < .001$ level

Positive Affect and Lingering Negative Affect

Results from the model examining the associations between daily positive affect and lingering negative affect are shown in table 2. As predicted, on days when people experienced a stressor, they reported greater levels of negative affect the next day. Additionally, on days when people experienced high positive affect, they reported less negative affect the next day. People also reported greater levels of daily negative affect if they had overall lower trait positive affect and experienced greater amounts of average stress.

Table 2

Multi-level Model of Effects of Prior Day Positive Emotions and Stressors on Current Day Negative Affect

Predictor	Outcome: Current day negative affect		
	Estimate	SE	95% CI
Intercept	0.24***	0.02	0.21, 0.28
Average stress	0.08***	0.01	0.06, 0.11
Age	0.00	0.00	0.00, 0.00
Gender (ref=female)	-0.00	0.01	-0.02, 0.01
Education	-0.01	0.00	-0.01, 0.01
Trait positive affect	-0.06***	0.01	-0.07, -0.05
Previous day stressor	0.07***	0.01	0.03, 0.05
Previous day positive emotions	-0.04***	0.01	-0.05, -0.03
Previous day stressor * Previous day positive emotions	- 0.02**	0.01	0.01, 0.03

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

In line with our main hypothesis, an interaction between previous day stressor and previous day positive emotions indicated that on stressor days when people experienced greater positive emotions, they experienced less negative affect the following day in response to the stressor. This finding supports the undoing hypothesis, whereby positive emotions “undo” some of the negative effects of stress and allow people to “bounce back” more rapidly from negative experiences. Figure 1 shows differences in lingering negative affect on days when people had

high positive affect versus days when people had low positive affect. Of note, this finding held even after adjusting for amount of stressor exposure and eliminating the possibility for same day reactivity, indicating that positive emotions experienced during stress had a unique effect on subsequent day affect. Furthermore, positive emotions influenced next day lingering negative affect above and beyond trait levels of positive affect, suggesting that elevated levels of positive affect at the time of stress specifically reduced next day negative affect as opposed to overall levels.

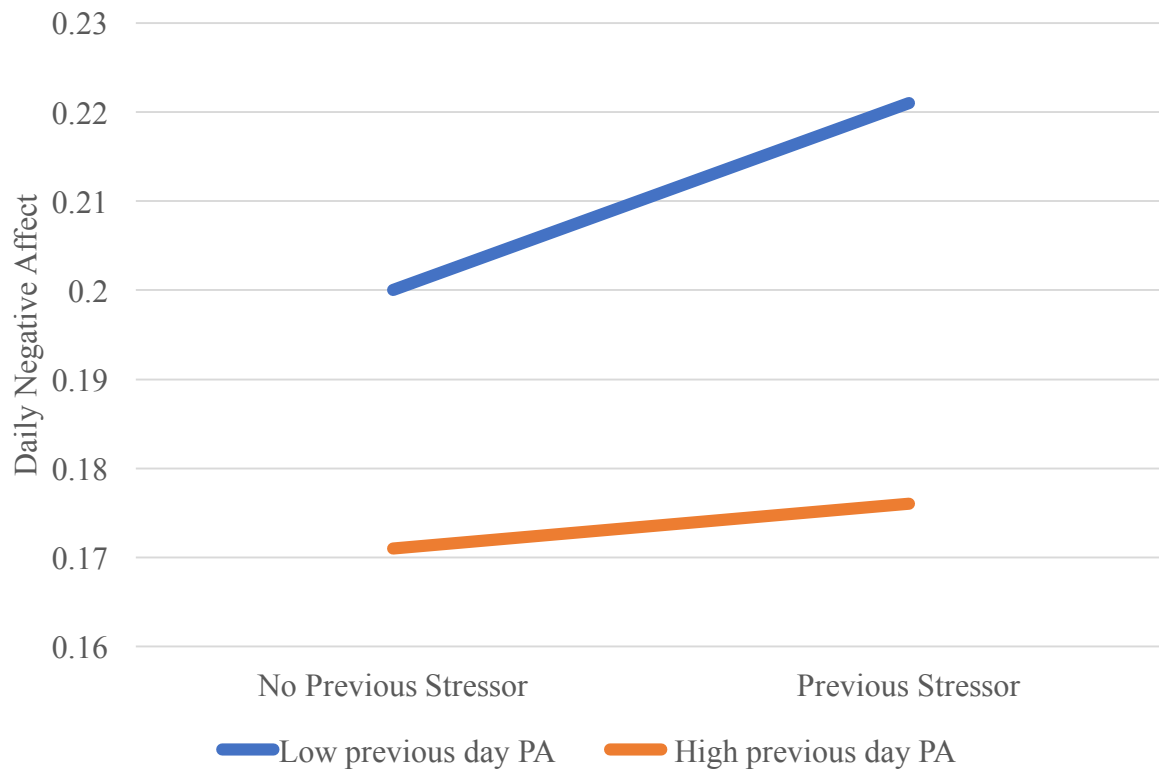


Figure 1. Lingering negative affect to a previous day stressor on days with low vs. high positive emotions

Discussion

Positive emotions play an important role in lessening the detrimental effects of stress. This study examined the effects of daily positive emotions on lingering negative affect in the day following a stressful event. Results indicated that positive emotions experienced the day of a stressor attenuated next day lingering negative affect. This relationship held above and beyond the influences of trait positive affect. Positive emotions serve several functions to help individuals recover from stress. This study illustrates that one of the ways in which positive emotions are beneficial is through their ability to speed next day emotional recovery from daily stress.

Positive Emotions and Lingering Negative Affect

During times of stress, people experience both positive and negative affect. (Folkman & Moskowitz, 2000; Scott, Sliwinski, Mogle, & Almeida, 2014). On days when people report stressors, their positive affect is lower than on days when they do not, but positive emotion is still present. Positive emotions experienced during times of stress may help facilitate the coping process and have important stress-buffering effects that help facilitate recovery from stress. (Lazarus, Kanner, & Folkman, 1980).

We found that on stressor days when people experience higher positive affect, they have less lingering negative affect the next day. The Broaden and Build Hypothesis views positive emotions as enhancing a person's ability to build resources that enables them to better regulate their emotional responses to stressors. Positive emotions that are experienced around the time of a stressor are beneficial in helping people reduce their negative emotions associated with that stressor. It suggests that positive emotions can facilitate quicker recovery from stressors by helping individuals more quickly return to a baseline negative affect and undo the effects of the

stressful event. However, next day emotional recovery from daily stressors has rarely been studied in daily life. Only one study has examined the effects of daily positive emotions on next day negative affect recovery (Ong et al., 2006). In this sample of older adults, the authors found that positive emotions experienced during daily stress led to quicker emotional recovery the following day. Our study extends these results to a large community-based sample of adults and suggests that daily positive emotions help speed emotional recovery from stress the following day throughout adult life.

Additionally, positive emotions experienced on the same day as a stressor were beneficial to speeding up next day emotional recovery even after adjusting for trait levels of positive affect. Both trait positive affect and daily positive emotions are beneficial to well-being and predict better life outcomes (Lyubomirsky et al., 2005; Pressman & Cohen, 2005). This study demonstrated that when daily positive emotions were disentangled from trait positive affect, daily positive emotions remained a significant contributor to next day affective recovery. In this case, it is not just overall trait positive affect, but also daily positive emotions that contribute to interrupting the stress process and hasten recovery from daily stressful events. One implication for this finding is that traits and skills that help people generate daily positive emotions may be particularly helpful for emotional recovery from stress. For example, daily positive emotions may be one way through which traits such as optimism are linked with better recovery from stressful events (Carver, Scheier, & Segerstrom, 2010).

