UNIVERSITY OF CALIFORNIA, MERCED

MINDFULNESS MECHANISMS AS DYNAMIC PROCESSES: USING A RANDOMIZED CONTROLLED CLINICAL TRIAL TO TEST CHANGES IN EVERYDAY LIFE AND IN RESPONSE TO A SMARTPHONE APP-BASED MINDFULNESS INTERVENTION

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

In

Psychological Sciences

by

Larisa Gavrilova

Committee in charge:

Professor Matthew J. Zawadzki, Chair
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Professor Anna Song

2022

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2022

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

First and foremost, I want to express my sincere appreciation and gratitude to my advisor and mentor Dr. Matthew Zawadzki. Thank you for your continuous mentorship and support. You have always believed in me even when I doubted myself. Thank you for always challenging me to be a better researcher and motivating me to grow professionally and personally. I feel truly fortunate to have had a chance to be your mentee and learn from you, and I cannot imagine having a better mentor. If I were to do my PhD all over again, I would not hesitate a minute to work with you.

To my committee members, Dr. Linda Cameron and Dr. Anna Song, I am grateful for your constant encouragement and support. Thank you for always encouraging innovative ideas and research. I am very grateful to you for your scientific advice and many insightful discussions.

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This work is dedicated to all of you.

CURRICULUM VITAE

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EDUCATION

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Dissertation – *Examining How Mindfulness Mechanisms Naturally Vary in Everyday Life and Following a Smartphone App-Based Mindfulness Intervention*

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Honors thesis – *Using documentaries in narrative medicine research*

PUBLICATIONS

Research Publications

Gavrilova, L. & Zawadzki, M. J. (2021). Testing the Associations Between State and Trait Anxiety, Anger, Sadness and Ambulatory Blood Pressure and Whether Race Impacts These Relationships. *Annals of Behavioral Medicine*.

Zawadzki, M. J., & **Gavrilova**, L. (2021). All the lonely people: Comparing the effects of loneliness as a social stressor to non-lonely stress on blood pressure recovery. *International Journal of Psychophysiology*, *167*, 94-101.

Lagana, L., **Gavrilova**, L., Carter, D.B., & Ainsworth, A.T. (2017). A randomized controlled study on the effects of a documentary on students' empathy and attitudes towards older adults. *Psychology and Cognitive Sciences, 3,* 79-88. doi: 10.17140/PCSOJ-3-127

CONFERENCE PRESENTATIONS

***** indicates work conducted with mentored undergraduate student

Paper Presentations

Reyes, S.*, **Gavrilova**, L. & Zawadzki, M. J. (2020, October). Differences in emotional reactivity after exposure to stressful life events among adults. Symposium presented at the annual Western Psychological Association Convention online.

Gavrilova, L. & Zawadzki, M. J. (2019, April). Testing the effects of avoidance, approach, and mindful coping approaches on mental and physical health. Paper presented at the annual Western Psychological Association Convention, Pasadena, CA.

Zawadzki, M. J., & **Gavrilova**, L. (2019, February). All the lonely people:

comparing social- and non-social-focused mental stress on blood pressure recovery. Paper presented at the annual Society for Personality and Social Psychology Convention health preconference, Portland, OR.

Poster Presentations

Gavrilova, L., & Zawadzki, M. J. (2020, December). *Mindfulness mechanisms in everyday life: testing the effects of acceptance, attention monitoring, decentering, and self-compassion on psychological distress and sleep outcomes*. Poster presented at the 2020 Virtual Meeting of the American Psychosomatic Society.
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Alvarado, G.*, **Gavrilova**, L., Zawadzki, M. J. (October 2020). The relation between perceived stress, burnout and worry on sleep quality. **Poster presented at the annual meeting of the Western Psychological Association online.**

Alvarado, G.*, **Gavrilova**, L., Zawadzki, M. J. (2020, August). Effects of an app-based mindfulness intervention on sleep duration and sleep latency: income as a moderator. Poster presented at 2020 Research and Creative Activities Virtual Showcase at University of California, Merced. (https://uroc.ucmerced.edu/2020-virtual-research-showcase)

Ordonez, J.P.*, **Gavrilova**, L., Zawadzki, M. J. (2020, September). Impact of gender on the relationship between stress and mindfulness intervention. Poster presented at the annual Summer Undergraduate Research Fellowship meeting online at University of California, Merced.

Alvarado, G.*, **Gavrilova**, L., Zawadzki, M. J. (2020, September). Effects of an app-based mindfulness intervention on sleep duration and sleep latency: income as a moderator. Poster presented at the annual Summer Undergraduate Research Fellowship meeting online at University of California, Merced.

Alvarado, G.*, **Gavrilova**, L., Zawadzki, M. J. (2020, September). The relation between perceived stress, burnout and worry on sleep quality. Poster presented at the annual Western Psychological Association Convention online.

Alvarado, G.*, **Gavrilova**, L. & Zawadzki, M. J. (2019, July). Impact of perceived stress, worry and burnout on sleep quality. Poster presented at the annual Summer Undergraduate Research Fellowship meeting at University of California, Merced. Merced, CA.

Reyes, S.*, **Gavrilova**, L. & Zawadzki, M. J. (2019, July). Differences in emotional reactivity after exposure to stress among adults. Poster presented at the annual Summer Undergraduate Research Fellowship meeting at University of California, Merced, Merced, CA.

Herring-Alderete*, S., Sanchez, S.*, **Gavrilova**, L., & Zawadzki, M. J. (2019, April). The effect of positive versus negative cognitive patterns on anxiety and depression in college students. Poster presented at the annual Western

Psychological Association Convention, Pasadena, CA.

Gavrilova, L., & Zawadzki, M. J. (2019, March). Predicting ambulatory blood pressure: comparing the effects of state and trait anxiety and sadness. Poster presented at the annual Scientific Meetings of the American Psychosomatic Society, Vancouver, BC.
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Gavrilova, L., Zawadzki, M. J., & Spruill, T. (2018, April). Evaluating the reproducibility of ambulatory blood pressure variability. Poster presented at the annual meeting of the Society of Behavioral Medicine, New Orleans, LA.

Lagana, L., **Gavrilova**, L., Grewe D., Zacarias A., Martinez, M., Pajulas, A. (2017, March). Viewing documentary on behavioral medicine approaches to pain reduction increases empathy among future health professionals. Poster presented at the annual meeting of the Society of Behavioral Medicine, San Diego, CA.

Carter, D., **Gavrilova**, L., Sholl, K., Prilutsky, R., & Lagana, L. (2016, May). The initial validation of a non-medical stress scale created for ethnically diverse older women. Poster presented at the annual meeting of the Association for Psychological Science, Chicago, IL.

Sholl, K., **Gavrilova**, L., Carter, D., & Sagastume, A., (2016, May). Degree of relative risk for a future fall related to older adults' reported difficulty with performing activities of daily living. Poster presented at the annual meeting of the Association for Psychological Science, Chicago, IL.

Kirakosian, A., & **Gavrilova**, L. (2016, May). Social support from parents as a buffer from perceived stress in first-year Latino and Asian students. Poster presented at the annual meeting of the Association for Psychological Science, Chicago, IL.

Gavrilova, L., Sholl, K., Markovic, Z., Carter, D., & Lagana, L. (2016, March). Ageism reasons and interventions to reduce it. A literature review. Poster presented at the annual meeting of the Western Psychological Association, Long Beach, CA.

Gavrilova, L., & Bordeaux, J. (2014, December). Effects of presentation display and format on memory. Poster presented at CSUN Psi Chi Research Competition, Northridge, CA.

Professional Presentations

Gavrilova, L. (2020, October). Mindfulness and cardiovascular risk reduction: examining potential mechanisms. Presented at the biweekly Health Psychology Colloquium at University of California, Merced, Merced, CA.

Gavrilova, L. (2019, October). Testing the effects of avoidance, approach, and mindful coping approaches on mental and physical health. Presented at the biweekly Health Psychology Colloquium at University of California, Merced, Merced, CA.

Gavrilova, L. (2018, November). Momentary assessment of anxiety as the most consistent predictor of ambulatory blood pressure: testing the between-

persons versus within-persons approaches. Paper presented at the biweekly Health Psychology Colloquium at University of California, Merced, Merced, CA.

Gavrilova, L. (2017, April). Effects of induced brooding, reflection and worry on affect, cardiovascular reactivity and recovery. Paper presented at the annual Psychological Sciences First-Year Student Presentations meeting at University of California, Merced, Merced, CA.

RESEARCH APPOINTMENTS

Graduate Lab Manager (2018-2019; 2021-present)

Stress and Health Lab, University of California, Merced

- managed day-to-day activities of a laboratory team of undergraduate research assistants to ensure the smooth running of research studies

Graduate Student Researcher (2018-2019)

Healthy Campus Network, University of California, Merced

- worked on a multi-site UC study assessing the effects of app-based mindfulness intervention (Headspace) on stress in a sample of UC employees

TEACHING & ADVISING

Instructor of Record

Psychological Sciences, University of California, Merced

- PSY001 Introduction to Psychology (Summer 2020)
- PSY156 Social Psychology (Summer 2021)

Graduate Teaching Fellow (Fall 2020 to present)

Center for Engaged Teaching and Learning, University of California, Merced

- Developed and executed over 15 workshop series on evidence-based teaching practices (based on the text "How Learning Works: Seven Research-Based Principles for Smart Teaching")
- Participated in planning of professional development programs for Teaching Assistants
- Collaborated with other units on campus to plan and design anti-racist pedagogy programs to support graduate student development in teaching and learning
- Managed Teaching Assistant Support Network – an online platform with resources for online teaching

Teaching Fellow

Department of Psychological Sciences, University of California, Merced

- PSY 156 Social Psychology (Spring 2021)
- PSY 190 Psychology of Gender (Fall 2020)
- PSY 001 Introduction to Psychology (Spring 2020)

- PSY 181 Clinical Neuropsychology (Fall 2021)
- PST 140 Clinical Psychology (Spring 2022)

Instructional Internship Program (2018-2019)

Center for Engaged Teaching and Learning, University of California, Merced

- Co-delivered pedagogy-based workshops to Teaching Assistants, postdoctoral fellows, and faculty

Teaching Assistant

Department of Psychological Sciences, University of California, Merced

- PSY 120 Health Psychology (Fall 2019)
- PSY 181 Clinical Neuropsychology (Fall 2017; Fall 2016)
- PSY 151 The Psychology of Stereotype and Prejudice (Fall 2016)

Department of Psychology, California State University, Northridge

- PSY 320 Statistical Methods in Psychological Research (Fall 2015)

Guest Lectures

PSY156 Social Psychology – Cognitive Dissonance (Spring 2021)
PSY 156 Social Psychology – Social Cognition (Spring 2021)
PSY190 Psychology of Gender – Gender and Health (Fall 2020)
PSY 001 Introduction to Psychology – Coping and Stress Management (Spring 2020)
PSY 120 Health Psychology – Mindfulness in Stress Management (Fall 2019)
PSY 120 Health Psychology – Science in Popular Press (Fall 2019)
PSY 120 Health Psychology – Stress and Health (Fall 2019)
PSY 181 Clinical Neuropsychology – Brain Neuroimaging Techniques (Spring 2017)

Grad-Excel Peer Mentor (2020-2021)

Graduate Division, University of California, Merced

- Provided mentorship to two incoming doctoral students

Certified Mindfulness Teacher

Center for KORU Mindfulness, evidence-based program developed by Duke University

- Taught 4-week mindfulness courses for undergraduate and graduate students at University of California, Merced (Fall 2018; Spring 2019; Fall 2019; Spring 2020)
- Led weekly Community Mindfulness Meditation Sessions during COVID-19 for UC Merced community through the Office of Equity, Diversity and Inclusion at University of California, Merced (Spring 2020)

English Tutor (2005-2008)

Smolensk, Russia

- Taught English to children 5-18 years of age

TEACHING-FOCUSED PROFESSIONAL DEVELOPMENT

Pedagogy Certifications

Center for Engaged Teaching and Learning, University of California, Merced

- Mastering the Classroom with 1st Generation College Students
- Preparing to Teach in the Online Environment
- Developing Teaching Strategies
- Improving Teaching by Assessing Learning

Pedagogy Training

UCLA Center X Culture & Equity Project, University of California, Los Angeles

- Participated in three day-long workshop series "Effective Practices for Culturally and Linguistically Diverse Online Classrooms" (2020, November)

Learning Management Systems: Canvas, Tophat

QUANTITATIVE TRAINING

Courses

- Research Design and Methodology
- Longitudinal Data Analysis and Bayesian Extensions
- Multilevel Modeling
- Structural Equation Modeling

Quantitative Training Certifications

University of California, Merced

- Certificate in Quantitative Methods

Statistical Programs: R, SAS, SPSS, Mplus, OpenBUGS

Study Design Platforms: Qualtrics, LifeData (for programming Ecological Momentary Assessment studies)

AWARDS AND HONORS

2022 Research Dissemination Award, awarded by University of California, Merced

2022 Outstanding Paper in Health Psychology Award, awarded by University of California, Merced

2021 Outstanding Teaching Award, awarded by University of California, Merced

2021 William R. Shadish Award for Leadership and Service 2021, awarded by University of California, Merced

2021 Graduate Dean's Advisory Council on Diversity Award, awarded by University of California, Merced

2021	Grad-Excel Peer Mentorship Program Award, awarded by University of California, Merced
2020	William R. Shadish Award for Leadership and Service 2020, awarded by University of California, Merced
2020	Graduate Dean's Advisory Council on Diversity Award, awarded by University of California, Merced
2020	Grad-Excel Peer Mentorship Program Award, awarded by University of California, Merced
2020	Graduate Student Development Support Award, awarded by University of California, Merced
2020	Graduate Fellowship Incentive Program Award, awarded by University of California, Merced
2020	Health Psychology Graduate Student Travel Award, awarded by University of California, Merced
2019	APS 2019 Young Scholar Award, awarded by American Psychosomatic Society
2019	Health Psychology Research Dissemination Award, awarded by University of California, Merced
2019	Graduate Fellowship Incentive Program Award, awarded by University of California, Merced
2019	Selected as a Featured Graduate Student for Department of Psychology, awarded by University of California, Merced
2019	Health Psychology Presentation Travel Award, awarded by University of California, Merced
2018	Healthy Campus Network Research Award, awarded by University of California, Merced
2016	Graduate Fellowship Incentive Program Award, awarded by University of California, Merced
2016-2017	Health Sciences Fellowship, awarded by University of California, Merced
2015-2016	Presidential Scholar Award, awarded by California State University Northridge
2014-2015	University Scholar Award, awarded by California State University Northridge
2015	Grand Prize at the 2015 Marina del Rey film festival for documentary on honors thesis
2014-2016	University Honors Program, California State University Northridge

OTHER TRAINING

Summer Institute on Innovative Methods (Analysis of Ecological Momentary Assessment Data Using Multilevel and Time-Varying Effect Modeling) 2018 Fellow by the Pennsylvania State University (2018, June).

Intercampus Consortium on Health Psychology 2017 Fellow by University of California, Los Angeles (2017, August).

Health Data Exploration Project Summer Institute 2017 Fellow by University of California, San Diego (2017, July).

Intensive Longitudinal Data Seminar Series presented by Psychological Sciences, University of California, Merced (2016-2017).