The impact of positive emotions on next day emotional recovery from stress has important implications for several aspects of health and well-being. Lingering emotions as a result of daily stress are associated with poor health behaviors such as sleep habits (Thomsen, Mehlsen, Christensen, & Zachariae, 2003) and worse physical health later in life (Leger et al.,

2018). Additionally, prolonged negative emotions have been linked with worse job satisfaction and lower levels of work productivity (Fritz & Sonnentag, 2005). Finally, sustained negative emotions are tied with perseverative cognitions such as rumination and worry (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008) and are implicated in mood and anxiety disorders (Watson, Clark, & Carey, 1988). Positive emotions, on the other hand, are predictive of several desirable outcomes including better health, productivity, and well-being (Ong, 2010). By hastening affective recovery from daily stressors, positive emotions may be contributing to better health and well-being. Future work should examine the relationship between positive emotions experienced during stress and next day affective recovery as predictors of physical and mental health and well-being.

Limitations

The main limitation in this study is that people were asked about affect and stressors over the past 24 hours. As such, stressors and affect were not measured when the stressors occurred and retrospective reports were used to calculate negative affect reactivity and lingering negative affect. It is possible that report biases may have led to spurious relationships between people's reports of stressors and emotion. Furthermore, because questions about stressors and affect were asked in the same interview, we cannot tease apart any temporal sequence for affect and stressors. However, lingering negative emotion does take place after the assessment of stressors and daily positive affect. Therefore, we were able to conclude that positive emotions experienced on days of stress relate to negative emotions experienced the next day. In addition, we could not be certain if positive emotions occurred during, before, or after the stressor occurred. Thus, our interpretation of the relationship between stressors, positive affect, and negative affect lingering were limited to the interplay of these factors on the daily level. It could be that positive emotions

experienced right after a stressful event occurs are more beneficial to speeding affective recovery than positive emotions experienced before or during that event. Future momentary sampling studies should produce more fine-grained analyses to capture positive emotions experienced at different points before, during, or after a stressor and assess how these differences relate to subsequent negative emotions.

Finally, even though participants were selected from a community-based cohort of adults, most of the participants were Caucasian and had more education and a higher socioeconomic status than the average American. Research has demonstrated that people's emotional reactions to daily stressors vary as a function of many factors, including socioeconomic status (Grzywacz, Almeida, Neupert, & Ettner, 2004), age (Neupert, Almeida, & Charles, 2007), and race (Carter & Reynolds, 2001). Future studies should specifically examine minority groups and individuals of lower income levels given that the relationship between daily stressor and emotional experience may be different for various groups of people.

Conclusion

Positive emotions are beneficial during times of stress. The current study demonstrated that one way through which positive emotions are beneficial is through their relationship with next day negative affect. If people experienced greater positive emotions on days of stress, then they also reported less lingering negative affect the following day. This finding adds to the literature on the relationship between daily positive and negative emotion during times of stress and extends it to show that not only do daily positive emotions provide a buffer against same day negative emotional consequences of daily stress, but that they also facilitate emotional recovery a full day later.

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CHAPTER 4:

Affective Recovery from Stress and Its Associations with Sleep

Abstract

Prolonged affective recovery from stress is detrimental to physical health. One way through which prolonged affective recovery from stress may shape health is through its relationship with sleep, a health behavior known to influence health outcomes. The current study examines both positive and negative affective recovery from a laboratory-induced stressor and their associations with self-reported sleep behavior. Furthermore, we examine whether cardiovascular recovery from the stress task was related to these associations. Participants ($N=182$) engaged in a laboratory psychosocial stress task and measures of affect, cardiovascular functioning, and reports of sleep were recorded. Positive and negative affective recovery were related to sleep, although prolonged negative affect recovery was associated with worse sleep quality whereas prolonged positive affect recovery was associated with worse sleep efficiency. Cardiovascular recovery from the stress task was not related to either affect or reported sleep. Findings suggest that prolonged affective recovery from stress is associated with poor sleep, but that this relationship is not accounted for by cardiovascular responses.

Affective Recovery from Stress and Its Associations with Sleep

Affective recovery from stress has important implications for our health and well-being. Successful recovery from stress has been proposed to be an essential factor in preventing stress from negatively impacting health (Brosschot, Gerin, & Thayer, 2006). In fact, many researchers have posited that recovery from stress may be more likely to influence physical health outcomes than reactivity (Linden, Earle, Gerin, & Christenfeld, 1997). One mechanism through which recovery from stress may influence future health is sleep behavior. Deficiencies in fundamental aspects of sleep, including sleep quality (feeling rested upon waking), and sleep efficiency (percentage of time in bed actually sleeping), have been found to influence a broad range of negative health outcomes including cardiovascular disease and mortality (Ayas et al., 2003; Kripke, Garfinkel, Wingard, Klauber, & Marler, 2002).

Daily life studies exploring the relationship between affective responses to stressors and their impact on sleep have found that days with higher negative affect are linked with poorer sleep the following night (Slavish et al., 2018). These studies capture emotions and sleep in a naturalistic setting, but they are unable to control specific aspects of a stressor that may influence the relationship between affective responses and sleep. Few studies have examined the relationship between affective responses to stress and sleep in the lab where it is possible to see if the tendency to have a prolonged affective response to a controlled stressor is tied to sleep outcomes. The current study examines both prolonged negative affective recovery (lingering increases in negative affect) and prolonged positive affective recovery (lingering decreases in positive affect) from a laboratory-based stressor task and their associations with sleep quality and efficiency, two holistic dimensions of sleep that have been tied with numerous health outcomes (Cohen, Doyle, Alper, Janicki-Deverts, & Turner, 2009; Matthews et al., 2013).

Affective Recovery and Sleep

The majority of research on the relationship between affect and sleep has established the connection between stable, trait-like affect and sleep quality (Gray & Watson, 2002; Ong, 2010; Steptoe, O'Donnell, Marmot, & Wardle, 2008), but several studies have also examined dynamic changes in negative and positive affect in response to stress. Daily studies find that days with higher negative affect are predictive of poorer sleep the following night (Slavish et al., 2018). These studies have focused on initial reactivity to stress, finding that greater decreases in positive affect in response to stressful events are associated with impaired sleep quality (Ong, Exner-Cortens, Riffin, Steptoe, Zautra, & Almeida, 2013) and experiencing high levels of state positive affect on days with high stress levels is beneficial for sleep efficiency (Pressman, Jenkins, Kraft-Feil, Rasmussen, & Sheier, 2017). Although these studies examine daily changes in affect and their associations with sleep, only one study has examined affective recovery from stress and its associations with sleep. Among fibromyalgia patients, poor sleep was associated with poor negative affective recovery on days with a high number of negative events (Hamilton et al., 2008).

Experimental studies on the relationship between sleep and emotional recovery from acute stress are sparse. In one study, participants who underwent a negative mood induction before sleep reported reduced sleep efficiency and total time awake (Vandekerckhove et al., 2011). A few studies have documented the relationship between perseverative cognition and sleep, showing that higher levels of worry and rumination in response to stress are related to poor sleep quality (Zawadzki, Graham, & Gerin, 2013). Studies have found that inducing rumination about a negative event predicts poor sleep quality the following night (Guastella & Moulds, 2006; Zoccola, Dickerson, & Lam, 2009). Rumination and negative emotions are each

independently related to sleep quality (Thomsen, Mehlsen, Christensen, & Zachariae, 2003), but studies have not examined emotional recovery and its associations with sleep. A recent review on the relationship between positive affect and sleep highlighted the dearth of research on the effects of positive affect recovery and sleep outcomes (Ong, Kim, Young, & Steptoe, 2017). To our knowledge, no study has examined lingering decreases in positive affect after a stressor and the relationship of these prolonged decreases in positive affect with sleep.

Affective Recovery and Sleep: Does Cardiovascular Functioning Play a Role?

A stressor elicits both an affective and a physiological response. One reason why lingering emotions in response to stress may be related to poor sleep is through co-occurring physiological arousal. Sustained cardiovascular hyperarousal is related to poor sleep outcomes and is thought to be a cause of sleep disturbances and sleep disorders (Baglioni, Spiegelhalter, Lombardo, & Riemann, 2010). Higher levels of resting heart rate and blood pressure have been associated with disruptions in sleep (Rodriguez-Colon et al., 2011). However, few studies have examined the relationship between sleep and cardiovascular responses to acute stress in a laboratory environment, and those that have focus on the impact of sleep deprivation on cardiovascular stress responses. These studies have yielded mixed results. One study found that individuals who underwent a night of sleep deprivation had greater systolic blood pressure reactivity, but not prolonged recovery in response to a speech task the next day (Franzen et al., 2011). Another study found no effects of sleep deprivation on blood pressure or heart rate reactivity or recovery to a series of stress tasks (Kato, Phillips, Sigurdsson, Narkiewicz, Pesek, & Somers, 2000). Only one study has examined the relationship between naturally cardiovascular recovery from acute stress and naturally occurring sleep among healthy individuals (Mezick, Matthews, Hall, Jennings, & Kamarck, 2014). Mezick and colleagues (2014) used actigraphy

assessment of sleep and found that shorter total sleep time was related to poorer diastolic, but not poorer systolic, blood pressure recovery to a series of stressor tasks in young adult men. No study has examined the relationship between cardiovascular recovery from acute stress and other measures of sleep, including sleep quality and sleep efficiency, in a healthy sample of adults.

In addition to the inconsistent findings on the relationship between cardiovascular recovery from stress and sleep, literature on the relationship between affective and cardiovascular responses to stress is mixed. Some research shows that experiencing prolonged negative emotional and cognitive responses in response to a stressor corresponds with cardiovascular activation (Brosschot et al., 2006; Glynn, Christenfeld, & Gerin, 2002). Yet, other research suggests that the relationship between cardiovascular and affective responses to a stressor is weak (Cohen, Manrick, Rodriguez, Feldman, Rabin, & Manuck, 2000; Waugh, Panage, Mendes, & Gotlib, 2010). For example, a study by Cohen and colleagues (2000) found that when subjected to a laboratory stress task, participants responded with increased anxiety and physiological responses, but stress-induced changes in affect were not associated with cardiovascular responses. Little is known about how lingering decreases in positive affect is related to physiological functioning. Studies have found that positive emotions are linked to faster cardiovascular recovery from both lab-induced stressors and stressful life events (Fredrickson & Levenson, 1998; Fredrickson, Mancuso, Branigan, & Tugade, 2000; Ong, Bergeman, Bisconit, & Wallace, 2006; Tugade & Fredrickson, 2004). Yet, to our knowledge, no study has examined lingering decreases in positive affect after a stressor and the relationship of these prolonged decreases in positive affect with cardiovascular recovery.

Current study

The current study investigated the relationship between prolonged affective recovery from an acute psychosocial stressor and two facets of self-reported sleep behavior: sleep quality and sleep efficiency. We chose to examine sleep quality and sleep efficiency because they are holistic evaluations of sleep that are associated with health outcomes and tap into potential disruptions to sleep as well as a person's perception of their own sleep (Cohen, Doyle, Alper, Janicki-Deverts, & Turner, 2009; Matthews et al., 2013). We hypothesized that people who experienced higher levels of lingering negative affect and lingering decreases in positive affect after the conclusion of a stressor task would report poorer sleep quality and sleep efficiency. We adjusted for measures of rumination and trait affect in order to test whether emotional recovery from the stressor was associated with sleep above and beyond the effects of trait cognition or affect. We also adjusted for affect reactivity during the task in order to isolate the unique effects of affective recovery. Lastly, we explored the potential role of cardiovascular recovery in the relationship between affective recovery and sleep.

Method

Participants

Participants ($N = 182$) were recruited to the study (age range 18-92, $M = 37.1$) through either an undergraduate subject pool at a university or through flyers placed around the university and in community venues. The majority of the participants were female (77%). The participants were Caucasian (36%), Asian (34%), or Latino (22%). Participants could not be taking any cardiovascular medications or be diagnosed with any cardiovascular disorders. Participants received either course research credit (if solicited through the human subjects pool)

or \$40 (if solicited through flyers in the community) for participation. The study protocol was approved by the University of California, Irvine Institutional Review Board.

Procedure

The study procedure involved a 1.5-2 hour appointment on the University campus. At the laboratory, participants read and signed a consent form and filled out questionnaires that pertained to measures of stress, affect, and health, including baseline positive and negative affect. Participants were then fitted with a blood pressure cuff to measure cardiovascular functioning including blood pressure throughout the study. After a 6-minute baseline resting period, participants completed a psychosocial stressor. The Trier Social Stress Test is a well validated stress task that includes aspects of both social evaluation and uncontrollability (Dickerson & Kemeny, 2004). In this task, participants were given two minutes to prepare a five-minute speech task and told that their performance would be evaluated by their peers. During the speech, the evaluators maintained a neutral or stern expression, made notes on a clipboard, and interrupted the participant to make them feel uncomfortable with phrases such as “please stop fidgeting.” After the completion of the speech task, the participant reported their positive and negative affect. The participants then completed the arithmetic portion of the Trier task, a math task that required them to count backward from 1,022 by intervals of 13 for five minutes in the presence of the stern evaluators. After the completion of the task, participants sat quietly for a 6-minute recovery period. After the recovery period, the participants were asked to evaluate their positive and negative affect for the third time, completed a few additional questionnaires, and were debriefed. Figure 1 provides a graphic of the study procedure.

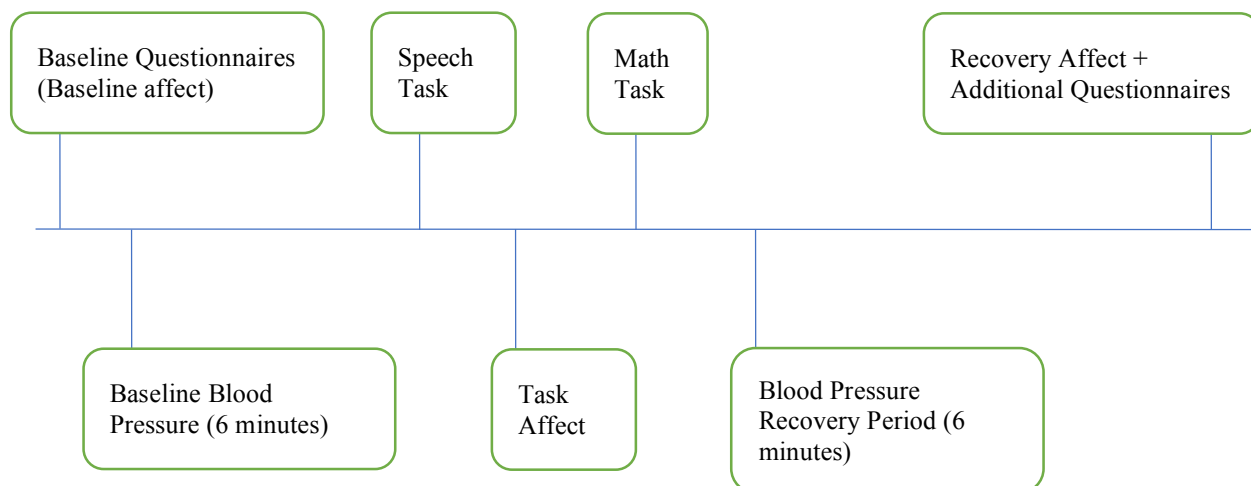


Figure 1. *Study design describing affect and blood pressure for three time periods*

Measures

Positive and negative affect. Positive and negative affective states were assessed with a 26-item checklist in which participants rated the extent to which they currently felt each emotion on a 5-point Likert scale, with 1 = not at all and 5 = extremely. Items were drawn from the Profile of Mood States (Shacham, 1983) and the Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegan, 1988). Positive affect was calculated by averaging across the positive emotions: active, attentive, excited, happy, enthusiastic, interested, relaxed, passive, cheerful, proud, confident, energized, and calm ($\alpha = .89$). Negative affect was comprised of the average across the negative emotions: stressed, unhappy, bored, lonely, anxious, irritable, angry, embarrassed, nervous, frustrated, sad, overwhelmed, and tired ($\alpha = .88$).