PROFESSIONAL SERVICE

Service to University of California, Merced

2021 (spring)	Chair, Graduate Student Mental Health and Well-Being workgroup
2020-2021	Chancellor's Advisory Council on Campus Climate, Culture, and Inclusion
2020-2021	Graduate Dean's Advisory Council on Diversity
2020-2021	Climate, Diversity, and Equity Officer, Graduate Student Association
2020 (summer)	Contributed a "Mindfulness Moment" column for UC Merced weekly newsletter with tips on well-being and mindfulness
2020	Graduate Student Association Panel, Graduate Division
2019-2020	Chancellor Search Advisory Committee member
2019-2020	Executive Council member, ex-officio, Graduate Student Association
2018-2020	Graduate Advisory Board, Health Sciences Research Institute
2018	Graduate Student Panel, Psi Chi Psychology Club

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Service to Field and External Organizations

2019-2020	Campus Representative for American Psychological Association Division 38: Society for Health Psychology
2019	Merced City Schools STEAM Center

ABSTRACT

Dissertation Title: Mindfulness Mechanisms as Dynamic Processes: Using a Randomized Controlled Clinical Trial to Test Changes in Everyday Life and in Response to a Smartphone App-Based Mindfulness Intervention
Name: Larisa Gavrilova
Degree Name: Psychological Sciences
University: University of California, Merced, 2022
Committee Chair: Matthew J. Zawadzki

Objective: Theoretical work has proposed that acceptance, attention monitoring, decentering, self-compassion, and nonreactivity may be mechanisms that explain beneficial effects of mindfulness. Yet, our understanding of how mindfulness mechanisms operate in everyday life is limited. The goal of this dissertation is to examine the extent to which these mechanisms naturally vary in everyday life and following a smartphone app-based mindfulness intervention.

Methods: A large-scale university-wide randomized controlled trial was conducted to test the effects of app-based mindfulness intervention (Headspace) on well-being of university employees (n = 143). The study utilized ecological momentary assessment design to measure mindfulness mechanisms in participants' natural environment. Study 1 examined whether mindfulness mechanisms represent independent constructs that naturally vary within a person over time, and whether naturally occurring fluctuations in mindfulness mechanisms differentially predict negative emotions. Study 2 investigated how mindfulness mechanisms change over the course of an 8-week app-based mindfulness intervention, with mindfulness mechanisms assessed at week 0 (pre-treatment), week 2, week 5, and week 8.

Results: For Study 1, multilevel factor analysis revealed four distinct mechanisms – acceptance-attention, decentering, self-compassion, and nonreactivity – that exhibit substantial moment-to-moment variation. Greater acceptance-attention, self-compassion, and nonreactivity were associated with lower negative emotions, while greater decentering predicted higher negative emotions when examined concurrently with the other mechanisms. Study 2 found that improvements in acceptance-attention, decentering, and nonreactivity occurred after two weeks of the intervention. These mechanisms continued improving steadily over the course of the 8-week intervention.

Conclusions: These findings highlight that not all mindfulness mechanisms may similarly relate to the same health outcomes. Although significant improvements in

mindfulness mechanisms occur after two weeks of mindfulness intervention, these effects compound over time suggesting that longer intervention format can lead to greater improvements in mindfulness mechanisms compared to shorter programs. Finally, the findings demonstrate that app-based mindfulness interventions can effectively teach mindfulness mechanisms and provide a suitable alternative for people who cannot access traditional in-person mindfulness interventions.

CHAPTER 1: GENERAL INTRODUCTION

Despite abundant evidence linking mindfulness to a variety of positive outcomes (for review, see Greeson & Chin, 2019; Tomlinson et al., 2018), there is still considerable debate about what mindfulness is, and what explains its beneficial effects (e.g., Van Dam et al., 2018). There is a broad agreement among researchers that mindfulness is an umbrella term used to characterize a large number of mental states and processes (Kabat-Zinn, 2011; Van Dam et al., 2018), often referred to as mindfulness components, dimensions, or mechanisms. Recently, there has been an increased interest in better understanding these constructs - herein, called mindfulness mechanisms – and their beneficial effects. Traditionally, mindfulness mechanisms have been conceptualized as personality traits that can be improved with mindfulness training (e.g., Schnepper et al., 2020). Mindfulness mechanisms have also been conceptualized as naturally occurring states observable in everyday life (Blanke & Brose, 2017; Brown & Ryan, 2003; Shapiro et al., 2006). Yet, our understanding of how mindfulness mechanisms operate in everyday life and the pattern with which they change within a person is limited. Understanding how sensitive these mechanisms are, including at what point in the interventions the proposed mindfulness mechanisms change, has important implications for development of optimized interventions. Thus, the first goal of this dissertation is to test to how sensitive mindfulness mechanisms are to change in everyday life, and whether their natural variations are meaningful in relation to emotional well-being. The second goal of the dissertation is to test how mindfulness mechanisms change over the course an 8-week mindfulness intervention.

Mindfulness Mechanisms

Currently, there is no clear consensus about how intervention programs that aim to promote mindfulness work and what mindfulness mechanisms they affect (e.g., Shapiro et al., 2006). While some theoretical models argue that mindfulness training has an impact on one or two key mindfulness mechanisms that drive its beneficial effects (e.g., Brown and Ryan, 2003; Lindsay & Creswell, 2017), other models propose that mindfulness training might influence a wider array of distinct but interrelated mechanisms (e.g., Baer et al., 2006). For example, Monitor and Acceptance Theory (MAT; Lindsay & Creswell, 2017) proposes that mindfulness training promotes attention monitoring and acceptance. Authors suggest that these two important mechanisms, in turn, can explain the salutary effects of mindfulness training on health and well-being. In contrast to MAT, Brown and Ryan (2003) conceptualize mindfulness as attention to and awareness of present-moment experiences which is similar to the mechanism of attention monitoring. These authors argue that while acceptance is important, it is subsumed within attention monitoring, and the beneficial effects of mindfulness training would be dependent on the presence or absence of attention monitoring. Decentering is another mechanism that has been conceptualized as the hallmark of mindful practice (Shapiro et al., 2006). Decentering has been proposed to promote additional mechanisms that contribute to the beneficial effects of mindfulness training (e.g., Shapiro et al., 2006). Other work has highlighted self-compassion as a mindfulness mechanism (Neff, 2003). This mechanism includes attending to one's present-moment experiences with compassionate and kind attitude (e.g., Baer et al., 2012). Finally, Kabat-Zinn's (1994)

original conceptualization of mindfulness defines mindfulness as nonjudgmental attention to experiences in the present moment. In line with this original definition, nonreactivity to inner experience has been proposed to be one of the core mindfulness skills (e.g., Bishop, 2002). Additionally, nonreactivity is one of the five dimensions of mindfulness proposed by Baer and colleagues (Baer et al., 2006) including acting with awareness, nonjudging, nonreacting (similar to nonreactivity), describing experiences, and observing (similar to attention monitoring).

Given growing empirical evidence on the link between the mechanisms of acceptance, attention monitoring, decentering, self-compassion, and nonreactivity and positive outcomes (e.g., Schnepper et al., 2020), these mechanisms are being increasingly targeted in mindfulness interventions. Despite an increasing amount of intervention research that targets these mechanisms, little is known about how these mechanisms change. Considering the growth of intervention work on these five mechanisms, it is imperative to better understand how sensitive these mechanisms are to change and the pattern with which these changes occur.

Beyond the focus of this dissertation, it should be noted that other mechanisms have been proposed, including but not limited to, body awareness (Hölzel et al., 2011), acting with awareness (Baer et al., 2006), nonjudging (e,g., Baer et al., 2006), values clarification (Shapiro et al., 2006), describing experiences (Baer et al., 2006), and self-transcendence (Vago & Silbersweig, 2012). These mechanisms have not been as extensively studied in the context of interventions, and more work is needed to establish the link between these mechanisms and positive outcomes. Therefore, the present dissertation focuses on the mechanisms of acceptance, attention monitoring, decentering, self-compassion, and nonreactivity, while acknowledging that future work may need to explore additional mechanisms not studied here. Below, the mindfulness mechanisms of acceptance, attention monitoring, decentering, self-compassion, and nonreactivity are outlined.

Acceptance. Acceptance, the ability to observe experiences with an attitude of non-judgment and openness, is one of the core principles of mindfulness (Kabat-Zinn, 1990). Research shows that self-reported acceptance skills are associated with lower physiological and affective arousal indicators (Paul et al., 2013; Shallcross et al., 2013; Troy et al., 2018). Acceptance has also been shown to promote positive emotions and reduce psychological distress (e.g., Simione et al., 2021). Furthermore, studies employing intervention dismantling designs demonstrate that removing acceptance skills training from mindfulness interventions reduces or eliminates the beneficial effects of mindfulness interventions on emotional well-being (e.g., Lindsay & Creswell, 2019). These findings point to acceptance as an important mechanism through which mindfulness training may exert it beneficial effects.

Attention monitoring. Mindfulness is commonly defined as paying attention to the present moment with an attitude of openness and acceptance (Kabat-Zinn, 1994). This ability to monitor momentary experience has been proposed to be a critical skill underlying mindfulness training (Hölzel et al., 2011; Lindsay & Creswell, 2017; Shapiro et al., 2006). Research has demonstrated that mindfulness training improves cognitive abilities, including improvements in selective and executive attention, as well as improved working memory capacity and executive functions (for review, see Chiesa et

al., 2011; Tang et al., 2015). Attention monitoring is associated with enhanced positive affectivity (e.g., Iani et al., 2017; Sahdra et al., 2017). For example, using an experience-sampling methodology one study found that when focusing on the present moment people experienced more positive affect (Blanke et al., 2017).

Decentering. Decentering may be conceptualized as the ability to relate to experiences in a wider field of awareness, or the ability to adapt a stance of a silent objective observer. In their model of mindfulness, Shapiro and colleagues (2006) contend that decentering is the hallmark of mindful practice. Evidence demonstrates that decentering increases after mindfulness training (e.g., Adair et al., 2018; Lau et al., 2006), and there is a strong association between decentering and positive health outcomes (Carmody et al., 2009; Ma & Siu, 2020). Integrating a neuroscientific perspective, Hölzel and colleagues (2011) also describe decentering as the driving force of mindfulness. It has been proposed that decentering sets the stage for more adaptive coping strategies (Bernstein et al., 2015). Decentering has previously been theorized to be a mechanism in cognitive therapies (Beck et al., 1979; Heimberg & Ritter, 2008). Preliminary evidence suggests the associations between decentering and psychological distress, including anxiety and depressive symptoms (for review, see Bennett et al., 2021; Pearson et al., 2015).

Self-compassion. Self-compassion involves treating oneself with the same kindness and patience as one would treat a friend in the same situation. It involves the ability to be caring towards oneself and offering nonjudgmental understanding to one's suffering. Several clinical trials have demonstrated that mindfulness interventions can improve self-compassion (e.g., Gard et al., 2012; Greenberg et al., 2018). Related to emotional well-being, research has shown a link between self-compassion and increased positive affect, decreased anxiety, and depressive symptoms (e.g., Carvalho et al., 2020; Kroshus et al., 2021; Neff & Vonk, 2009). For example, one experimental study found that self-compassionate participants reported less negative affect when faced with a social-evaluative stress (Luo et al., 2018). Another study found that higher levels of dispositional self-compassion attenuated the relationship between state negative affect and psychopathology highlighting the potential role of self-compassion as a resilience resource (Trompetter et al., 2017).

Nonreactivity. In line with Kabat-Zinn's (1994) original conceptualization of mindfulness, Bishop (2002) posits that nonreactivity to inner experience may explain how mindfulness training produces positive outcomes. The practice of mindfulness involves approaching stressful situations more skillfully without reacting to them. The practitioner becomes less controlled by particular emotions and thoughts that arise, and is able to inhibit the tendency to judge and act in an automatic and habitual way. Research indeed suggests that mindfulness practice can improve emotional and cognitive reactivity to daily stress (e.g., Wenzel et al., 2021; Zou et al., 2020). For example, evidence indicates that people with high dispositional mindfulness tend to show less cognitive reactivity to negative emotions, and mindfulness-based cognitive therapy has been shown to significantly reduce cognitive reactivity (Raes et al., 2009).

Mindfulness Mechanisms as Naturally Occurring States

Although much work examined mindfulness mechanisms in the context of interventions, there is evidence to suggest that mindfulness mechanisms are naturally

occurring states that vary within-person over time (Brown & Ryan, 2003; Shapiro et al., 2006). In recent years, there has been an increased interest in better understanding mindfulness mechanisms as states (e.g., being self-compassionate in the current moment) that occur in everyday life, as this knowledge can allow researchers to understand the link between being mindful (or, accepting, self-compassionate, etc.) in the moment and real-world behaviors and emotional experiences. For example, one study found a reciprocal relationship between state mindfulness and positive emotions, with state mindfulness (defined as being aware of what one is doing without judgements) and positive emotions enhancing one another (Du et al., 2019). Related to mindfulness mechanisms, Blanke and colleagues (2017) used an experience-sampling methodology to examine whether the mindfulness mechanisms of attention monitoring and acceptance are differentially related to emotional well-being. Researchers found that participants experienced more positive affect when they were paying attention to the present moment, and they experienced less negative affect when they were more accepting of their present moment experiences. Additionally, only acceptance buffered the impact of daily hassles on emotional well-being.

However, research examining mindfulness mechanisms as naturally occurring characteristics in the context of everyday life is still in a nascent phase posing an important research gap to be addressed. Answering this research question requires assessing mindfulness mechanisms across time as within-person processes. This approach can help researchers better understand mindfulness mechanisms as dynamic variables changing in everyday life and uncover what predicts natural fluctuations in mindfulness mechanisms. Furthermore, this approach can help to determine what mechanisms might be more malleable, which has important implications for developing interventions and allowing researchers to detect if an intervention is working as expected at an earlier time point by focusing on mechanisms.

Mindfulness Mechanisms as Intervention Targets

Related to research examining mindfulness mechanisms in the context of interventions, research has started to examine mindfulness mechanisms using mediation analysis. These studies examine indirect effects of mindfulness interventions on outcomes through the proposed mindfulness mechanisms. Gu and colleagues (2015) conducted a systematic review of mediation studies in order to identify mechanisms underlying the effects of mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1982) and mindfulness-based cognitive therapy (MBCT; Segal, Williams, & Teasdale, 2018) on psychological outcomes. Researchers found strong, consistent evidence for cognitive and emotional reactivity (i.e., labeled nonreactivity in this dissertation), moderate and consistent evidence for mindfulness, rumination, and worry, and preliminary but insufficient evidence for self-compassion and psychological flexibility as mechanisms responsible for the positive effects of mindfulness on psychological outcomes. In another systematic review, researchers evaluated mechanisms of change in MBCT in randomized controlled trials for major depressive disorder (van der Velden et al., 2015). Researchers found evidence supporting the mediating role for mindfulness, rumination, worry, compassion, and meta-awareness (a process that according to Bernstein et al., 2015, constitutes decentering). In addition, preliminary evidence was found for attention (similar to attention monitoring), memory specificity, self-discrepancy, emotional

reactivity (similar to nonreactivity) and positive and negative affect. A more recent systematic review investigated evidence on mindfulness mechanisms in mindfulness interventions in populations with physical and/or psychological conditions (Alsubaie et al., 2017). The study found that global changes in mindfulness show potential as a potential mechanism of change; this finding pertained more to interventions targeting psychological rather than physical health outcomes.