Blood Pressure. Participants were fitted with a BP cuff using the Dinamap Procare Ambulatory Monitor. The BP cuff was placed on the non-dominant arm, and the monitor was placed in a control room so that the readings could not be observed by the participant. Blood

pressure was assessed every 90 seconds and averaged across each of the three time periods (baseline, stressor, and recovery).

Depressive symptoms. Participants reported their depressive symptoms using the Center for Epidemiologic Studies Depression Scale (CES-D), a 20-item scale that asks participants to report the frequency with which each item occurred in the past week on a Likert scale ranging from 1 = “rarely” to 4 = “most days.” The scale included items such as “I felt depressed” and “I enjoyed life.” Items were summed so that higher scores reflected more depressive symptoms (Radloff, 1997).

Rumination. Rumination was assessed through the Response Styles Questionnaire (Nolen-Hoeksema & Morrow, 1991). This 22-item rumination scale asked participants to indicate what they generally do when they feel sad or down, on a scale from 1 = “almost never” to 4 = “always.” Items included “think about how alone you feel,” “write down what you are thinking about and analyze it,” and “think about how sad you feel.”

Trait positivity. Dispositional happiness was assessed with the 4-item General Happiness Scale (Lyubomirsky & Lepper, 1999). Participant’s rated each item on a 7-point scale with items such as “In general, I consider myself a very happy person.” Items were scored so that higher scores were indicative of greater levels of happiness.

Demographics, body mass index, and smoking status. Participants reported their age, gender, and race. BMI was based on height and weight measurements and was assessed by dividing body weight by height. Participants also reported their smoking status.

Sleep. Questions from the Pittsburgh Sleep Quality Index (PSQI) was used to assess both sleep quality and sleep efficiency (Buysse, Reynolds, Monk, Berman & Kupfer, 1989). Sleep quality was assessed by asking participants to rate their sleep quality in general on a scale of 1 =

“very bad” to 4 = “very good”. Sleep efficiency was calculated by dividing each participant’s actual sleep duration by his or her total length of time in bed. This score represented the percentage of time a person is asleep in bed out of their total time in bed, coded on a likert scale from less than 65% = 1, 65-74% = 2, 75-84% = 3, and more than 85% = 4. A higher score represents better sleep efficiency.

Statistical Analyses

Recovery analyses. Affective recovery was calculated by regressing post-recovery affect on baseline and task affect and creating standardized residuals for affect recovery (Waugh et al., 2010). Adjusting for baseline and task values assures that any relationship between affect recovery and sleep is not driven by reactivity to the stressor (Page-Gould, Mendes, & Major, 2010). A separate residual was calculated for both positive and negative affect recovery. Higher scores are indicative of greater amounts of lingering negative affect and lingering decreases in positive affect, and thus poorer affective recovery. Systolic and diastolic blood pressure recovery were calculated by regressing mean recovery scores on average baseline and average task blood pressure scores and creating standardized residuals for systolic and diastolic blood pressure. Higher scores indicated poorer blood pressure recovery.

Hypothesis testing. OLS regression was used to determine the relationship between affective recovery, cardiovascular recovery, and sleep variables. Demographic variables of age, gender, and ethnicity were included in all analyses. First, sleep variables were regressed on the standardized residual scores for negative affective recovery. Depressive symptoms and trait rumination were included based on their associations with sleep and emotion. Next, sleep variables were regressed on residual scores for positive affect recovery. Trait positivity was included as a covariate. Next, blood pressure recovery was regressed on the standardized

residuals for negative affect recovery and repeated for positive affect recovery. Finally, sleep variables were regressed on the standardized residuals for systolic and diastolic blood pressure recovery. Covariates in these analyses included BMI and nicotine use based on their associations with cardiovascular functioning (Mezick et al., 2014).

Results

Descriptive Statistics

Table 1 displays correlations for sleep, affect, and cardiovascular variables at baseline values. Sleep quality was negatively correlated with negative affect and positively correlated with positive affect at baseline. Sleep quality was negatively correlated with systolic blood pressure but was not correlated with diastolic blood pressure. Sleep efficiency was not significantly correlated with either positive or negative affect. Sleep efficiency was also not correlated with systolic or diastolic blood pressure. Sleep efficiency and sleep quality were moderately positively correlated with each other. Trait rumination was negatively correlated with sleep quality ($r = -0.44, p < .001$) and sleep efficiency ($r = -0.15, p = .04$) and was positively correlated with negative affect at baseline ($r = 0.54, p < .001$). Depressive symptoms were negatively correlated with sleep quality ($r = -0.44, p < .001$) and positively correlated with negative affect at baseline ($r = 0.53, p < .001$). Trait happiness was positively correlated with sleep quality ($r = 0.33, p < .001$) and positive affect experienced during baseline ($r = 0.40, p < .001$). Systolic blood pressure was positively correlated with both nicotine use ($r = 0.15, p = .04$) and BMI ($r = 0.44, p < .001$).

Table 1

Descriptive Statistics Among Sleep Variables and Baseline Affect and Blood Pressure

	M	SD	1	2	3	4	5	6
Sleep Quality	2.78	0.65	-					
Sleep Efficiency	2.41	0.76	0.24	-				
Baseline Negative Affect	1.87	0.61	-0.32	0.04	-			
Baseline Positive Affect	2.55	0.61	0.29	0.03	-0.25	-		
Baseline Systolic Blood Pressure	102.70	12.78	-0.22	-0.14	0.19	-0.34	-	
Baseline Diastolic Blood Pressure	65.03	6.58	-0.08	-0.13	0.04	0.02	0.55	-

Note. Significant values are indicated in bold and are significant at the $p < .05$ level, Sleep quality was measured on a scale of 1 (very bad) to 4 (very good), Sleep efficiency was measured on a scale from 1 (less than 65% efficiency) to 4 (more than 85% efficiency).

Affective Responses

To determine whether people displayed prolonged affective recovery in response to the stress task, we compared participants' affective responses after the recovery period with their responses during baseline and after the first stressor task. Repeated measure ANOVAs were conducted on both positive and negative affect. There were significant main effects of time for both positive ($F(1,181) = 135.06, p < .001$) and negative ($F(1,181) = 22.78, p < .001$) affect. Figure 2 demonstrates the pattern of responses, illustrating that negative affect increased from baseline to task, followed by a slight decrease from task to post-recovery period. The figure also

illustrates that participants decreased in positive affect from baseline to task, but unlike negative affect, did not rebound after the recovery period. These results indicate that participants did not fully recovery affectively after the 6-minute recovery period and that they continued to experience both lingering increases in negative affect and lingering decreases in positive affect in response to the stressor task after the recovery period.

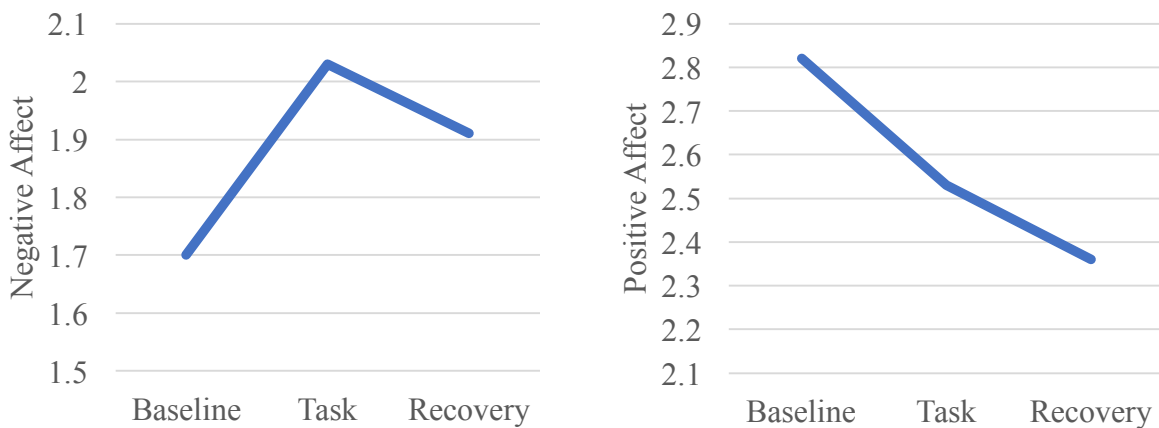


Figure 2. Positive and negative affect throughout the procedure.