Despite this preliminary evidence, authors of these reviews agree that there is a lack of methodological rigor in this area of research that precludes definitive conclusions. Furthermore, key to any mediation analysis is better understanding a mediating variable (i.e., mindfulness mechanisms), and how it might be changing as a result of an intervention. Most research to date testing changes in mindfulness mechanisms following mindfulness intervention predominantly focused on pre-post treatment changes in mindfulness mechanisms. Yet, little is known about how mindfulness mechanisms change over the course of a mindfulness intervention and at what point in the intervention changes in the proposed mechanisms occur. Uncovering this knowledge has important implications for developing optimal interventions that allow researchers to detect if an intervention is working as expected at an earlier time point by focusing on mechanisms.

Present Dissertation

The overall goal of the present dissertation is to contribute to the growing body of literature on mindfulness mechanisms and understand how the proposed mindfulness mechanisms change. Study 1 tested whether the mindfulness mechanisms of acceptance, attention monitoring, decentering, self-compassion, and nonreactivity represent independent constructs that naturally vary in everyday life, and whether these fluctuations are meaningful in predicting negative emotions. Study 2 examined how mindfulness mechanisms change over the course of an 8-week app-based mindfulness intervention. Specifically, the study assessed at what point in the mindfulness intervention mindfulness mechanisms begin to improve, and whether changes in mindfulness mechanisms following mindfulness intervention compound over the course of the intervention.

CHAPTER 2: MINDFULNESS MECHANISMS IN EVERYDAY LIFE: EXAMINING VARIANCE IN ACCEPTANCE, ATTENTION MONITORING, DECENTERING, SELF-COMPASSION, NONREACTIVITY AND ITS LINK TO NEGATIVE EMOTIONS

Mindfulness is an umbrella term used to characterize a large number of mental states and processes (Kabat-Zinn, 2011; Van Dam et al., 2018), often referred to as mindfulness components, dimensions, or mechanisms. Abundant evidence links mindfulness to a variety of positive outcomes, including reductions in negative emotional states (for review, see Greeson & Chin, 2019). Yet, there is still considerable debate about what mindfulness is, and what can explain its beneficial effects (e.g., Van Dam et al., 2018). Mindfulness training has been theorized to improve emotional well-being through promoting adaptive mental states and processes, including acceptance, attention monitoring, decentering, self-compassion, and nonreactivity - herein, called mindfulness mechanisms. Although this has led to calls among researchers to customize mindfulness interventions to target these active mechanisms (e.g., Loucks et al., 2019), it is not clear how malleable these mechanisms are. One way to test this is to measure these mechanisms repeatedly over time in everyday life to discern whether there is substantial within-person variability suggesting the potential for modifiability.

Additionally, it is important to understand whether these mechanisms represent distinct constructs. When testing mechanisms, existing literature has typically focused on a limited set of mechanisms for concurrent examination (Hölzel et al., 2011). Thus, it is unclear if these mechanisms are all associated with outcomes due to the same underlying shared variance (e.g., they are positive valenced or include adaptive cognitions), or if they have unique relationships with outcomes. The present study takes an initial innovative step in investigating the relationships between an array of mindfulness mechanisms (i.e., acceptance, attention monitoring, decentering, self-compassion, nonreactivity) and negative emotions in the context of people's everyday life. The study examines whether these mechanisms represent unique constructs that naturally vary within a person over time, and whether naturally occurring fluctuations in mindfulness mechanisms independently relate to negative emotions.

Mindfulness Mechanisms

Currently, there is no clear consensus about how interventions that aim to promote mindfulness work and what mindfulness mechanisms they affect (e.g., Shapiro et al., 2006). While some theoretical models argue that mindfulness training has an impact on one or two mindfulness mechanisms (e.g., Brown & Ryan, 2003; Lindsay & Creswell, 2017), other models propose that mindfulness training might influence an array of distinct but interrelated mechanisms (e.g., Baer et al., 2006) highlighting the importance of distinguishing between the proposed mindfulness mechanisms. *Attention monitoring* involves recognizing when the mind wanders off and redirecting attention back to the focus of meditation (Hölzel et al., 2011; Shapiro et al., 2006). *Acceptance* is the ability to observe experiences with an attitude of non-judgment and openness and is one of the core principles of mindfulness (Bishop et al., 2004; Kabat-Zinn, 1990). Some more recent theoretical work – the Monitor and Acceptance Theory (Lindsay & Creswell, 2017) – posits that both attention monitoring and acceptance should be considered in

tandem as they are the basic mechanisms underlying mindfulness. *Decentering* may be conceptualized as the ability to reflect on negative experiences from a self-distanced, rather than self-immersed perspective (Shapiro et al., 2006). *Self-compassion* involves recognizing that being imperfect and making mistakes is part of the common human experience and thus enhances feelings of interconnectedness and concern for others (Neff, 2003; Neff et al., 2007). *Nonreactivity* inhibits the tendency to judge and act in automatic and habitual patterns and allows to approach stressful situations more skillfully (Bishop, 2002; Kabat-Zinn, 1994).

Theoretical and empirical work has largely sought to identify individual (or a small subset of) mechanisms and/or the relationship between those mechanisms and outcomes (e.g., Bernstein et al., 2015; Lindsay & Creswell, 2017; Shapiro et al., 2006; Tang et al., 2015; Vago & Silbersweig, 2012). While this work advances our understanding of a specific mechanism and its effects, it inadvertently limits our understanding of how mindfulness mechanisms relate to each other and to what extent they have independent relationship with outcomes such as negative emotions. It remains unclear whether the beneficial effects of these mechanisms can be explained by shared variance, or whether there is something specific to each mechanism. The first goal of the study is to test the relationships among the commonly proposed mechanisms of acceptance, attention monitoring, decentering, self-compassion, and nonreactivity.

Mindfulness Mechanisms as Naturally Occurring States

Although much work examined mindfulness mechanisms in the context of interventions, there is evidence to suggest that mindfulness mechanisms are naturally occurring states that vary within-person over time (e.g., Blanke & Brose, 2017; Brown & Ryan, 2003; Shapiro et al., 2006). In recent years, there has been an increased interest in better understanding mindfulness mechanisms as states (e.g., being self-compassionate in the current moment) that occur in everyday life, as this knowledge can allow researchers to understand the link between being mindful (or, accepting, self-compassionate, etc.) in the moment and real-world behaviors and emotional experiences. For example, one study examining the relationship between state mindfulness and positive emotions in the naturalistic environment found a reciprocal relationship between state mindfulness and positive emotions, with state mindfulness and positive emotions enhancing one another (Du et al., 2019). Related to mindfulness mechanisms, Blanke and colleagues (2018) used an experience-sampling methodology to examine whether the mindfulness mechanisms of attention monitoring and acceptance are differentially related to emotional well-being. Researchers found that participants experienced more positive affect when they were paying attention to the present moment, and they experienced less negative affect when they were more accepting of their present moment experiences. Additionally, only acceptance buffered the impact of daily hassles on emotional well-being.

Despite this preliminary work, research examining mindfulness mechanisms as naturally occurring characteristics in the context of everyday life is still in a nascent phase. Moreover, much of this work has conceptualized state mindfulness as unidimensional (e.g., the Mindful Attention Awareness Scale, MAAS – State; Brown & Ryan, 2003) posing an important research gap to be addressed. Findings by Blanke and Brose (2017) highlight the importance of distinguishing between different facets of state mindfulness. Researchers corroborated that mindfulness has multidimensional structure

at both the trait and the state level. In particular, they found that the mindfulness mechanisms of nonjudgmental acceptance, present-moment attention, and nonreactivity (in this paper, labeled acceptance, attention monitoring, and nonreactivity, respectively) that have been conceptualized and measured at the trait level can also be identified at the state level. Examining mindfulness mechanisms at the state level can help researchers better understand mindfulness mechanisms as dynamic variables changing in everyday life and uncover what predicts natural fluctuations in mindfulness mechanisms. Furthermore, this approach can help to determine what mechanisms might be more malleable which has important implications for developing interventions. For example, mechanisms, by definition, precede the change that an intervention targets; thus a focus on examining the change in mechanisms might allow researchers an opportunity to detect if an intervention is working as expected at an earlier time point or stage of the intervention. Thus, the second goal of the study is to assess whether mindfulness mechanisms naturally vary within a person.

Relationships between Mindfulness Mechanisms and Negative Emotions in Everyday Life

In assessing whether natural fluctuations in mindfulness mechanisms are meaningful, we tested the relationships between mindfulness mechanisms and negative emotions due to strong associations between negative emotions with health and well-being (e.g., Suls, 2018). Namely, extensive data indicate that the tendency to experience the negative emotions of anxiety, anger, and sadness is associated with morbidity and mortality from a range of chronic illnesses (e.g., Suls, 2018). Although there is considerable construct and measurement overlap among these emotions (Suls & Bunde, 2005), research has shown that they differentially predict health outcomes (e.g., Kubzansky et al., 2006). Given the unique features and contributions of anxiety, anger, and sadness to health outcomes, the present study assessed these three emotions together to create a composite negative emotionality measure.

Recent work suggests that mindfulness training may be a promising framework in improving emotional well-being (for review, see Eberth & Sedlmeier, 2012). For example, when people do not pay attention to what they are currently doing, they report being less happy regardless of the nature of their activities and how enjoyable they are (Killingsworth & Gilbert, 2010). Acceptance, decentering, and self-compassion are also associated with emotional well-being including increased positive emotions and reduced anxiety and depressive symptoms (Neff & Vonk, 2009; Pearson et al., 2015). Decentering, for example, is theorized to set the stage for more adaptive coping strategies and aid people in their attempts to adaptively analyze negative experiences (Bernstein et al., 2015). Heightened emotional and cognitive reactivity to daily stress and negative emotions has been shown to contribute to dysfunctional thinking, perpetuate psychopathology, and play a key role in depressive relapse/recurrence (Lau et al., 2004; Scher et al., 2005). Thus, reduced reactivity to daily stress may be linked to low emotional distress.

Much of past work has only looked at a limited set of mechanisms at a time, inadvertently limiting in our understanding of whether mindfulness mechanisms make unique contributions to negative emotions. Yet, understanding whether these mechanisms produce unique effects to each other, or interact to predict outcomes, can allow

researchers to tailor mindfulness and other interventions to target specific outcomes. Interventions can be made more effective and efficient by focusing only on those mechanisms that robustly predict a target outcome. Furthermore, these mechanisms can serve as meaningful outcomes to assess the effectiveness of mindfulness interventions knowing the downstream effects on clinical endpoints. The third goal of the study is to investigate whether naturally occurring variance in mindfulness mechanisms is independently related to negative emotions.

The Present Study

In the present study, we examined the relationships between mindfulness mechanisms and how they relate to negative emotions in everyday life. Research question 1 investigated whether mindfulness mechanisms represent distinct constructs. Research question 2 examined whether mindfulness mechanisms naturally vary within person. Research question 3 examined whether this naturally occurring variance in mindfulness mechanisms is related to negative emotions. Finally, we conducted a follow-up exploratory analysis to test possible interaction effects between each pair of momentary mindfulness mechanisms.

In answering these research questions, we used Ecological Momentary Assessment (EMA) that involves repeated measurement of participants' current or recent state in the context of their everyday life (Stone & Shiffman, 1994). EMA has been increasingly used in examining relationships between constructs as they unfold within a person over time, including research on mindfulness. For example, a recent systematic review (Enkema et al., 2020) assessed the utility of intensive longitudinal assessment methods to investigate the effects of mindfulness on various mental health outcomes. The authors conclude that traditionally used trait measurement methods of mindfulness may not adequately assess mindfulness and the effects of mindfulness training which are hypothesized to occur at the state-level. Therefore, these researchers advocate for the use of intensive longitudinal assessment methods including EMA in mindfulness research.

Method

Participants

The study was conducted in a public university located in Central California. Participants were 143 university employees between the ages of 21 and 65. Participants self-identified as primarily White and Hispanic/Latino females (74.8% female; 53.8% White; 25.2% Hispanic/Latino); see Table 2-1 for demographics. As part of the main study testing the effects of mindfulness intervention on stress in university employees, participants were recruited through university emails and flyers. Inclusion criteria were having access to a smartphone with internet access every day, being fluent in English, being a non-student and non-faculty employee of the university, and being at least of 18 years of age. Data for the present study was analyzed from the baseline period as part of a larger study testing the effect of app-based mindfulness training. In line with the eligibility criteria of this larger project, participants who were experienced meditators, defined as having participated in a sitting meditation practice more than twice a week (for 10 minutes or greater) over the last three months, were excluded.

Materials

Baseline Measures

During baseline, participants first completed demographic information about their age, gender (coded as 0 = male, 1 = female), and ethnicity (coded as 0 = non-Hispanic/Latino, 1 = Hispanic/Latino), and other measures not relevant to the present study. To test if those with trait mindfulness also reported higher levels of mindfulness mechanisms, trait mindfulness was assessed using MAAS (Brown & Ryan, 2003). MAAS is a 15-item trait measure of one's tendency to attend to present-moment experiences in everyday activities, with items on a scale from 1 (*almost always*) to 6 (*almost never*). Items were averaged together such that higher scores indicated higher levels of dispositional mindfulness ($\alpha = .89$).

Mindfulness Mechanisms Assessment

To assess mindfulness mechanisms at the state level, we used the influential conceptualizations of mindfulness and the most commonly used scales to identify items needed to measure these constructs (e.g., Bishop et al., 2004; Brown & Ryan, 2003; Hölzel et al., 2011; Neff, 2003). This approach is similar to previous work on assessing mindfulness mechanisms at the state level (e.g., Blanke & Brose, 2017). For example, nonreactivity items were drawn from the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006), one of the most commonly used measures of mindfulness. As another example, the self-compassion items were formulated in line with Neff's (2003) conceptualization of self-compassion as being kind and patient towards oneself. Drawing from previous work on daily diary/experience sampling methodology studies (e.g., Hox & Kleiboer, 2007; Moore et al., 2016; Roesch et al., 2010; Stone & Neale, 1984), each mindfulness mechanism was assessed using two items (see Table 2-2 for items). All items were asked on a sliding scale from 0 (*not at all*) to 10 (*extremely*) and started with a common question stem "Since the last survey, ...?" As is shown in Table 2-2, the scales demonstrated moderate to high reliability to detect within-subject differences in change over time, $R_C = .59$ - .84 (Bolger & Laurenceau, 2013).

Negative Emotions Assessment

Negative emotions were assessed using EMA, with participants separately rating their anxious, angry, and sad emotional states on a 0 (*not at all*) to 10 (*extremely*) sliding scale. A composite score of the three items was created to account for a general state of negative emotionality ($R_C = .73$).

Procedure

As part of the baseline period of a study testing the effects of mindfulness intervention on stress in university employees, individuals interested in the study logged on to a secure website and read information about the study. Those interested in taking part in the study were prompted to complete a screening survey relevant to the inclusion and exclusion criteria. Eligible participants who consented to participate in the study received a link to the baseline questionnaire battery via Qualtrics.

Following the baseline survey, participants attended one 60-minute in-lab orientation (in groups of up to four) on campus between October 2018 to May 2019. During the orientation, participants received training on how to download and use an application called RealLife Exp (LifeData Corporation, Marion, IN) on their smartphone that served as a platform for EMA surveys. Surveys were programmed to appear on

participants' smartphone at random times within specified time windows (i.e., 8:00 am-10:00 am, 10:30 am-12:00 pm, 1:00 pm-3:00 pm, 3:30 pm-5:30 pm, 6:00 pm-8:00 pm) between 8am and 8pm five times a day for 4 consecutive days (Wednesday through Saturday).

During the in-lab orientation, research staff explained to participants each of the EMA items assessing mindfulness mechanisms to ensure that these items were clear to all participants regardless of their prior experience with mindfulness. As an example, one of the attention monitoring items "Since the last survey, how much were you paying deliberate attention to your surroundings?" was explained in the following way, "This question asks how much since the last survey you stopped to look at your surroundings. Often times, we are in a rush and all we want is to get from point A to point B, to get things done, and so on. This question asks you, how often you stopped to observe the world around you?" In this manner, research staff guided participants through each question in a practice survey to ensure participants understand the items and how to use the app on their smartphone to complete the surveys. At the end of an in-lab session, each participant received a printed user guide that provided explanation of each EMA item, frequency of the surveys, relevant information about the study, and FAQs concerning the RealLife Exp app. Researchers' contact information was provided on the first page of the user guide and participants were encouraged to contact research team if needed.

Analytic Plan

Our data analytic strategy modeled a hierarchical structure with momentary observations (within-person; Level 1) nested within individuals (between-person; Level 2). To investigate whether mindfulness mechanisms represent distinct constructs (research question 1), we used Multilevel Factor Analysis (MLFA; Dunn et al., 2015; Reise et al., 2005; Roesch et al., 2010) using Mplus Version 8 to test the factor structure of the 10 mindfulness mechanism items. MLFA allowed us to model mindfulness mechanisms at both the person (between-person) and momentary (within-person) levels by decomposing the total sample variance-covariance matrix into within-cluster and between-cluster matrices and simultaneously modeling distinct latent factor structures at each of these levels (Muthén, 1991; 1994). Rather than assuming that the factor structure is the same at both levels, this method allows for the possibility of two different latent factor structure at the two levels allowing us to better understand the variation in structure and meaning that exists across the two levels (Dunn et al., 2015). This approach is in line with previous work investigating the between-person and within-person variance in mindfulness mechanisms. In particular, Blanke & Brose (2017) used this approach to develop the Multi-State Mindfulness Questionnaire to measure mindfulness.

In the analysis, we allowed as few as two factors and up to five factors at each level (although the five factor models failed to converge). Geomin rotation that permits correlations among factors was used for all models. Model fit was determined based on a range of indicators indicators including the extent to which identified factors are orthogonal to each other, coherence of items on factors in line with the dimensions targeted with each item, comparative fit index (CFI; values above .95 indicate good fit); Tucker-Lewis index (TLI, values above .95 indicate good fit), Root Mean Square Error of Approximation (RMSEA; values less than or equal to 0.05 with a confidence interval

(CI) from 0.00 to 0.08 indicate good fit; see Hu & Bentler, 1999), and Standardized Root Mean Square Residual (SRMR; values less than .08 indicate good fit).

Next, we examined whether mindfulness mechanisms naturally vary within person (research question 2). We created scales based on items that loaded strongly together and used these scales to test whether mechanisms vary within persons over time. We ran an empty hierarchical mixed effects model using PROC MIXED in SAS 9.4, with each mechanism as an outcome, and accounting for the nested nature of the data. These models allowed us to partition the variance in the mechanism at the within-person and between-person levels, specifically looking at both within-person within-day (moment) and within-person across days (day) levels, along with the between-person level.

Finally, we conducted hierarchical mixed effect modeling to test whether naturally occurring variance in mindfulness mechanisms is related to momentary fluctuations in negative emotions (research question 3). We entered the mechanisms both as an average of all measurements across the four days (labeled as "average") and as the momentary effect (labeled as "momentary"). Average level variables (Level 2) were entered to account for participants' average of the mindfulness mechanisms across the four days. Momentary level variables (Level 1) were person-mean centered around the individual's overall mean to examine the within-person effects of mindfulness mechanism separately from the between-person effects (Bolger & Laurenceau, 2013). Time of the day, day of the study, weekend, age, gender, and ethnicity (0 = non-Hispanic/Latino, and 1 = Hispanic/Latino) were included as control variables. Analyses were done in an iterative fashion, first running each mechanism as a separate model, and then testing the mechanisms concurrently to identify if any mechanism had an independent effect. As a follow-up exploratory analysis, we tested two-way interactions between momentary mindfulness mechanisms.

Results

Demographics of the sample as well as means, standard deviations, and correlations for mindfulness mechanisms are shown in Table 2-3. Overall, participants reported an average negative emotionality of 2.53 (*SD* = 1.64) and an average trait mindfulness score of 3.66 (*SD* = 0.86).

Research Question 1

MLFA tested different potential factors structures across all moments (within-person) as well as across individuals (between-person). As reported in Table 2-4, the four-level solution at both levels was the strongest fit to the data on all indicators. The item loadings across the factors are reported in Table 2-5. At the within-person level, results indicated that the acceptance and attention monitoring items loaded on one factor (herein labeled acceptance-attention), the decentering items loaded on another, the self-compassion items loaded on a third factor, and the nonreactivity items loaded on a fourth factor. The resulting acceptance-attention factor demonstrated acceptable reliability to detect within-subject differences in change over time, R_C = .72 (Bolger & Laurenceau, 2013). The fit was generally consistent at the within- and between-person levels for the acceptance-attention, decentering, self-compassion, and non-reactivity factors. One exception to this was that one attention-monitoring item (i.e., Since the last survey, how much were you in tune were you with your emotions?) cross-loaded on two factors on the between-person level, and the second attention-monitoring item did not have a high

loading for the acceptance-attention factor. We used the factor structure at the within-person level when creating acceptance-attention factor, but we note this as a limitation in the discussion. Table 2-3 provides the means and standard deviations of all mindfulness mechanisms.

Correlations among the resulting mechanisms were assessed. Furthermore, we tested how these measures (at the between-person level) compare to trait mindfulness as measured with the MAAS that conceptualizes mindfulness unidimensionally with a focus on the acting with awareness mechanism. We correlated mindfulness mechanisms, both as individual mechanisms and aggregated score across the four mindfulness mechanisms, with the MAAS. Modest correlations with the MAAS were observed (*rs* = 0.19-0.24; see Table 2-3), with the strongest correlation between the nonreactivity factor and the MAAS. The correlations between decentering factor and MAAS failed to reach significance.

Research Question 2

An empty multilevel model (SAS 9.4) was run to partition variance for the four resulting mindfulness mechanisms scales. Results revealed that for the resulting acceptance-attention factor, 44% was explained by within-person within-days, 13% by within-person across days, and 43% by between-person. For decentering, 50% was explained by within-person within-days, 13% by within-person across days, and 37% by between-person. For self-compassion, 42% was explained by within-person within-days, 9% by within-person across days, and 49% by between-person. For non-reactivity, 48% was explained by within-person within-days, 9% by within-person across days, and 43% by between-person.

Research Question 3

When testing each mechanism in separate models (see Table 2-6), results revealed that in the moments when participants reported greater acceptance-attention, decentering, self-compassion, and nonreactivity, they reported lower negative emotions (*ps* < .001). When all the mechanisms were examined concurrently (see Table 2-6, All Mechanisms Model), higher reports of momentary acceptance-attention, self-compassion, and non-reactivity were still related to reports of reduced negative emotions (*p*s < .002), while decentering was related to higher levels of negative emotions (*p* = .001). For all mechanisms, beta coefficients dropped suggesting that although they have unique associations with negative emotions, these mechanisms share some variance.

Exploratory Analyses

Finally, we explored whether mindfulness mechanisms interact in predicting negative emotions. No significant interactions were found (*ps* > .287).

Discussion

First, the study tested whether mindfulness mechanisms represent distinct constructs (research question 1). Decentering, self-compassion, and nonreactivity emerged as distinct mechanisms highlighting the need for more work assessing these mechanisms as possible distinct pathways through which mindfulness training may influence health and well-being. In contrast, attention monitoring and acceptance loaded on one factor. One possible inference from this finding is that attention monitoring and acceptance may not be separable constructs. They might be closely intertwined in such a way that this mechanism involves bringing an attitude of acceptance to every experience.

These results are consistent with the general perspective of Monitor and Acceptance Theory (Lindsay & Creswell, 2017) that views attention monitoring and acceptance together comprising the active mechanisms for mindfulness training effects. Our results also provide support for Shapiro and colleagues' (2006) view of attention monitoring and acceptance as interwoven aspects. The authors posit that although mindfulness is often associated with the ability to bring attention to moment-to-moment experiences, the attitude of acceptance toward these experiences is crucial (Shapiro et al., 2006).

Secondly, we examined whether the mechanisms naturally vary within person over time (research question 2). Results revealed substantial moment-to-moment variation (within-person within-days variance ranged from 42-50% of the variance, with another 9-13% at the within-person across-days level) underscoring that mindfulness mechanisms are naturally occurring states that vary. These results show that mindfulness mechanisms can be measured as momentary states, and this moment-to-moment variation in mindfulness mechanisms suggests that they may be facilitated or dulled by a variety of factors. Future research on what factors may facilitate mindfulness mechanisms may have important implications for interventions. For example, it has been previously proposed that nature can be used to enhance mindful awareness (Van Gordon et al., 2018), and a recent study found greater improvements in mental health and well-being following mindfulness training carried out in a natural outdoor environment than indoor or built environment (Choe et al., 2020). Thus, research is necessary to uncover how mindfulness mechanisms naturally develop and what factors may enhance or hinder their momentary expression. This knowledge may provide valuable insight into facilitating naturally occurring mindfulness mechanisms as well as optimizing interventions aimed at promoting them.

Next, we tested whether naturally occurring variance in mindfulness mechanisms is related to negative emotions (research question 3). Acceptance-attention, decentering, self-compassion, and nonreactivity emerged as significant predictors of negative emotions indicating their independent effects on emotional well-being. These mechanisms each independently related to negative emotions when tested separately. However, in the model with all mechanisms greater decentering was now related to higher negative emotions. This would appear to reveal a suppression effect of decentering that might require a more nuanced understanding of how decentering and distress relate (for review, see Bernstein et al., 2015). For example, although decentering has the potential to reduce negative emotions, decentering might also be used as a main coping strategy to cope with more extreme negative experiences. Or perhaps when the shared variance is taken into account, this might reveal that decentering has a "dark side" to it in that it may not actively work to address or change the negative emotions, thus allowing negative emotions to return at a later timepoint. Future work will benefit from understanding the conditions under which decentering has positive and negative associations with outcomes.

Importantly, the finding that mechanisms have independent associations with negative emotions highlights the value of testing the shared influences of mindfulness mechanisms. Although the two-way interactions were not significant, it is plausible that there is a combination of mechanisms that could have differential effects on outcomes, and that multiple types of relations could be involved in predicting the effects of

mindfulness mechanisms on emotional well-being. For example, it is possible that decentering interacts with self-regulation to produce synergistic effects. Or, mindfulness mechanisms might produce beneficial effects in a cascade sequence, with one mechanism facilitating the other mechanisms. This possibility could at least, partially account for the lack of the interaction effects between mindfulness mechanisms.

The present study was among the first attempts in the literature to assess multiple mindfulness mechanisms within a person simultaneously. We hope this work will motivate more empirical research that differentiates between different mechanisms, examines their interplay, and temporal effects to provide more complex framework of mindfulness mechanism and how they influence health and well-being. Given our research questions were focused on within-person variation, we used the factor structure at the within-person level when interpreting MLFA results. This structure lined up well with the between-person level structure for decentering, non-reactivity, and self-compassion, but only moderately well for acceptance-attention. As a result, acceptance-attention was measured less well at the person-level that increased error and likely made it more difficult to detect between-person effects. Considering this limitation of the study, future work refining how acceptance-attention is measured at both the within-person and between-person levels is needed, including testing whether a common set of items can be found that assess both levels of the construct.

The study has several limitations that reflect general concerns within mindfulness literature. Although research staff explained mindfulness mechanisms items in detail during an in-lab orientation, it possible that participants with some mindfulness background had different interpretations of these mechanisms compared to mindfulness novices. Grossman (2011) argued that self-report attempts to measure mindfulness might be influenced by one's personal meaningfulness of item characteristics. Furthermore, the author questioned whether individuals might be able to accurately rate their own level of mindfulness. Future work can address these limitations by considering alternative approaches to the measurement of mindfulness and ensuring equivalence of semantic item interpretation among groups with different levels of knowledge about mindfulness. To test the validity of the resulting mindfulness mechanisms obtained with MLFA, we correlated the resulting items with MAAS. Given the unidimensional nature of MAAS and its focus on the acting with awareness mechanism, the correlations were not high. Therefore, interpretation of these intercorrelations and their ability to assess the validity of the resulting items should be taken with caution. Future work should consider comparing these items to mindfulness scales that utilize a multidimensional approach.

In testing the relationships between mindfulness mechanisms, the study focused on acceptance, attention monitoring, decentering, self-compassion, and nonreactivity that are commonly proposed mechanisms of mindfulness training. Yet, theoretical work suggests an array of distinct mindfulness mechanisms, and many of them remain largely unexplored. Some of these mechanisms include body awareness (Hölzel et al., 2011), self-regulation and self-management (Shapiro et al., 2006), exposure (Baer, 2003; Shapiro et al., 2006), values clarification (Shapiro et al., 2006), and self-transcendence (Vago & Silbersweig, 2012). It has also been proposed that mindfulness mechanisms may facilitate each other. For example, Shapiro et al. (2006) suggested that decentering may lead to additional mechanisms including values clarification and exposure that contribute

to positive outcomes. Future work is needed to study these less studied mechanisms and how they relate to other mechanisms. Finally, given the cross-sectional nature of the study, future work needs to determine the directionality of the relationship between mindfulness mechanisms and negative emotions. It is also plausible that negative emotions can lead to a reduction in mindfulness mechanisms (e.g., acceptance, self-compassion).

Conclusion

The results indicate that mindfulness mechanisms naturally vary within person and these fluctuations relate to negative emotions. Importantly, mindfulness mechanisms do not similarly relate to the same health outcomes, and some mechanisms can even have negative effects. The results suggest that rather than focusing on a single mechanism, researchers need to develop a more comprehensive framework that describes the role of each mechanism and how they work together as a process. This work has important implications for progressing towards a precision medicine framework and developing tailored mindfulness and other interventions that target specific health outcomes.

Table 2-1

Demographics of Participants (n = 143)

Characteristic	Statistic
Age	
Range	21-65
Mean	38.20
Sex	
Female (*n*, %)	107, 74.8%
Male (*n*, %)	34, 23.8%
Missing (*n*)	2, 1.4%
Race	
White (*n*, %)	77, 53.8%
Hispanic or Latino (*n*, %)	36, 25.2%
Asian (*n*, %)	7, 4.9%
Black or African American (*n*, %)	5, 3.5%
American Indian or Alaska Native (*n*, %)	1, 0.7%
Hawaiian or Pacific Islander (*n*, %)	1, 0.7%
Mixed race (*n*, %)	11, 7.7%
Other (*n*, %)	5, 3.5%

Note. n = sample size

Table 2-2

Mindfulness Mechanisms Assessment

Mechanism	Items	Source	Reliability (R_C)
Acceptance	(1) Since the last survey, how accepting did you feel of your thoughts and feelings? (2) Since the last survey, to what extent did you feel connected to what's happening here and now without being in denial or feeling frustrated about something that is out of your control?	Bishop et al., 2004; Brown & Ryan, 2003; Lindsay & Creswell, 2017	.62
Attention monitoring	(1) Since the last survey, how much were you in tune were you with your emotions? (2) Since the last survey, how much were you paying deliberate attention to your surroundings?	Brown & Ryan, 2003; Hölzel et al., 2011	.59
Decentering	(1) Since the last survey, how much were you concerned with openly observing your experiences rather than controlling or changing them? (2) Since the last survey, how much were you able to step outside your immediate thoughts/feelings and observe them from a third-person objective?	Lau et al., 2006; Bernstein et al., 2015	.56
Self-compassion	(1) Since the last survey, how kind were you to yourself? (2) Since the last survey, how patient were you with yourself?	Neff, 2003	.84
Nonreactivity	(1) Since the last survey, how much do you think you would be able to pause without reacting to your thoughts? (2) Since the last survey, how much do you think you would be able to pause without reacting to your feelings?	Baer et al., 2006	.83

Note. Results of Multilevel Factor Analysis indicated that acceptance and attention monitoring loaded on one factor. This resulted in collapsing these two mechanisms into one, labeled as Acceptance-Attention, with $R_C = .72$.