Affective Recovery and Sleep

Sleep quality. In line with our hypothesis that prolonged negative affective recovery would be related to poor sleep, there was a main effect of negative affect recovery on sleep quality ($b = -0.14, p = .04$) such that those who had greater lingering negative affect after the recovery period reported worse sleep quality (Table 2, Model 1). The effects of negative affect recovery remained significant after adjusting for depressive symptoms and rumination, indicating that negative emotions that linger after a stressor are related to sleep quality above and beyond the influence of both trait affect and ruminative thoughts. These effects were not qualified by age or gender interactive effects, suggesting that this relationship between poor

sleep quality and lingering negative affect after a stressor do not differ based on age or gender, but that levels of negative affect were significantly elevated during and after the recovery period for those who reported poorer quality sleep. Figure 3 shows an illustration of these effects.

Table 2

OLS Regression Models with Lingering Increases in Negative Affect and its Associations with Sleep Quality and Efficiency

Variable	Model 1		Model 2	
	Sleep Quality		Sleep Efficiency	
	b	95% CI	b	95% CI
NA recovery	-0.14*	-0.28, -0.00	-0.03	-0.12, 0.20
Depressive symptoms	-0.02*	-0.18, -0.001	-0.01	-0.03, 0.01
Trait rumination	-0.01*	-0.02, -0.00	-0.01*	-0.02, -0.00
Gender (ref=male)	0.03	-0.18, 0.25	0.05	-0.21, 0.32
Age	0.01	0.00, 0.01	0.00	-0.00, 0.01
Ethnicity (ref=white)				
Asian	0.08	-0.18, 0.34	0.07	-0.25, 0.41
Latino	0.13	-0.15, 0.42	0.11	-0.23, 0.47
R ²	0.28***		0.09*	

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

Note: Higher NA recovery scores reflect greater amounts of lingering increases in negative affect and thus poorer recovery

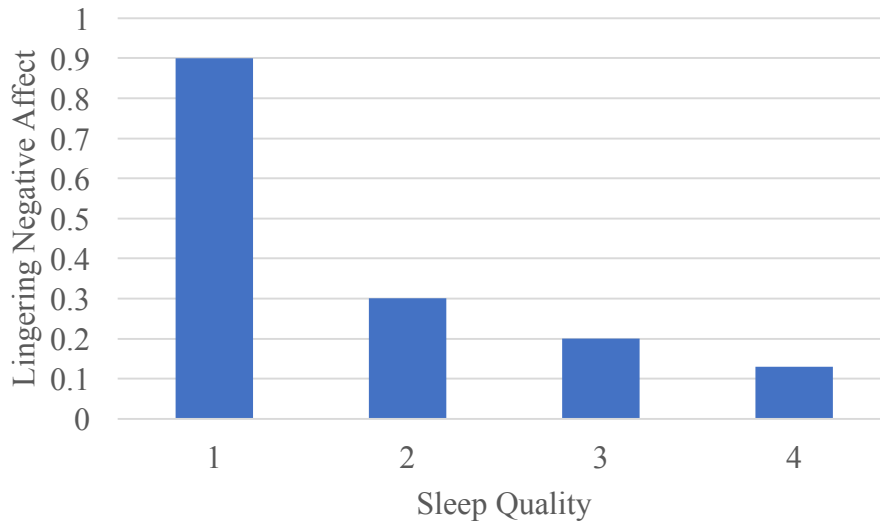


Figure 3. The relationship between lingering increases in negative affect after the completion of the stressor task and sleep quality. Lingering negative affect scores reflect marginal means of prolonged affective recovery while adjusting for model covariates.

Contrary to our hypothesis, there was no effect of positive affect recovery on sleep quality ($b = -0.04, p = ns$). There was an effect of trait happiness on sleep quality such that those who reported greater levels of general happiness reported higher sleep quality (Table 3, Model 1).

Sleep efficiency. There was no effect of negative affect recovery on sleep efficiency ($b = -0.03, p = ns$, Table 2, Model 2). However, there was an effect of positive affect recovery on sleep efficiency ($b = -0.17, p = .04$) such that those who reported greater decreases in positive affect after the conclusion of the stressor task reported worse sleep efficiency (Table 3, Model 2). As with the association between sleep quality and negative affect recovery, the relationship between sleep efficiency and positive affect recovery did not differ by either age or gender. Furthermore, the relationship held even after adjusting for trait positivity. Figure 4 shows the

illustration of these effects, indicating that for those people who reported greater efficient sleep, their positive affect was more likely to bounce back and recover during the recovery period.

Table 3

OLS Regression Models with Lingering Decreases in Positive Affect and its Associations with Sleep Quality and Efficiency

Variable	Model 1		Model 2	
	Sleep Quality		Sleep Efficiency	
	b	95% CI	b	95% CI
PA recovery	-0.05	-0.14, 0.05	-0.17*	-0.34, -0.00
Trait happiness	0.15**	0.06, 0.23	0.14*	-0.14, 0.05
Gender (ref=male)	0.03	-0.20, 0.26	0.06	-0.32, 0.20
Age	0.01	0.00, 0.01	0.00	-0.00, 0.01
Ethnicity (ref=caucasian)				
Asian	0.10	-0.18, 0.39	0.09	-0.24, 0.41
Latino	0.20	-0.10, 0.51	0.11	-0.25, 0.45
R ²	0.17***		0.10*	

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

Note: Higher PA recovery scores reflect greater amounts of lingering decreases in positive affect and thus poorer recovery

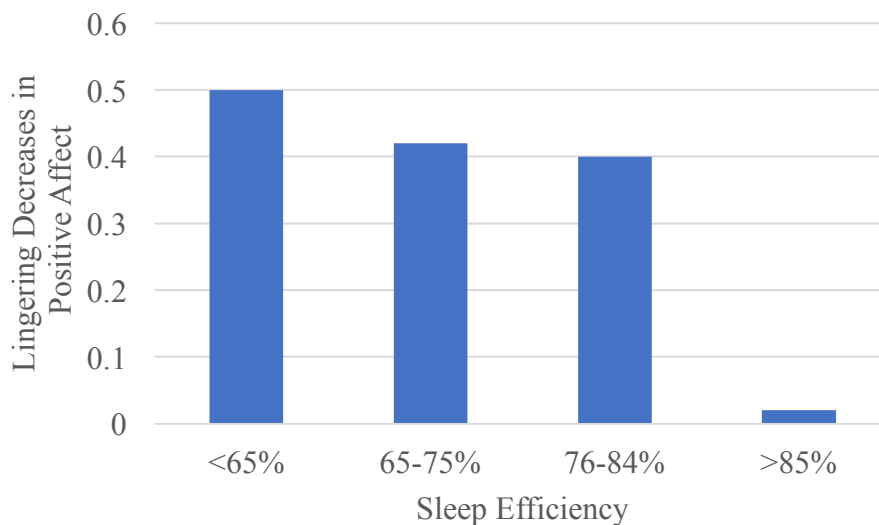


Figure 4. The relationship between lingering increases in positive affect after the completion of the stressor task and sleep efficiency. Lingering positive affect scores reflect marginal means of prolonged affective recovery while adjusting for model covariates. Higher values are indicative of greater decreases in positive affect.