Table 2-3

Intercorrelations Between Acceptance-Attention Monitoring, Decentering, Self-Compassion, Nonreactivity, both as Independent Mechanisms and Aggregated, and the Mindful Attention Awareness Scale (MAAS)

	M (SD)	1	2	3	4	Mechanisms Aggregated
1. Acceptance-Attention	5.86 (1.25)					
2. Decentering	4.80 (1.36)	.60***				
3. Self-Compassion	6.14 (1.50)	.73***	.30***			
4. Nonreactivity	5.78 (1.43)	.80***	.46***	.71***		
5. MAAS	3.66 (.86)	.19*	.02	.22**	24**	.20*

Note. M and SD are used to represent mean and standard deviation, respectively.
***$p < .001$; **$p < .01$; *$p < .05$; $^{+}p < .10$

Table 2-4

Multilevel Factor Analysis Results Summary

	χ^2	df	CFI/TLI	RMSEA	SRMR (between/within)
2 Factors Between					
2 within	1066.68***	52	.884/ .799	.096	.050/.082
3 within	369.56***	44	.963/ .924	.059	.027/ .076
4 within	174.04***	31	.984/ .952	.047	.005/ .076
3 Factors Between					
2 within	971.06***	44	.894/ .783	.100	.051/ .051
3 within	288.15***	36	.971/ .928	.058	.027/ .025
4 within	120.27***	29	.990/ .968	.039	.011/ .027
4 Factors Between					
2 within	889.15***	37	.902/ .763	.105	.051/ .020
3 within	212.65***	29	.979/ .935	.055	.027/ .020
4 within	56.76***	22	.996/ .984	.027	.009/ .020

Note. CFI = comparative fit index, TLI = Tucker Lewis index, RMSEA = root-mean square error of approximation, SRMR = standardized root mean square residual.

Table 2-5

Mindfulness Mechanisms and Results for Multilevel Factor Analysis

	Within-Person Level				Between-Person Level			
Items	1	2	3	4	1	2	3	4
1. Acceptance (1)	-.080	.806	.025	.027	.009	1.409	.007	-.003
2. Acceptance (2)	.040	.379	.095	.137	-.027	.121	.715	.129
3. Attention monitoring (1)	.109	.636	-.013	-.023	.396	.159	.352	.133
4. Attention monitoring (2)	.201	.474	-.010	-.018	.591	-.015	.026	.277
5. Decenter (1)	.635	-.035	.003	-.022	.997	.003	-.443	.010
6. Decenter (2)	.567	.150	.019	.071	.866	.004	.075	-.090
7. Self-compassion (1)	-.014	-.021	.950	-.031	.014	.001	-.009	1.015
8. Self-compassion (2)	.021	.046	.696	.139	.009	.017	.212	.794
9. Nonreactivity (1)	.052	.057	.127	.655	.043	.003	.916	.039
10. Nonreactivity (2)	-.024	-.026	-.027	.965	.040	-.029	1.012	-.047

Table 2-6

Unstandardized Beta Estimates (Standard Errors) for Negative Emotions with Acceptance-Attention Monitoring, Decentering, Self-Compassion, and Nonreactivity as Independent and Concurrent Predictors

	Acceptance -Attention Model	Decentering Model	Self-Compassion Model	Nonreactivity Model	All Mechanisms Model
Fixed effects					
Intercept	5.88**	3.59***	6.95***	5.93***	6.40***
	(.90)	(.98)	(.83)	(.81)	(.88)
Time	-.0004*	-.0005	-.0003^{+}	-.0003*	-.0002
	(.0001)	(.0002)	(.0001)	(.0001)	(.0001)
Day	-.20***	-.19***	.14**	-.17**	-.15**
	(.05)	(.06)	(.05)	(.05)	(.05)
Weekend	.09	- .03	.06	.05	.10
	(.14)	(.14)	(.13)	(.13)	(.12)
Age	.005	.006	-.0009	.008	.006
	(01)	(.01)	(.01)	(.01)	(.01)
Gender	.31	.10	.07	.16	.03
	(.29)	(.32)	(.26)	(.27)	(.26)
Hispanic/Latino	-.53^{+}	-.60^{+}	0.67*	-.44	-.50^{+}
	(.29)	(.33)	(.27)	(.28)	(.28)
Acceptance-Attention (momentary)	-.33***	--	--	--	-.10**
	(.03)				(.03)
Acceptance-Attention (average)	-.55***	--	--	--	.13
	(.10)				(.19)
Decentering (momentary)	--	-.10***	--	--	.06*
		(.02)			(.02)
Decentering (average)	--	-.10	--	--	.16
		(.10)			(.10)
Self-Compassion (momentary)	--	--	-.42***	--	-.29***
			(.02)		(.03)
Self-Compassion (average)	--	--	-.61***	--	-.48***
			(.07)		(.12)
Nonreactivity (momentary)	--	--	--	-.34***	- .19***
				(.02)	(.02)
Nonreactivity (average)	--	--	--	-.56***	-37**
				(.08)	(.14)
Random effects					
UN (1,1)	1.77***	2.19***	1.44***	1.57***	1.36***
	(.26)	(.31)	(.21)	(.23)	(.20)
Residual	1.19**	1.02**	1.20***	1.13***	1.18***
	(.25)	(.41)	(.19)	(.25)	(.15)
Model statistics					
AIC	6963.3	6963.3	6627.8	6702.6	6553.9
BIC	6975.0	6975.0	6639.5	6714.3	6565.6
Pseudo R^2	.18	.04	.27	.24	.31

Note. ***$p < .001$; **$p < .01$; *$p < .05$; $^{+}p < .10$

CHAPTER 3: MINDFULNESS INTERVENTION AS A DYNAMIC PROCESS: EXAMINING HOW MINDFULNESS MECHANISMS DEVELOP OVER THE COURSE OF AN 8-WEEK SMARTPHONE APP-BASED MINDFULNESS INTERVENTION

Mindfulness interventions teach practitioners to cultivate deliberate and nonanalytic awareness of moment-to-moment experience (Kabat-Zinn, 1994). These interventions have been linked to a broad range of positive effects (for review, see Khoury et al., 2013). In explaining these effects, researchers proposed that mindfulness interventions work by promoting an array of adaptive mental states, including acceptance, attention monitoring, decentering, self-compassion, and nonreactivity - herein, called mindfulness mechanisms. Yet, there is no agreed upon unifying theoretical framework of how mindfulness interventions change these mechanisms (Alsubaie et al., 2017). Moreover, much of what is currently known about the effects of mindfulness interventions on mindfulness mechanisms comes from studies assessing these changes at pre- and post-treatment (e.g., Josefsson et al., 2014; Shapiro et al., 2005) that provide limited insights into how mindfulness mechanisms develop over the course of a mindfulness intervention. Given that mindfulness mechanisms represent distinct skills, it is plausible that they develop at different time points during the intervention (Baer et al., 2012). Establishing the sequence with which mindfulness mechanisms change can allow researchers to have tools to detect if the intervention is working. Thus, the goal of the study is to investigate how mindfulness mechanisms change over the course of an 8-week app-based mindfulness intervention.

Mindfulness Mechanisms

Mindfulness interventions can influence an array of mindfulness mechanisms including acceptance, attention monitoring, decentering, self-compassion, and nonreactivity. *Acceptance* is commonly defined as the ability to observe experiences with an attitude of non-judgment and openness (Kabat-Zinn, 1990). *Attention monitoring* involves ongoing awareness of one's present moment sensory and perceptual experiences (Hölzel et al., 2011; Lindsay & Creswell, 2017; Shapiro et al., 2006). Theoretical work and empirical evidence provide support that attention monitoring and acceptance should be considered in tandem, as the combination of both attention monitoring and acceptance skills contributes to beneficial health and well-being outcomes (e.g., Chin et al., 2019; Gavrilova & Zawadzki, 2021; Lindsay & Creswell, 2017). *Decentering* is defined as the ability to reflect on negative experiences from a self-distanced, rather than self-immersed perspective (Shapiro et al., 2006). *Self-compassion* involves treating oneself with the same kindness and patience as one would treat a friend in the same situation (Neff, 2003). *Nonreactivity* has been conceptualized as the ability to approach stressful situations without reacting to them and acting in automatic habitual patterns (Bishop, 2002; Kabat-Zinn, 1994).

Change in Mindfulness Mechanisms over the Course of a Mindfulness Intervention

Despite growing work suggesting that mindfulness interventions bring about changes in the proposed mechanisms (Gu et al., 2015; van der Velden et al., 2015; Alsubaie et al., 2017), there is a lack of methodological rigor in this area of research that

precludes conclusions (Alsubaie et al., 2017). Moreover, much of this work has predominantly focused on pre-and post-treatment changes (Josefsson et al., 2014; Shapiro et al., 2005) that limit an understanding of the pattern of change over the course of the intervention. As one exception, Lu and colleagues (2021) investigated the week-to-week development of state mindfulness over the course of an 8-week app-based mindfulness intervention. Researchers found a relatively strong linear increase in state mindfulness, but with a lower rate of increase toward the end of the program. In another study, Baer and colleagues (2012) explored weekly change in a variety of mindfulness mechanisms and perceived stress in participants who completed an 8-week course in the mindfulness-based stress reduction (MBSR) program (Kabat-Zinn, 1982; Kabat-Zinn & Hanh, 2009). Results showed that early change in mindfulness over the first three weeks predicted change in perceived stress over the rest of the intervention. Related to specific mindfulness mechanisms, the magnitude of change was largest for the nonreactivity mechanism; nonreactivity was notably lower than the other mechanisms (i.e., nonjudge, describe, observe, act with awareness) at week 1 and showed a large improvement following week 2. Findings from these studies suggest that mindfulness mechanisms do not change at the same rate over the course of the intervention period. As such, more research is needed to better understand this rate of change in mindfulness mechanisms, as it might predict the extent of improvement in outcomes. The first goal of the study is to assess at what point in the mindfulness intervention mindfulness mechanisms begin to improve.

Another important issue concerning mindfulness interventions in general is that the literature reports varying lengths of intervention required to observe beneficial effects. The scientific community has often focused on MBSR and other 8-12-week mindfulness-based interventions (Creswell, 2017). These programs are designed to be an intensive training experience requiring significant time demands. The standard 8-week MBSR format requires 32 hours of class hours in addition to 30-45 minutes per day for home practice (Carmody & Baer, 2009). Although this training has been shown to be effective in improving a broad range of outcomes (for review, see Creswell, 2017), the time commitment is often reported as a primary reason for potential participants to decline to participate in MBSR (Carmody & Baer, 2009). Yet, research on how long a mindfulness intervention has to be for it to produce beneficial effects has produced mixed findings. For example, studies showed significant improvements in mindfulness mechanisms after completing six sessions (e.g., Duarte & Pinto-Gouveia, 2016) and as few as three sessions (Beaumont et al., 2016). Strikingly, some work even suggests the lack of a dose-response relationship between the length of the mindfulness intervention and psychological benefits (Carmody & Baer, 2009). If mindfulness programs with lower time demands produce similar improvements in mindfulness mechanisms, the length of the mindfulness intervention might be modified to make mindfulness interventions more accessible and sustainable. Thus, the second goal of the present study was to investigate whether changes in mindfulness mechanisms following mindfulness intervention compound over the course of the intervention.

Measuring Mindfulness Mechanisms in Everyday Life

A complementary approach to measuring mindfulness mechanisms in a pre- and post-treatment cross-sectional format is using repeated measures of mindfulness

mechanisms to track how they change during treatment. Ecological momentary assessment (EMA) involves repeated sampling of real-time data of participants' current experiences and behaviors in their naturalistic environment (Shiffman et al., 2008; Smyth & Stone, 2003). Studies have shown that EMA could have a greater sensitivity to change and increase the precision of detecting intervention effects, particularly to understanding mindfulness mechanisms as dynamic and complex developmental processes over time (Shoham et al., 2017). Furthermore, repeated measurements can be aggregated across multiple time points throughout the intervention to characterize the participant's average state. One major advantage of this approach is that the aggregate-level values contain multiple measurements and are more reliable than assessments at a single time.

Smartphone App-Based Mindfulness Intervention

Most mindfulness interventions rely on traditional in-person format. Yet, approximately 81% of US adults report having a smartphone (Silver et al., 2019), and there is growing interest in mindfulness interventions delivered via digital tools. Some potential advantages of app-based mindfulness interventions include wider availability, anonymity, accessibility at any time or place, standardization of intervention instruction, and personalization of content (Mrazek et al., 2019). Given that the preference for digital psychotherapeutic interventions continues to grow (Renn et al., 2019), app-based mindfulness training may represent a promising intervention alternative to traditional in-person training. Although evidence on the benefits of app-based mindfulness training is growing and some studies found benefits comparable to traditional delivery methods on outcomes of subjective well-being and mental health outcomes (e.g., Howells et al., 2016), research on the effects of app-based mindfulness training on mindfulness mechanisms is still in a nascent stage. A recent meta-analysis showed some promising results with respect to the mindfulness mechanisms of acceptance and self-compassion. The study demonstrated that these mechanisms can indeed be improved through smartphone apps (Linardon, 2020). Thus, the present study makes an important contribution to the limited work on the effects of app-based mindfulness training on mindfulness mechanisms.

The Present Study

The present study examined the effects of an 8-week app-based mindfulness intervention on the mindfulness mechanisms of acceptance, attention monitoring, decentering, self-compassion, and nonreactivity. Research Question 1 investigated when during the intervention period mindfulness mechanisms improved, examining potential changes from week 0 (i.e., baseline) to week 2, week 5, and week 8. Consistent with previous work (Baer et al., 2012), we hypothesized that the mechanisms of acceptance and attention monitoring would be the first to change followed by improvements in decentering and nonreactivity. Given that self-compassion is a more specialized skill that is not explicitly taught in mindfulness interventions, we expected improvements in self-compassion to occur at the end of the intervention. Research Question 2 assessed whether these changes compound over the course of the intervention. We hypothesized that mindfulness mechanisms would compound in a linear fashion.

Method

Participants

The study was conducted at a public university in Central California. In order to participate, participants had to be non-student and non-faculty employees at the university. Participants were recruited through university emails and flyers to participate in the study testing the effects of mindfulness training on workplace stress. As compensation, participants received a free one-year subscription to Headspace. For each weekly survey (week 0, 2, 5, and 8), participants received $15. Additionally, participants could receive up to $20 bonus for a high completion rate (i.e., over 80% surveys completed) across the study. Other compensation was included for parts not relevant for the current study. Interested participants completed an online survey related to eligibility criteria. Inclusion criteria were having access to a smartphone with internet access every day, being fluent in English, being an employee of the university where the study was conducted, and being at least of 18 years of age. Participants who were experienced meditators, defined as having participated in a sitting meditation practice more than twice a week (for 10 minutes or greater) over the last three months, were excluded to ensure that participants did not differ in dispositional mindfulness prior to the intervention.