Cardiovascular Responses

Next, we compared participant's cardiovascular responses during the recovery period with their responses during baseline and after the first task. Repeated measures ANOVAs were conducted on systolic and diastolic blood pressure and heart rate. There was a significant main effect of time for both systolic blood pressure ($F(1,176) = 166.5, p < .001$) and diastolic blood pressure ($F(1,181) = 111.65, p < .001$). Figure 5 shows the patterns of responses. Systolic blood pressure and diastolic blood pressure remained elevated during the recovery period relative to baseline. These results indicate that participants did not fully recovery physiologically after the 6-minute recovery period.

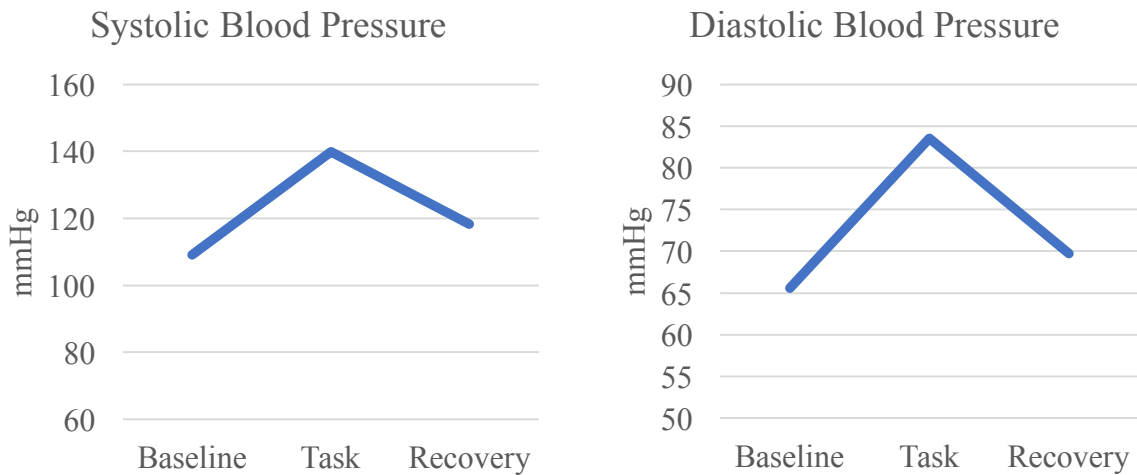


Figure 5. Systolic and diastolic blood pressure throughout the procedure.

Cardiovascular and Affective Recovery

To explore whether cardiovascular recovery was related to affective recovery and sleep, we first compared affective recovery and cardiovascular recovery. Increases in lingering negative affect post-stressor task were not associated with prolonged systolic ($b = 0.44, p = ns$) or diastolic blood pressure ($b = 0.51, p = ns$). Similarly, failure to return to baseline levels of positive affect after the stressor task were not associated with either systolic ($b = 0.19, p = ns$) or diastolic blood pressure ($b = 0.60, p = ns$). Figure 6 demonstrate changes in slopes for systolic blood pressure reactivity and recovery by whether or not people recovered emotionally from the stressor task. This graph illustrates that there was no difference in blood pressure trajectory between people who did recover affectively from the stressor task compared to those who did not.

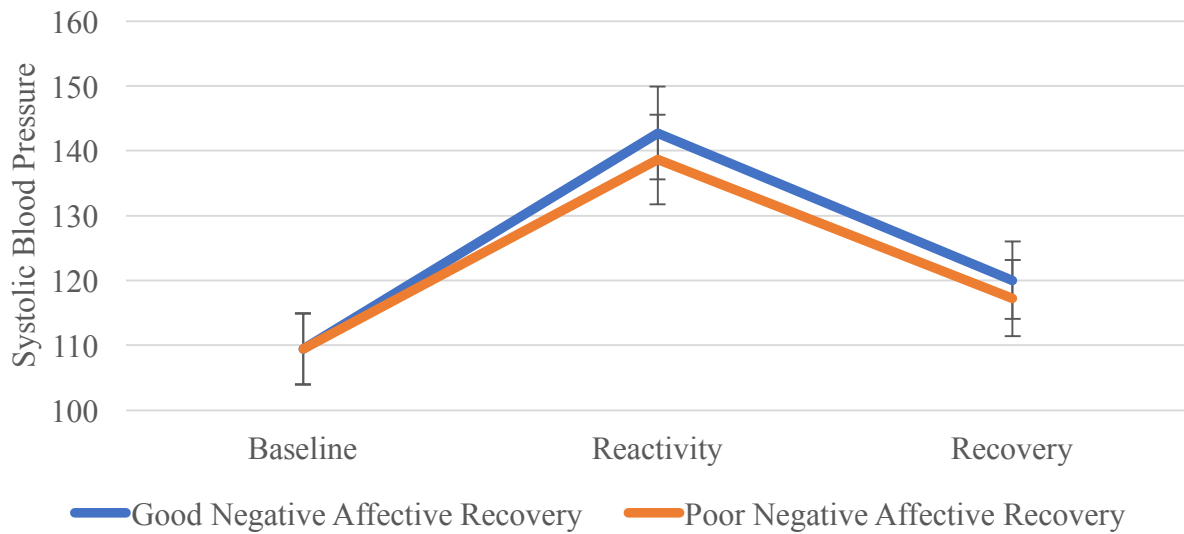


Figure 6. Systolic blood pressure during each section of the procedure by amount of negative affect recovery. There was no difference in systolic blood pressure recovery slopes based on differences in negative affect recovery.

In addition, sleep quality was not related to either prolonged systolic blood pressure ($b = -.01, p = ns$) or prolonged diastolic blood pressure ($b = -.003, p = ns$). We also did not find a relationship between sleep efficiency and prolonged systolic blood pressure ($b = .003, p = ns$) or prolonged diastolic blood pressure ($b = -.02, p = ns$).

Discussion

The current study explored prolonged affective recovery from a lab-based stressor and its association with self-reported sleep behavior. Affective recovery was related to sleep behavior, but these relationships differed for positive and negative affect. Greater levels of lingering negative affect in response to stress were related to worse sleep quality, whereas greater lingering decreases in positive affect were related to worse sleep efficiency. These relationships

held even after adjusting for trait affect and rumination and were unrelated to cardiovascular recovery.

Affect Recovery and Sleep

We found that lingering negative affect after the conclusion of the stressor was associated with worse reported sleep quality above and beyond the influences of trait negative affect levels and trait rumination. Past research on the relationship between negative affect and sleep has focused on either trait like levels of negative affect or on people's tendency to ruminate when distressed (Baglioni et al., 2010; Guastella & Moulds, 2007). Studies suggest that rumination prolongs people's emotional responses to stress (Nolen-Hoeksema & Morrow, 1991) and interferes with their sleep (Guastella & Moulds, 2007). Therefore, it is unclear if lingering negative emotions after a stressor are simply an indication of rumination and not independently associated with sleep. However, the results of this study show that this is not the case. Negative emotions that linger after a stressor occurs are uniquely related to sleep quality independently of trait rumination. This suggests that trait rumination is not the only factor that determines how people respond emotionally to a specific acute stressor. Trait rumination is not a static construct but rather one that can change overtime (LeMoult, Arditte, Avanzato & Joorman, 2013). The tendency to ruminate is associated with prolonged negative mood in response to stress (Nolen-Hoeksema & Morrow, 1991), but the current study demonstrates that the associations between prolonged negative affective recovery and sleep are not solely a result of ruminative thought. This finding underscores the importance of assessing affective recovery from stress and dynamic changes in emotion that influence sleep separately from trait rumination and affect.