Materials

Baseline Measures

During baseline, participants first completed demographic information about their age, gender (coded as 0 = male, 1 = female), and ethnicity (coded as 0 = non-Hispanic/Latino, 1 = Hispanic/Latino), and other measures not relevant to the present study.

Mindfulness Mechanisms Assessment

To assess mindfulness mechanisms at the state level, we utilized items from commonly used scales (e.g., Bishop et al., 2004; Brown & Ryan, 2003; Hölzel et al., 2011; Neff, 2003), similar to prior work (e.g., Blanke & Brose, 2017). For example, nonreactivity items were drawn from the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006), while the self-compassion items were formulated in line with Neff's (2003) conceptualization of self-compassion as being kind and patient towards oneself. The factor structure of these items was validated in previous work (Gavrilova & Zawadzki, 2021) showing that attention monitoring and acceptance loaded on one factor resulting in four distinct mechanisms – acceptance-attention, decentering, self-compassion, and nonreactivity. Drawing from experience sampling methodology studies (e.g., Moore et al., 2016; Roesch et al., 2010), each mindfulness mechanism was assessed using two items. All items were asked on a sliding scale from 0 (*not at all*) to 10 (*extremely*) and started with a common question stem "Since the last survey, ...?" As an example, one of the items assessing acceptance read, "Since the last survey, how accepting did you feel of your thoughts and feelings?" For attention monitoring, one of the items read "Since the last survey, how much were you paying deliberate attention to your surroundings?" For decentering, one of the items read "Since the last survey, how much were you concerned with openly observing your experiences rather than controlling or changing them?" Lastly, one of the self-compassion items read "Since the last survey, how kind were you to yourself?" The scales demonstrated moderate to high reliability to detect within-subject differences in change over time at all four time points, R_C = .56 - .89

(Bolger & Laurenceau, 2013). One exception to this was lower reliability for decentering at week 8, $R_C = .24$.

Mindfulness Intervention

The intervention was delivered through a commercially available mindfulness meditation app (Headspace; https://www.headspace.com) that has been widely used in previous intervention studies (e.g., Flett et al., 2020). Headspace provides a variety of formal guided and unguided meditation practices, with the content of training built on well-established concepts and practices within the mindfulness literature (Kabat-Zinn et al., 1992). Instructions are delivered through short animated videos and sound files. Headspace is available as an iOS, Android, and web app.

Participants were instructed to use the app to meditate for 10 minutes a day for 8 weeks. Intervention group was instructed to start meditating using the Basics pack. This pack is designed as an introduction to mindfulness meditation and can be used as an opportunity for participants to get familiar with the Headspace teaching style. It presents the concept of mindfulness and encourages one to pay attention to breathing and notice patterns of mind-wandering and thoughts. Once participants completed Basics 1, 2, and 3 (10 days each), they were instructed to move on to the Stress pack. The Stress pack lasted for 30 sessions, about 10 minutes each. This pack was more specialized; it combined visualization and body scanning to help users learn to accept their emotions and pay close attention to the present moment.

Procedure

The study was registered on clinicaltrials.gov (NCT03652168). Individuals interested in the study logged on to a secure website and read information about the study. Those interested in taking part in the study, were prompted to complete a screening survey relevant to the inclusion and exclusion criteria. Eligible participants who consented to participate in the study received a link to the baseline questionnaire battery via Qualtrics related to demographics and other surveys relevant to the main study.

Following the baseline survey, participants attended one 60-minute in-lab orientation (in groups of up to four) on campus between October 2018 to May 2019. During the orientation, participants received training on how to download and use an application Lifedata (RealLife Exp, Life Data Corporation, Marion, IN) on their smartphone that served as a platform for EMA surveys. Surveys were programmed to appear on participants' smartphone at random times within specified time windows – 8:00am-10:00am, 10:30am-12:00pm, 1:00pm-3:00pm, 3:30pm-5:30pm, 6:00pm-8:00pm – five times a day for 4 consecutive days. All EMAs were completed from Wednesday through Saturday to standardize the comparison days across participants. Research staff guided participants through each question in a sample survey and allowed participants to practice answering questions. At the end of the in-lab session, each participant received a printed user guide that described each EMA question, the frequency of the surveys, and relevant information about the study, and provided FAQs concerning LifeData and researcher contact information. For the mindfulness mechanisms data, at week 0 we had up to 2066 assessments ($M = 15.6$ per person), 1844 at week 2 ($M = 14.9$), 1424 at week 5 ($M = 13.8$), and 993 at week 8 ($M = 13.1$). After week 0, participants were randomly assigned into either the Headspace intervention or waitlist control group using a 2:1 allocation ratio. Participants in the intervention group were sent a personalized email with

download instructions for the app and a code granting them a 12-month access to Headspace. Participants were instructed to use the app to meditate for 10 minutes a day for 8 weeks. After using the Basics pack for 30 days, participants moved on to the Stress pack that lasted for 30 sessions. Participants in the intervention group were tracked for downloading and using the app, with participants' objective data being provided by Headspace. If participants did not download and/or use the app, they received text messages reminding them to download and use the app. Participants in the waitlist control group received access to the Headspace app after 4 months. They were also asked not to participate in any mindfulness activities (e.g., yoga, meditation) during this time.

Analytic Plan

Chi-square and *t*-tests were used to examine group difference in baseline demographic characteristics and mindfulness mechanisms. In line with best practices, intervention effects on mindfulness mechanisms were examined using both an intention-to-treat (ITT) and complete-case analysis (Altman, 2009). For both approaches, hierarchical mixed effect modeling was used to test whether the intervention improved mindfulness mechanisms across week 0, week 2, week 5, and week 8. Although multiple imputation is often used to handle missing data in intervention research, we did not use this method for several reasons. Firstly, multiple imputation assumes that the missing data are missing at random (Rubin, 2004). However, it has been previously argued that in the context of a randomized clinical trial this assumption is very restrictive, often untenable, and can hardly be verified empirically using the observed data (Cornelisz et al., 2020). Instead, it is most appropriate to assume that the missing data are missing not at random that may result in analyses based on multiple imputation to be biased and misleading. Next, the study had considerable attrition rates between week 0 and week 8 assessment (30.63% mindfulness mechanisms data missing), and the presence of scant information makes it difficult to produce strong reliable imputations. Therefore, if considerable proportions of data are missing on important variables, multiple imputation should not be used (Jakobsen et al., 2017). Finally, research has indeed demonstrated that in the context of growth models, maximum likelihood method yields trustworthy estimates, and imputation might be a less serviceable choice compared to direct likelihood (McNeish, 2018). Considering these issues, all analyses in the present study were conducted in SAS 9.4 using the PROC MIXED procedure with restricted maximum likelihood. Rather than imputing missing data, this approach uses available data to calculate maximum likelihood estimates.

Data had a hierarchical structure with weeks (i.e, weeks 0, 2, 5, 8; Level 1) nested within participants (Level 2). A single weekly score for each mechanism was calculated for every participant during week 0, week 2, week 5, and week 8 as the average of all measurements for that week. Participants could have up to 20 observations at each week. In order to ensure measurement for each week was reliable, participants had to have at least 5 observations for that week. Data for participants who had less than 5 observations was set to missing. We used psuedo r-squared as our effect size index. Age, gender, and ethnicity (0 = non-Hispanic/Latino, and 1 = Hispanic/Latino) were included as control variables. Week (0, 2, 5, 8) and study condition (coded as 0 = waitlist control group, 1 = intervention group) and the interaction between these terms were entered as predictors in

the study. Random intercepts were included to account for individual differences in mindfulness mechanisms at baseline.

Research Question 1 examined at what point in the intervention mindfulness mechanisms begin to improve. To answer this research question, week 2, 5, 8 were entered as categorical variables, with week 0 as the comparison group. With this coding we tested whether mindfulness mechanisms at weeks 2, 5, 8 were significantly different from week 0. Research Question 2 examined whether there were linear improvements in mindfulness mechanisms during the intervention. In these models, the week variable was used as a continuous variable, indicating the number of weeks that have elapsed from the start of the intervention. Follow-up analyses tested whether the effects of time showed a quadratic (non-linear) trend. Week was entered both as a linear and quadratic term, with both week terms interacting with condition.

For the complete case analysis, participants who completed the outcome measures at least at week 0 and week 8 assessment points were included.

Results

Participant Enrollment

A total of 291 employees were screened for eligibility, 271 were eligible and 20 were excluded from the study. Of the 271 eligible participants, 186 people provided consent. Before the study began, 43 participants dropped out from the study. A total of 143 participants were randomized. Data for 11 participants excluded from the subsequent analyses: 6 participants dropped out from the study after randomization, and 5 participants had all mechanisms data as missing (after data for participants who had less than 5 observations was set to missing). Numbers of participants at each stage of the trial are illustrated in Figure 3-1. At week 0, our sample consisted of 132 participants, with 92 (69.7%) participants randomized into the Headspace group and 40 (30.3%) into the waitlist control group. At week 2, 84 (91.3%) of participants in the Headspace group and 39 (97.5%) of the control group completed EMA survey. At week 5, 66 (71.7%) of participants in the Headspace group and 36 (90%) of the control group completed EMA survey. At week 8, 50 (54.3%) of participants in the Headspace group and 25 (62.5%) of the control group completed EMA survey.

Descriptive Statistics and Baseline Equivalence

Participants (n = 132) were between the ages of 21 and 65 (M = 38.5, SD = 11.1) and self-identified as primarily White and Hispanic/Latino females (76.5% female; 54.5% White, 22.0% Hispanic/Latino). Table 3-1 shows baseline characteristics of the sample for both groups. There were no differences between the intervention and control group on gender and race/ethnicity (chi-square tests, all ps > .153). Participants in the intervention group were significantly younger than those in the control group (t-test, p = .037). Groups did not differ on mindfulness mechanism scores at baseline (two-sample t-tests, all ps > .159). Table 3-2 presents descriptive statistics for mindfulness mechanisms at all four time points for the intervention group and the waitlist control group.

Intention-to-Treat Analysis

Research Question 1 tested whether mindfulness mechanisms improved from week 0 to week 2, week 5, and week 8. As Table 3-3 shows, hierarchical mixed effects analysis revealed that acceptance-attention increased from week 0 to week 2 (p = .044), week 0 to week 5 (p = .016), and week 0 to week 8 (p = .023) in the mindfulness group.

Decentering revealed marginal increase at week 2 (p = .056), week 5 (p = .083), and week 8 (p = .063) compared to week 0. No significant changes were observed in self-compassion over the course of the intervention (ps >.094). Nonreactivity increased significantly from week 0 to week 2 (p = .022), week 0 to week 5 (p = .005), and week 0 to week 8 (p = .027). For the control group, no significant effects were observed for acceptance-attention (ps > .352). Surprisingly, a significant increase was observed for decentering in the control group from week 0 to week 8 (p = .029), but not from week 0 to week 2 and week 5 (ps > .124). No significant effects were found in the control group for self-compassion (ps > .543) and nonreactivity (ps > .668).

Research Question 2 tested linear effects of the intervention on mindfulness mechanism. As Table 3-4 shows, tests of linear effects revealed that the mechanisms of acceptance-attention (p = .013) and nonreactivity (p = .010) increased steadily in a linear trend in the mindfulness group. Decentering revealed marginal linear effects (p = .058). No significant linear effects were observed for self-compassion (p = .198). For the control group, no significant linear effects were observed for acceptance-attention, self-compassion, or nonreactivity (ps > .718). However, decentering exhibited a significant linear trend (p = .013).

Follow-up analyses revealed no significant quadratic effects of time (i.e., week) on any of the mindfulness mechanisms in the intervention group (ps > .142). For the control group, no significant quadratic effect was found for acceptance-attention (p = .211), self-compassion (p = .613), and nonreactivity (p = .108). A significant quadratic effect was observed for decentering (p < .001) for the control group.

Complete Case Analysis

Participants who completed week 8 of the study were comparable to non-completers on baseline characteristics, except for Hispanic/Latino participants being more likely to complete week 8 of the study compared to non-Hispanic/Latino participants (chi-square test, p = .019). In testing whether mindfulness mechanisms improved from week 0 to week 2, week 5, and week 8 (Research Question 1), complete case analysis revealed a somewhat similar pattern of results considering that there were fewer participants than in the ITT analyses. Acceptance-attention did not significantly increase from week 0 to week 2 (p = .114) in the intervention group. Acceptance-attention showed significant increases from week 0 to week 5 (p = .034) and a marginal effect from week 0 to week 8 (p = .051). Decentering revealed marginal effects only at week 2 (p = .086), but not weeks 5 and 8 (ps > .128), compared to week 0. No significant increases were observed in self-compassion (ps > .487). No significant improvements were observed in nonreactivity from week 0 to week 2 (p = .190). However, nonreactivity revealed marginal effects at week 5 (p = .061) and week 8 (p = .085) compared to week 0. For the control group, no significant effects were found for acceptance-attention (ps > .581). Similar to the results of the intention-to-treat analysis, a significant increase was observed for decentering in the control group from week 0 to week 8 (p = .035), but not from week 0 to week 2 and week 0 to week 5 (ps > .141). No significant effects were found in the control group for self-compassion (ps > .358) and nonreactivity (ps > .299).

Tests of linear effects (Research Question 2) revealed a marginal linear effect for acceptance-attention (p = .058). No significant linear effect was observed for decentering (p = .223), self-compassion (p = .666), and nonreactivity (p = .095). For the control

group, no significant linear effects were observed for acceptance-attention, self-compassion, or nonreactivity (*p*s > .466). Follow-up analyses revealed no significant quadratic term for any of the mindfulness mechanisms in the intervention group (*p*s > .374). For the control group, no significant quadratic effect was found for acceptance-attention ($p = .100$) and self-compassion ($p = .265$). A significant quadratic effect was observed for decentering ($p < .001$), with a marginal quadratic effect for nonreactivity ($p = .082$).

Discussion

The goal of the study was to investigate how mindfulness mechanisms develop over the course of an 8-week app-based mindfulness intervention. Considering high attrition rates common to mindfulness intervention studies (Nam & Toneatto, 2016), the discussion will focus first on the ITT results which were the most powered results. We will return to complete case analysis results as well as the issue of attrition later in the discussion.

First, the study examined at what point in the intervention mindfulness mechanisms begin to improve. Results indicated that improvements in the mechanisms of acceptance-attention, decentering, and nonreactivity occurred after two weeks of the intervention. Results for decentering were less reliable with only marginal effects observed. Our findings are in line with Baer et al. (2012) who also observed significant increases in general tendency to be mindful as well as the mindfulness mechanisms of observing (similar to attention monitoring) and nonreactivity by the second week of the intervention. Taken together, these findings suggest that acceptance-attention, decentering, and nonreactivity develop at a similar rate, and that these mechanisms improve early in intervention. Therefore, lack of improvements in these mindfulness mechanisms in the first few weeks of intervention might indicate that intervention is not working as expected. Tracking these early changes in mindfulness mechanisms might be especially important considering previous work suggesting that early changes in mindfulness mechanisms predict changes in well-being outcomes over the course of intervention (Baer et al., 2012). Moreover, findings of this study have important implications regarding the length of mindfulness training suggesting that 2 weeks is sufficient to detect significant benefits. Given that time demands of the standard 8-week MBSR program is the primary reason to decline participation (Carmody & Baer, 2009), a shorter format might lead to greater participation in mindfulness interventions for populations for whom a longer time commitment might be a barrier their ability or willingness to participate.