Lingering decreases in positive affect after the stress task were associated with decreased sleep efficiency independent of trait levels of positive affect. Positive emotions experienced

during stress are associated with better sleep that night (Pressman et al., 2017). Additionally, positive affect reactivity is also related to poorer sleep (Ong et al., 2013). This is the first study to examine the tendency to experience prolonged decreases in positive affect in response to a controlled laboratory-based stressor. Findings from this study demonstrate that prolonged positive affect recovery from a controlled stressor is related to sleep efficiency and that this relationship exists independently of trait positivity. This relationship suggests that it is not just the presence or absence of positive affect that is helpful or harmful for sleep, but for how long positive emotions are depleted after stressful experiences. Therefore, the regulation and maintenance of positive emotions after times of stress is particularly important for sleep.

Finally, prolonged negative and positive affective recovery were associated with different facets of sleep. Lingering increases in negative affect were related to poorer sleep quality, but not efficiency. Lingering decreases in positive affect were related to poorer sleep efficiency, but not quality. These findings underscore how positive and negative affect are separate constructs related to different aspects of sleep. Sleep efficiency has been shown to be the aspect of sleep most closely tied to positive affect (Pressman et al., 2017). Why might lingering decreases in positive emotion be tied to perceived sleep efficiency, but not sleep quality? Unlike prolonged increases in negative emotion, perhaps prolonged decreases in positive emotion do not shape the more subjective aspects of sleep quality such as overall feelings of restfulness or perceived depth of sleep. Instead, decreases in positive emotion may be more important for actual sleep disruptions. For example, one study found that feeling relaxed is associated with being able to fall asleep faster (Kalmbach, Pillai, Roth, & Drake, 2014). It could be that if a stressor leads to prolonged decreases in positive emotions such as feeling calm and relaxed, it may be harder to fall and stay asleep. Along these lines, perhaps prolonged increases in negative affect shape the

more subjective aspects of sleep such as overall perceived sleep quality, but have less of an impact on actual sleep disruptions. Negative affect in particular is associated with global perceptions of tiredness, fatigue, and somatic complaints (Watson & Pennebaker, 1989). Therefore, prolonged increases in negative affect may be more important for overall perceptions of sleep quality and less so for sleep disruptions. These findings demonstrate the need to examine positive in addition to negative affect recovery, as variations in positive and negative affective responses to stress may not impact sleep and health in the same way.

Accounting for the Relationship Between Affect and Sleep

Because responses to stressors include both an affective and physiological component, we looked to see if co-occurring cardiovascular recovery was responsible for the relationship between affective recovery and sleep. Blood pressure recovery did not account for the relationship between negative affective recovery from stress and sleep. In fact, affective recovery from stress was not related to blood pressure trajectories during or after the completion of the stressor task. This finding is contrary to studies showing that both positive and negative emotions are linked with cardiovascular recovery from stressful situations (Fredrickson & Levenson, 1998; Ottaviani, Shapiro, & Fitzgerald, 2011). However, the finding is in line with studies showing that changes in affect in response to stress are not associated with cardiovascular responses (Cohen et al., 2000). One potential explanation for the lack of an association is that cardiovascular responses to stressful situations may not be driven by affective responses but instead by the amount of effort required to meet an external challenge (Peters et al., 1998). For example, undergoing a stressful event, such as giving a public speech, requires physical effort and engagement. Physiological responses to such an event are thus potentially due to both psychological states as well as the amount of effort put into the environment. Therefore,

cardiovascular responses to stress-reactivity tasks may be driven less by emotional responses to threat and more so by how engaging the task is (Cohen et al., 2000).

Why might prolonged affective recovery be related to sleep? The relationship between affective recovery and sleep did not correspond with cardiovascular arousal. Additionally, associations between affective recovery and sleep held even after adjusting for trait levels of affect and rumination. Both prolonged physiological arousal and perseverative cognitions such as rumination have been proposed as mechanisms through which prolonged emotional responses to stress may impact sleep behavior (for a review, see Kahn, Sheppes, & Sadeh, 2013). Yet, this study shows that the relationship between prolonged emotional responses to stress and sleep exists above and beyond these factors. One possibility is that lingering negative emotions in response to stress may reflect certain coping styles and emotion regulations strategies that may in turn impact sleep. For example, using emotion focused as opposed to problem focused coping strategies as a means of regulating emotional responses to have been shown to prolong negative emotional responses to stressful events and is predictive of worse sleep quality (Sadeh, Keinan, & Daon, 2004). Another explanation is that prolonged affective recovery may be related to poor sleep through health behaviors such as poor diet and reduced exercise. Poor diet and inactivity have been linked with both worse sleep (Irish et al., 2013) and increased negative mood (Fulkerson, Sherwood, Perry, Neumark-Sztainer, & Story, 2004). It could be that prolonged increases in negative emotions or decreases in positive emotions impacts people's diet and exercise habits which in turn disrupts their sleep.

Cardiovascular Functioning and Sleep

Finally, it is worth noting that we did not find an association between cardiovascular recovery from stress and sleep behavior. The literature on the relationship between

cardiovascular responses to experimentally induced stress and sleep is inconsistent. The results of this study are in line with several studies that found no relationship between cardiovascular responses to lab-based stressors and sleep (Kato et al., 2000; Gehrman et al., 2016). Results from this study were also partially in line with another study that found no relationship between sleep and prolonged systolic blood pressure responses to stressful laboratory tasks in healthy adults (Mezick et al., 2014). However, Mezick and colleagues did find a relationship between sleep and prolonged diastolic blood pressure responses to stress. Additionally, self-reports and objective measures of sleep are associated with coronary heart disease and hypertension (Ayas et al., 2003; Chen et al., 2008), and delayed blood pressure recovery from stress is thought to lead to cardiovascular outcomes (Chida & Steptoe, 2010). However, these results suggest that prolonged blood pressure recovery from laboratory-induced stressors is not related to sleep in healthy adults. One explanation for this discrepancy could be that this study examined normal sleep behaviors and cardiovascular responses to a laboratory-based stress task in a sample of health adults. It is possible that for a relationship between sleep and prolonged cardiovascular responses to stress to be present it would be necessary to examine more severe sleep disruptions, certain clinical populations, or major naturalistic stressors or a cumulative toll of multiple stressors over time.

Limitations and Future Directions

The findings of this study are qualified by a few limitations. First, this study examined the correlation between prolonged affective recovery from stress and assessment of general sleep behavior, and as such we are unable to draw conclusions about the causal relationship between them. A large literature has demonstrated the bidirectional nature of these associations (e.g. Sin, Almeida, Crain, Kossek, Berkman, & Buxton, 2017). Poor sleep can lead to worse psychological

well-being and worse recovery from stressors (Hamilton et al., 2008; Meerlo, Sgoifo, & Suchecki, 2008). Poor sleep may impact affective recovery through diminished inhibitory control over negative emotions as a result of diminished brain functioning (Dahl & Lewin, 2002). This study provides an important step in understanding the association between affective recovery and sleep, and now further research is needed to disentangle the temporal nature of the relationship between lingering emotions in response to stress and sleep behavior.

Second, our sleep measures were based on self-report. Although self-reports of sleep have been tested and shown to be comparable to other sleep measurements methods including actigraphy (Landis, Frey, Lentz, Roethermen, Buchwald, & Shaver, 2003), it is possible that people's perceptions of their own sleep are a biased version of their actual sleep habits. Moreover, self-reports of sleep have been connected to many psychological and physical health outcomes, including mortality (Ayas et al., 2003; Buxton et al., 2018; Dew et al., 2003). In order to gain a deeper understanding of sleep behavior, however, future work should extend these findings to incorporate multiple methods of sleep assessment.

Finally, the results of this study showed that the associations between affective recovery from stress and sleep in our nonclinical sample of healthy adults did not differ based on age, gender, or race. Future research should expand these findings with a clinical sample and examine if these relationships are similar amongst people with sleep or mood disorders.

Conclusion

In sum, this study found that affective recovery was related to sleep, but that there were differences with positive and negative affect. Lingering increases in negative affect were associated with poor sleep quality and lingering decreases in positive affect were associated with poor sleep efficiency. These relationships held above and beyond the influence of trait affect and

trait rumination. Additionally, the links between affective recovery and sleep were not attenuated by cardiovascular arousal. Consequently, the relationship between affective recovery from stress and sleep and their implications for physical health is an important avenue of research that may point to areas of intervention to help ameliorate the deleterious effects of stress on health and well-being.

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Leger, K.A., & Charles, S.T. (In Preparation). Affective Recovery from Stress and Its Associations with Sleep.

CHAPTER 5:

Epilogue

Epilogue

We know little about how affective recovery from everyday stressors impacts physical health and how affective recovery from stressors is related to positive emotions and sleep behavior. This dissertation addressed these significant gaps in the literature. Chapter 2 first established that people experience increases in negative affect on the days following a minor stressor, providing support for the previously untested idea that people feel lingering negative affect as a result of a minor stressor the day before. Furthermore, results from Chapter 2 found that lingering negative affect in response to a stressor the day before was associated with physical health outcomes nearly 10 years later, even after adjusting for same day reactivity and stressor exposure. Results from Chapter 2 solidified that it is not just how we react, but how we recover emotionally from stressful experiences in our daily lives that matters for our physical health.

Given these findings point to the detrimental effects of prolonged affective recovery, Chapter 3 then explored a means through which lingering negative emotions may be attenuated: positive emotions. Chapter 3 examined how the experience of positive emotions during days of stress impacted lingering negative affect people felt the following day. This study found that when a person experienced greater positive emotions on a stressor day, they experienced less lingering negative affect the following day than on days when they experienced less positive emotions. This association existed above and beyond trait levels of positive affect. This finding provides support for an existing body of literature that demonstrates that positive emotions experienced during times of stress help facilitate the coping process and have important stress-buffering effects that hasten recovery from stress (e.g. Frederickson & Levenson, 1998).

Importantly, this chapter extends these findings to show that daily positive emotions lessen lingering negative affect in response to a stressor the next day.

Finally, why is prolonged affective recovery predictive of poor health? Chapter 4 explored this question by examining the relationship between prolonged affective recovery and one indicator of physical health: sleep behavior. Chapter 4 explored lingering affective change in a shorter temporal span and used a laboratory-based study to explore the relationship between prolonged affective recovery from a lab-based stressor and its association with sleep behavior. This study further examined the role of cardiovascular recovery in the link between affective recovery and sleep. Affective recovery was related to sleep behavior, but there were differences with positive and negative affect. Greater lingering increases in negative affect were related to worse sleep quality, whereas greater lingering decreases in positive affect were related to worse sleep efficiency in participants. Cardiovascular recovery was not related to either affective recovery or either sleep quality or sleep efficiency. These findings showed that the relationship between affective recovery and sleep was not accounted for by prolonged cardiovascular arousal and that they existed independently of trait affect and rumination. Furthermore, these findings suggest that sleep may be one way one potential mechanism through which affective recovery influences physical health.

Together, findings from these three studies identify prolonged affective recovery in response to a stressor as a unique emotional process that is vital to the connection between stress and health. The studies in this dissertation combined both laboratory-based study designs and daily diary designs in order to examine lingering negative affect in response to daily stressors in addition to prolonged affective recovery in a laboratory-based stress task. The methodological benefits of using both study designs allowed for an examination of affective recovery as it

actually plays out in real life through naturalistic stressors as well as a close examination of a tendency to recover from a controlled psychosocial stressor in a laboratory setting (Cohen & Hamrick, 2003; Kamarck & Lovallo, 2003). In both settings, lingering affect had unique associations with physical health and health-related behaviors. In a naturalistic setting, negative affect that lingered a day after a stressful event predicted future health above and beyond both same day reactivity to stressors and amount of stressor exposure. In the laboratory-based study, prolonged affective recovery from the stressor task was associated with poor sleep behavior independent of the effects of trait affect, rumination, and cardiovascular arousal. These findings are the first to show that lingering affect or prolonged affective recovery from stress is a unique and separate aspect of emotion regulation, independent of trait affect, affect reactivity, and rumination. Furthermore, this dissertation demonstrates that lingering affect in response to stress has its own unique relationship with physical health.

A major strength of this dissertation is that it used a multi-modal approach and combined both a laboratory-based study design and a daily diary design to examine lingering affective change in response to both daily stressors and a laboratory-based stress task. Lingering affect in response to a stressor can be conceptualized on many different time scales. Emotions can linger minutes after a stressor (as assessed in the laboratory design) and days after a stressor (as assessed in the daily diary design). Emotional processes can serve different functions depending on the time frame they are experienced (Parkinson, Briner, Reynolds, & Totterdell, 1995). It is important to understand if the processes through which the relationship between lingering affect and health occur is similar or different based on these varying timeframes. This dissertation has established the importance of lingering affect with two different time scales in separate samples of participants. Future work should combine both methodologies and conduct lab-based studies

and daily life studies on the same sample to further explore aspects of lingering affect and their impact on physical health and health behaviors.

This dissertation has established a link between lingering affect and physical health, and now future research is needed to further explore *who* is most likely to experience lingering affect in response to stressors, *when* lingering affect is most likely to occur, and *how* lingering affect impacts physical health. For example, research has examined individual differences in affective reactivity to stressors, finding that factors such as SES (Grzywacz, Almeida, Neupert, & Ettner, 2004) and personality (Bolger & Zuckerman, 1995; Leger, Charles, Turiano, & Almeida, 2016), contribute to differences in affective reactivity to stressors. Future work should apply this same examination of individual and cultural differences to lingering affect in response to stressor and further explore factors that may moderate the relationship between lingering affect and physical health.

This dissertation used a theoretical framework proposing that stressful experiences lead to prolonged changes in affect which in turn shape future health outcomes (e.g. Almeida, Piazza, Stawski, & Klein, 2011). Chapter 2 examined the ability of lingering negative affect to predict future physical health, and now more longitudinal research is needed to examine why lingering affect is related to health. Longitudinal studies can help disentangle the temporal nature of the relationship between lingering emotions in response to stress and sleep behavior. Future research should also explore other potential mechanisms that may explain the associations between lingering affect and health. Negative moods have been linked to poorer health behaviors including less physical activity, higher drug use, and diets high in fat and sugar (Fulkerson, Sherwood, Perry, Neumark-Sztainer & Story, 2004). Increases in lingering negative affect may lead people to engage in poorer health behaviors, which may in turn influence physical health

later in life. Although this dissertation did not find a relationship between prolonged affective recovery and cardiovascular recovery, there are still many reasons to continue to examine the relationship between affective and physiological response to stressors and implications for physical health. It may be that other physiological systems such as the HPA axis may play more of a role between lingering affect and health (McEwen, 1998). Future research should examine the relationship between lingering affect and HPA markers such as cortisol. Alternatively, it may be that even though short term changes in lingering affect are not related to short term changes in cardiovascular functioning, persistent activation and prolonged emotional responses to stressors may build up overtime to influence physiological systems that may lead an individual vulnerable to disease. There are many potential pathways that may account for the relationship between lingering affect and health that are yet to be explored.

This dissertation highlights the importance of affective recovery, and not just affective reactivity, to the relationship between stress and health. Findings from this dissertation and other work on emotional responses to stress will enhance interventions that focus on limiting negative emotions in response to stressors. For example, mindfulness training promotes a focus on current thoughts and experiences rather than a preoccupation with past or future events (Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008). This present-moment awareness has been shown to have several benefits in daily life, including facilitating adaptive stress responses, increased mood and improved well-being (Donald, Atkins, Parker, Christie, & Ryan, 2016). These findings emphasize the importance of emotion regulation strategies that quicken affective recovery from stressful events and temper emotions that linger after a stressful event has occurred. Finally, the continuing study of the dynamic process of emotional experience in response to stressful

experiences, and how these processes influence our health, is vital for the enhancement of physical health and well-being.

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