Next, we examined whether the effects of mindfulness training on mindfulness mechanisms compound over the course of the intervention. We found that the mindfulness mechanisms of acceptance-attention, decentering, and nonreactivity improved steadily over the course of the intervention, with marginal effects for decentering. This pattern of change is consistent with the finding of Lu et al. (2021) who found a strong overall linear effect on state mindfulness, with a lower rate of increase in mindfulness toward the end of the program. Similarly, Shoham and colleagues (2017) found that levels of mindfulness and decentering increased continuously in a linear trend over the course of 3-weeks of mindfulness training. These findings provide strong evidence that there is additional benefit to longer programs beyond early effects that

might be observed within the first few weeks of training. Therefore, the 8-week format may be worthwhile for populations who are able to commit to the length of the program. It is possible that longer intervention allows participants to better grasp the principles of mindfulness and provide more opportunities to apply the principles learned to their everyday life, thus leading to further improvements in these mindfulness mechanisms.

Implications of Headspace on Specific Mindfulness Mechanisms

Related to changes in specific mindfulness mechanisms, significant improvements in acceptance-attention and nonreactivity are in line with our predictions. Inherent in mindfulness training is an emphasis on continually bringing attention to the present moment and relating to this experience with a curious, open, accepting stance (Bishop et al., 2004; Kabat-Zinn, 1994). When unpleasant or difficult experiences arise, students are encouraged to approach these experiences with a gentle curiosity and acceptance, rather than judging, suppressing, or pushing them away. The findings are also in line with previous studies that found that participating in mindfulness intervention leads to increases in both acceptance and attention monitoring (e.g., for review, see Chiesa et al., 2011; Yang et al., 2019). Similarly, we expected to observe significant improvements in nonreactivity observed in the intervention group. During mindfulness practice, practitioners are taught to allow thoughts and feelings come and go without reacting to them. This way, mindfulness practice teaches practitioners to cultivate healthier and adaptive ways of responding to stress and exploring present experiences nonreactively (Kabat-Zinn et al., 1992). Therefore, a systematic retraining of nonreactivity is considered a common process across mindfulness-based interventions (Chambers et al., 2009).

For decentering, only marginal effects were observed suggesting generally smaller effect sizes for changing decentering. Decentering has been described as a fundamental shift in perspective (Shapiro et al., 2006) and “an undoing of the automatic processes that control perception and cognition” (Deikman, 1982, p. 137). As such, it is possible that decentering is a complex skill that takes longer to cultivate, and a longer intervention (or assessment period than was done in this study) is needed to further advance the ability to decenter. We also agree with other authors who argue the lack of significant decentering effects is a question of what type of meditation exercises are practiced during mindfulness training (Josefsson et al., 2014). Mikulas (2011) makes a strong argument for mindfulness being often conceptualized in terms of relaxation and or/stress reduction in the Western world. As such, mindfulness training emphasizes concentration-based meditation to help focus and calm the mind. In contrast, Buddhist meditation is more of an insight-oriented practice that emphasizes the cultivation of intuitive wisdom. Although many meditation practices involve some combination of concentration and insight meditation, given that concentration meditation is intended for stress reduction it is plausible that mindfulness training for stress reduction focuses more on concentration than insight. One important implication behind this distinction is that it has been proposed that insight-oriented practices activate the decentering mechanism to a greater extent (Josefsson et al., 2014). Therefore, it is possible that marginal decentering effects were due to a more concentration based focus of the intervention.

Contrary to our predictions, no significant changes in self-compassion were observed. We propose several possible reasons for the absence of self-compassion

effects. First, although some evidence suggests that mindfulness-based interventions can increase self-compassion (for review, see Golden et al., 2020), these interventions devote relatively little time explicitly teaching self-compassion (Neff & Germer, 2013). Instead, self-compassion is taught implicitly as an attitudinal foundation of mindfulness practice; it is mainly conveyed in the way the instructor relates to the participants and in the way participants are encouraged to relate to their experiences (Neff & Dahm, 2015). Therefore, conveying self-compassion implicitly might not be sufficient to elicit changes, and more targeted interventions are needed. Indeed, results from two systematic reviews suggest that although mindfulness-based interventions and compassion-based programs may both increase self-compassion, there is a trend towards compassion-added programs showing greater increases in self-compassion (Golden et al., 2020; Møller et al., 2019). Thus, the fact that mindfulness intervention in the present study did not include a specific session on self-compassion may partially explain no significant improvements in self-compassion. Another possible explanation to our finding is that self-compassion may take longer to develop. Pidgeon and colleagues (2014) tested the effectiveness of a brief retreat-based mindfulness program targeting mindfulness and self-compassion for increasing resilience in human services professionals. Researchers found no significant differences between the intervention and control groups following the intervention. However, significant improvements in self-compassion were observed over time at one and four months. Authors explain their findings by suggesting that participants require time to practice and apply the skills learned before benefits can be observed. Given that mindfulness is a prerequisite to self-compassion (Neff & Germer, 2013), it is possible that self-compassion develops later, and a longer study is necessary to track such changes.

Implications for Future Research

The study contributes to the growing literature on the effects of app-based interventions on mindfulness mechanisms. Although evidence demonstrates the benefits of mindfulness mechanisms on well-being (e.g., Neff & Germer, 2013), most interventions teaching these skills are conducted in-person which can limit their dissemination (Kazdin, 2017). Findings of our study demonstrate that app-based mindfulness interventions can effectively teach the mindfulness mechanisms of acceptance-attention and nonreactivity. Therefore, smartphone apps represent an inexpensive, easily accessible, and effective alternative to teaching mindfulness mechanisms for people who cannot access traditional in-person training.

Another important implication of the study is that it demonstrates the value of mindfulness in the workplace. Although the benefits of mindfulness on well-being have been well documented and there has been a dramatic increase in the use of mindfulness training to improve workplace functioning, research evaluating the beneficial effects of mindfulness interventions in the workplace is still limited (for review, see Jamieson & Tuckey, 2017). To date, there have been very few rigorously designed studies examining the effects of mindfulness intervention in a sample of employees, and mindfulness in work settings remains an emerging area of research that needs more research (Good et al. 2016). Therefore, the results of the study add to a small body of empirical evidence demonstrating that mindfulness intervention can improve the mindfulness mechanisms of acceptance-attention and nonreactivity. In the context of work, these mechanisms are

thought to facilitate beneficial workplace outcomes. Good et al. (2016) highlighted attention monitoring as a key mechanism that improves attentional stability, control, and efficiency, which in turn lead to better employee performance, relationships, and well-being. Additionally, authors posit that reduced emotional reactivity (similar to nonreactivity) may lead to less intense emotional reactions to negative feedback and quicker recovery from negative emotions.

As is common with most app-based mindfulness studies, the present study utilized an inactive control group (i.e., waitlist). Lack of active control groups has been previously discussed as a methodological limitation in meditation research (Davidson & Kaszniak, 2015), as it does not allow to account for non-specific effects of intervention (e.g., confidence that intervention will be beneficial). However, it is often challenging to identify appropriate control groups for mind-body interventions delivered using a smartphone app that are structurally equivalent (Flett et al., 2020). Given this limitation, future work will need to develop and test appropriate control groups as they attempt to replicate and extend these results.

The issue of attrition needs to be considered when interpreting the results. The participant attrition rate from pre- to post-intervention was 56.8% (75/132), which is comparable with the dropout rates of other studies using digital mental health interventions (Doherty et al., 2012). High attrition rates have been a significant concern for digital interventions, as attrition undermines the potential of interventions to be effective. It is plausible that intensive longitudinal design of the study contributed to increased attrition. Although this powerful design allowed for granularity of measurement, it added significant burden perhaps leading to dropout. This might also explain a slightly higher attrition in the experimental group, given that participants in this group had a larger participant burden. Despite somewhat high attrition, we were still able to detect effects, with complete case analyses revealing a similar pattern of results compared to ITT. This demonstrates that the results were robust across both complete case and ITT analyses.

Mindfulness mechanisms in the study were not tracked beyond 8 weeks. Therefore, the long-term effects of the intervention on mindfulness mechanisms are unknown. It is plausible that the beneficial effects of the intervention on the mechanisms continued compounding, or the effects began to taper off post-intervention. Future work should consider a longer study to test at what point in the intervention these benefits start to taper off to better understand how long the intervention should be until its beneficial effects diminish.

Although the present study investigated the effects of mindfulness intervention on mindfulness mechanism, we did not assess how changes in mindfulness mechanisms relate to health outcomes over the course of the intervention. It has been previously argued that studies of mechanisms are more convincing when they establish that change in mindfulness mechanisms predicts changes in the outcomes of interest over the course of intervention (Baer et al., 2012; Kraemer et al., 2002). Baer et al. (2012) conducted the first study showing that extent of change in mindfulness mechanisms during the first three weeks predicted change in perceived stress over the course of the intervention. Findings like this provide important evidence that improvement in mindfulness mechanisms early in treatment predicts extent of overall improvements in the outcome

variables. More work assessing change in mindfulness mechanisms and the outcomes variables over the course of treatment is needed, as this evidence facilitates more conclusive investigation of the mechanistic role of these mindfulness mechanisms in mindfulness interventions.

Conclusions

Two weeks is sufficient to detect significant improvements in the mindfulness mechanisms of acceptance-attention and nonreactivity, with marginal effects for decentering. These effects also compounded linearly over time. Therefore, a longer intervention format can lead to greater improvements in mindfulness mechanisms compared to shorter programs. The study demonstrates that app-based mindfulness interventions can effectively teach mindfulness mechanisms and smartphone apps can provide a suitable alternative for people who cannot access traditional in-person mindfulness interventions.

Table 3-1

Demographics of Participants (n = 132)

Characteristic	Intervention group (*n* =92)	Waitlist control group (*n* =40)
Age		
Range	21-63	22-65
M (SD)	37.2 (11.0)	41.6 (10.8)
Sex		
Female (*n*, %)	71, 77%	30, 75%
Male (*n*, %)	21, 23%	10, 25%
Missing (*n*, %)		
Race		
White (*n*, %)	48, 52.1%	24, 60%
Hispanic or Latino (*n*, %)	23, 25%	6, 15%
Asian (*n*, %)	4, 4.3%	3, 7.5%
Black/African American (*n*, %)	2, 2.2%	1, 2.5%
American Indian/Alaska Native (*n*, %)	0	1, 2.5%
Hawaiian/Pacific Islander (*n*, %)	0	1, 2.5%
Mixed race (*n*, %)	10, 10.9%	2, 5%
Other (*n*, %)	2, 2.2%	2, 5%
Missing (*n*, %)	3, 3.3%	0

Note. M (SD) = mean (standard deviation); n = sample size

Table 3-2

Means and SDs for Mindfulness Mechanisms at Week 0, 2, 5, 8 (n=132)

	Acceptance-Attention	Decentering	Self-Compassion	Nonreactivity
		Headspace		
Week 0	5.85 (1.25)	4.71 (1.32)	6.25 (1.53)	5.72 (1.49)
Week 2	6.13 (1.51)	5.26 (1.66)	6.53 (1.62)	6.15 (1.56)
Week 5	6.41 (1.56)	5.76 (1.76)	6.60 (1.49)	6.41 (1.60)
Week 8	6.48 (1.65)	6.11 (1.66)	6.43 (1.77)	6.33 (1.73)
		Control		
Week 0	6.07 (1.33)	5.08 (1.42)	6.24 (1.42)	6.08 (1.43)
Week 2	5.93 (1.24)	5.10 (1.19)	6.08 (1.24)	5.96 (1.25)
Week 5	6.04 (1.21)	5.42 (1.20)	6.12 (1.35)	6.12 (1.19)
Week 8	5.97 (1.28)	5.49 (1.59)	6.17 (1.50)	5.98 (1.29)

Note. SD = standard deviation; n = sample size

Table 3-3

Parameter Estimates (Standard Errors) for Mindfulness Mechanisms with Headspace, Week, and the Interaction Between Headspace and Week as Predictors

	Acceptance-Attention	Decentering	Self-Compassion	Nonreactivity
Fixed effects				
Intercept	5.80***	5.88***	6.55***	5.83***
	(.56)	(.59)	(.61)	(.60)
Hispanic/Latino	.30	-.40	.001	.30
	(.28)	(.29)	(.30)	(.30)
Age	.01	- .02	- .002	.01
	(.01)	(.01)	(.01)	(.01)
Female	.04	- .07	- .23	- .001
	(.27)	(.28)	(.29)	(.29)
Headspace	- .31	- .43	- .03	- .45
	(.28)	(.30)	(.30)	(.30)
Week 2	- .16	.04	- .08	- .08
	(.17)	(.21)	(.18)	(.18)
Week 5	- .04	.34	- .12	- .01
	(.18)	(.22)	(.20)	(.19)
Week 8	-.001	.52^{+}	- .06	- .04
	(.20)	(.24)	(.21)	(.21)
Headspace*Week2	.41*	.47^{+}	.31	.50*
	(.20)	(.25)	(.22)	(.22)
Headspace*Week5	.54*	.46^{+}	.40^{+}	.66**
	(.22)	(.27)	(.24)	(.23)
Headspace*Week8	.56*	.55^{+}	.28	.57*
	(.24)	(.30)	(.26)	(.26)
Random effects				
UN (1,1)	1.51***	1.56***	1.75***	1.75***
	(.21)	(.23)	(.25)	(.25)
Residual	.48***	.70***	.55***	.53***
	(.04)	(.06)	(.05)	(.05)
Model statistics				
AIC	1122.6	1225.3	1176.9	1166.8
BIC	1128.4	1231.1	1182.7	1172.6
Pseudo R^2	.02	.08	.02	.03

Note. ***$p < .001$; **$p < .01$; *$p < .05$; $^{+}p < .10$. Hispanic/Latino is coded as 0 = non-Hispanic/Latino, 1 = Hispanic/Latino. Female is coded as 0 = male, 1 = female. Headspace is coded as 0 = waitlist control group, 1 = Headspace intervention group. Week 0 is used as a comparison group, with all comparisons made against this time point.

Table 3-4

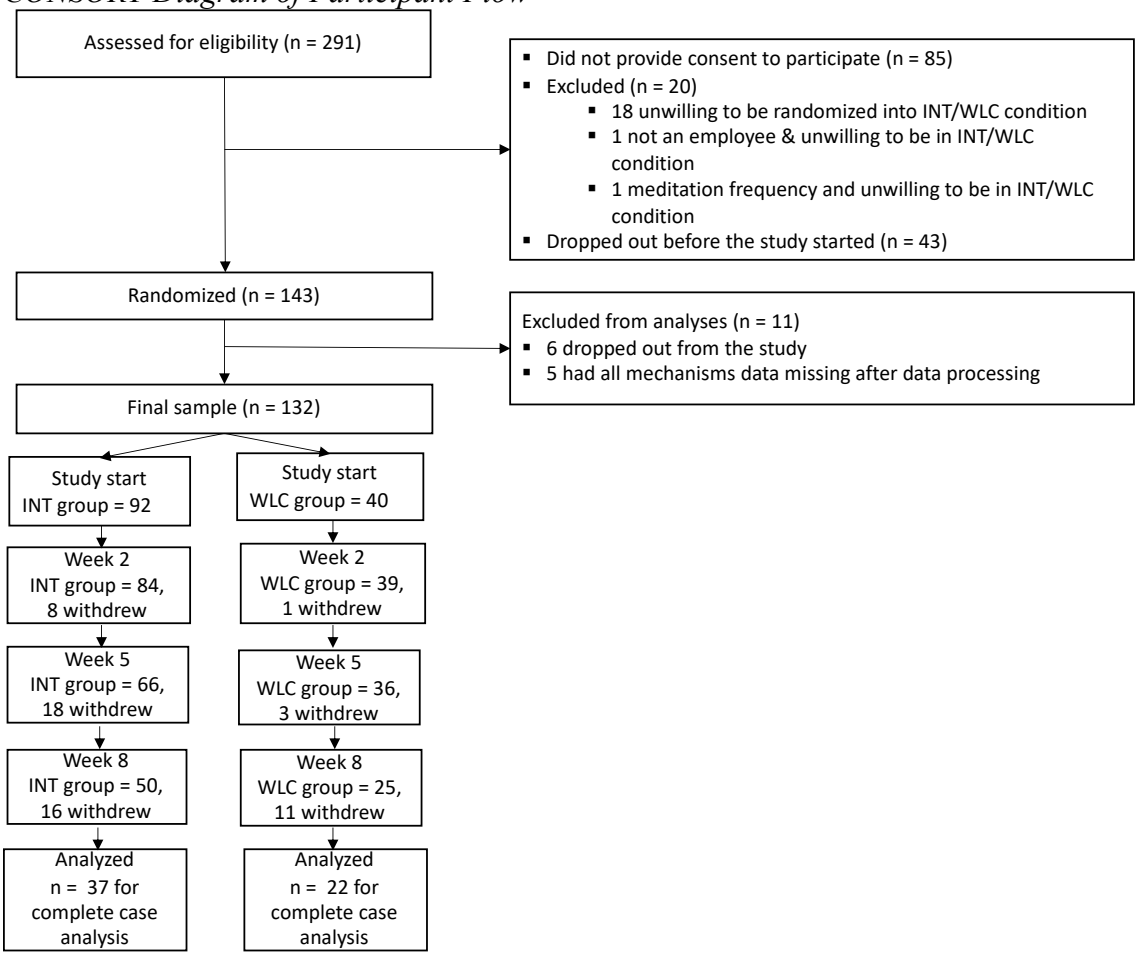
Test of the Linear Effects of Mindfulness Intervention on Mindfulness Mechanisms. Parameter Estimates (Standard Errors) for Mindfulness Mechanisms with Headspace, Week, and the Interaction Between Headspace and Week as Predictors

	Acceptance-Attention	Decentering	Self-Compassion	Nonreactivity
Fixed effects				
Intercept	5.74***	5.83***	6.52***	5.80***
	(.56)	(.58)	(.60)	(.60)
Hispanic/Latino	.30	-.39	.01	.30
	(.28)	(.29)	(.30)	(.30)
Age	.01	- .02	- .002	.01
	(.01)	(.01)	(.01)	(.01)
Female	.04	- .06	- .22	.004
	(.27)	(.28)	(.29)	(.29)
Headspace	- .20	- .30	.07	- .31
	(.26)	(.28)	(.28)	(.28)
Week	.004	.07	- .01	- .002
	(.02)	(.03)	(.02)	(.02)
Headspace*Week	.07*	.06^{+}	.04	.08*
	(.03)	(.03)	(.03)	(.03)
Random effects				
UN (1,1)	1.51***	1.56***	1.76***	1.74***
	(.21)	(.23)	(.25)	(.25)
Residual	.48***	.70***	.55***	.55***
	(.04)	(.06)	(.05)	(.05)
Model statistics				
AIC	1125.3	1230.5	1180.3	1177.0
BIC	1131.0	1236.2	1186.1	1182.7
Pseudo R^2	.02	.08	.01	.02

Note. ***$p < .001$; **$p < .01$; *$p < .05$; $^{+}p < .10$. Hispanic/Latino is coded as 0 = non-Hispanic/Latino, 1 = Hispanic/Latino. Female is coded as 0 = male, 1 = female. Headspace is coded as 0 = waitlist control group, 1 = Headspace intervention group. Week is used as a linear term, with Headspace*Week denoting a term for a linear effect.

Figure 3-1

CONSORT Diagram of Participant Flow



CHAPTER 4: GENERAL DISCUSSION AND CONCLUSIONS

Within the past few decades, there has been strong interest in learning what underlies beneficial effects of mindfulness training. Growing evidence indicates that the mindfulness mechanisms of acceptance, attention monitoring, decentering, self-compassion, and nonreactivity might be driving these effects. Much of this work examined mindfulness mechanisms as stable personality traits that can be promoted with mindfulness training. However, our understanding of how mindfulness mechanisms operate in everyday life, and the pattern with which they change within a person, is limited. This dissertation aimed to address this important research gap by investigating an array of mindfulness mechanisms within a person using an intensive longitudinal assessment method (i.e., EMA). The studies presented in this dissertation have important implications for the field of mindfulness research and provide avenues for future research on mindfulness mechanisms.

Study 1 (Chapter 2) examined whether mindfulness mechanisms represent independent constructs that naturally vary within a person over time, and whether these naturally occurring fluctuations in mindfulness mechanisms relate to negative emotions. The results revealed that mindfulness mechanisms varied within person and across days, with substantial variation at the within-person level. Moreover, these natural fluctuations were meaningful as they differentially related to negative emotions. Notably, decentering appeared to have negative effects in some models, suggesting that not all mechanisms that changed are beneficial once assessed beyond general change. Overall, the results of Study 1 highlight the importance of simultaneously assessing a range of mindfulness mechanisms as naturally occurring states and uncovering how they relate to well-being outcomes in the context of everyday life.

Study 2 (Chapter 3) examined how mindfulness mechanisms changed over the course of an 8-week app-based mindfulness intervention. Results indicated that significant improvements in the mechanisms of acceptance-attention and nonreactivity occurred after two weeks of the intervention, with marginal effects for decentering. No significant improvements in self-compassion were observed. Regarding the pattern of change in mindfulness mechanisms, the mindfulness mechanisms of acceptance-attention and nonreactivity improved steadily over the course of the intervention, with marginal effects for decentering. These results suggest that longer intervention format can lead to greater improvements in mindfulness mechanisms compared to shorter programs.

Implications

This dissertation has several important implications. First, it provides strong empirical evidence that mindfulness mechanisms can be conceptualized and measured at the state level and contributes to growing empirical work demonstrating that mindfulness mechanisms are contextualized and dynamic processes (Blanke & Brose, 2017; Shoham et al., 2017). This finding is particularly intriguing considering that most mindfulness research has conceptualized mindfulness mechanisms as stable personality traits. Although the trait approach is important in its own right, it is not optimally suited to gain insights into how mindfulness works and why mindfulness is linked to well-being. For example, knowing that the trait tendency to experience self-compassion is linked to low

trait anxiety provides important information that these variables are linked. However, this approach is unable to answer the question of how self-compassion affects anxiety. To better understand whether being more self-compassionate (accepting, etc.) in the moment relates to greater well-being, it is essential to study these processes at the within-person level. Therefore, one important contribution of this dissertation is that it supports growing research demonstrating that studying mindfulness mechanisms as dynamic within-person processes over time may complement the traditional trait approach and may be fundamental to gaining insights into how mindfulness mechanisms manifest in people's daily lives (Blanke & Brose, 2017; Brown & Ryan, 2003; Shoham et al., 2017; Shapiro et al., 2006).

This dissertation also demonstrates the importance of longitudinal assessment methods of mindfulness mechanisms. Reliance on retrospective self-report surveys to quantify mindfulness and mindfulness mechanisms has received criticism due to recall bias, as people might not be able to accurately recall their behavior across a variety of contexts over an extended period of time (Enkema et al., 2020; Grossman, 2011). Recall may also be subject to bias due to the person's context and mental state at the time of recall, as our emotional and motivational states may affect what we perceive and remember (Kihlstrom et al., 1999; Shiffman et al., 2008). For example, retrospective reports of self-compassion (or other mindfulness mechanisms) may not be primarily based upon actual levels of person's self-compassion in a particular moment. Instead, they may be influenced by a person's general sense of self-compassion and other mental states at the time of retrieval. EMA is well-suited to address these limitations associated with the traditional retrospective measures. In the context of this dissertation, it allowed us to characterize participants' average states more reliably than as one-survey assessment by aggregating a set of mindfulness mechanism measurements across multiple time points. This approach may be key to better understanding how mindfulness mechanisms respond to intervention and increasing the precision of detecting changes in mindfulness mechanisms over the course of an intervention.

The finding that significant improvements in mindfulness mechanisms were observed by the second week of app-based mindfulness training has important implications for development and delivery of interventions for people who cannot commit to intensive mindfulness-based interventions that require significant time demands. For example, populations such as caregivers, healthcare professionals, in-patient populations may already have an overcommitted schedule. Therefore, longer time commitment may represent a barrier to their ability or willingness to participate (Carmody & Baer, 2009). This finding highlights the utility of low-intensity mindfulness interventions in observing the initial benefits for these populations. Low-intensity adaptations can reduce barriers associated with longer time commitment interventions and allow people to effectively learn mindfulness mechanisms without creating a significant strain in their schedule and excluding them from the possibility of participating.

The findings of this dissertation also add to the growing literature demonstrating that an app-based format is effective in delivering mindfulness interventions and improving mindfulness mechanisms. Digital mindfulness interventions offer several advantages and overcome a variety of challenges associated with traditional in-person

format. One important advantage of digital mindfulness interventions is that they can increase access for those for whom health, transportation, or physical accessibility represent barriers to attending in-person (Mrazek et al., 2019). In addition, research has shown that users report enjoying scheduling flexibility and the ability to access intervention across devices and at the location of their choice (Mrazek et al., 2019; Stjernswärd & Hansson, 2017). Overall, the present dissertation makes an important contribution to the growing literature showing that mindfulness interventions delivered via digital technology hold great promise in making mindfulness interventions more accessible (Linardon, 2020).

Avenues for Future Research

Findings from this dissertation provide multiple avenues for future research. Study 1 focused on the link between mindfulness mechanisms and negative emotions. Yet, more work is needed to better understand how these mechanisms relate to other well-being and health outcomes, both at the state level and as long-term emotional and physical health outcomes. Alsubaie and colleagues (2017) conducted a systematic review on the mechanisms of action in mindfulness interventions in populations with physical and/or psychological conditions. Although researchers found evidence that global changes in mindfulness are linked to better outcomes, this evidence pertained more to interventions targeting psychological (e.g., stress, anxiety) rather than physical health conditions. Yet, mindfulness-based interventions were initially developed for people with chronic physical problems, specifically people who were managing pain (Kabat-Zinn, 1990), with evidence showing that mindfulness interventions have small to medium effect sizes on physical symptoms across a range of chronic somatic conditions (e.g., Abbott et al., 2014). Therefore, it is important to understand the mechanisms of change through which mindfulness interventions target physical health outcomes. Future work testing how the mindfulness mechanisms of acceptance-attention, decentering, self-compassion, and nonreactivity relate to physical health outcomes would be useful.

The present dissertation demonstrated that the mindfulness mechanisms of acceptance-attention and nonreactivity independently relate to negative emotions, and these mechanisms significantly improved following the intervention. Yet, testing mediation was outside the scope of this dissertation, and it remains unknown whether improvements in acceptance-attention and nonreactivity mediate the effects of mindfulness training on negative emotions, as has been suggested in other research (Baer et al., 2012). Therefore, studies testing these relationships in statistical mediation analyses are needed. The field of mindfulness research would benefit from more work testing mindfulness mechanisms as mediators to provide additional support for the growing literature suggesting that mindfulness mechanisms explain the beneficial effects consistently observed in mindfulness training participants (Baer et al., 2012; Kraemer et al., 2002).

In addition to identifying mediators, identifying for whom and under what conditions mindfulness interventions work (i.e., possible moderators) is another important step in understanding how mindfulness interventions produce their beneficial effects. This knowledge might provide insights into which participants might be most responsive to a specific mindfulness mechanism, and which participants might benefit from learning other, more appropriate for them, mindfulness mechanisms. For example,

one study examining the effects of a mindfulness training in a sample of adolescents found that the trajectory of self-compassion changes over the course of mindfulness training was influenced by education and marginally by sex (Bluth & Eisenlohr-Moul, 2017). In particular, high school participants reported more robust increases in self-compassion from pre- to post-treatment compared to middle-school participants. There was also a trend for females to show more robust increases in self-compassion as compared to males. Findings like these highlight the need to better understand mindfulness training moderators to inform the development of personalized interventions targeting specific mechanisms that are most appropriate for a particular population. In the present dissertation, Study 2 revealed that participants who identified as Hispanic/Latino were more likely to complete the intervention. Although this finding might indicate the acceptability of the mindfulness intervention among Hispanic/Latino university employees, there is currently no consensus on the empirical evidence to support the use of mindfulness interventions among Hispanics and Latinos (Castellanos et al., 2020). Understanding the acceptability and effectiveness of mindfulness interventions for these groups is one possible direction future research could take, especially considering that the Hispanic population is the fastest growing ethnic minority in the USA (United States Census Bureau 2015).

Finally, the present dissertation focused on the mechanisms of acceptance, attention monitoring, decentering, self-compassion, and nonreactivity. However, other mechanisms that have not been extensively studied in the context of interventions have been proposed. For example, some of the proposed mechanisms include, but are not limited to, body awareness (Hölzel et al., 2011), acting with awareness (Baer et al., 2006), nonjudging (e,g., Baer et al., 2006), values clarification (Shapiro et al., 2006), describing experiences (Baer et al., 2006), and self-transcendence (Vago & Silbersweig, 2012). Moreover, it has also been proposed that certain mindfulness mechanisms can facilitate other mechanisms. Shapiro et al. (2006) proposed that decentering may facilitate multiple mechanisms, including self-regulation, values clarification, exposure, and emotional, cognitive, and behavioral flexibility. An important direction for future research is to better understand these less studied mechanisms, how they relate to well-being, and how they respond to mindfulness training.

Limitations

Although the findings from this dissertation make important contributions to the literature, they have several limitations. The study was a large-scale university-wide study targeting university employees who were recruited through university emails and flyers to participate in the study testing the effects of mindfulness training on workplace stress. Given that the study was framed as an investigation into the effects of mindfulness on stress in the university employees, caution should be exercised when attempting to generalize the findings of the present dissertation to other populations. It is plausible that this framing of the study may have biased the study cohort to expect beneficial effects from the intervention. Although previous studies have shown that participant positive believes about a treatment can improve outcomes (Mao et al., 2010), the role of expectancy in mindfulness interventions remains unknown, with some studies showing that mind-body interventions may be independent of preconceived expectations (Haddad

et al., 2020; Hicks et al., 2016). Future work should consider measuring the impact of expectancy on mindfulness interventions outcomes.

Measurement issues also must be considered. Although the approach for constructing mindfulness mechanisms was consistent with previous work, and the resulting items demonstrated moderate reliability in Study 1, additional studies are needed to test the psychometric properties of the developed items. Another concern that is common to mindfulness research is whether people are able to accurately rate their own levels of mindfulness (Grossman, 2011). Therefore, it is important for researchers to establish alternative objective measures that could be combined with self-reports assessment, such as behavioral measures (Levinson et al. 2014; Wong et al., 2018), qualitative assessments (e.g., interview data), or neuropsychological approaches (e.g., Grossman, 2008; 2011). It has also been argued that experience with mindfulness practice may influence the meaning that participants derive from items associated with mindfulness experience (Grossman, 2011). That is, it is plausible that participants with more mindfulness experience interpreted items related to mindfulness differently. Although experienced meditators were excluded from the study, rising public interest in mindfulness makes it challenging to recruit naïve participants. Future work should ensure equal levels of knowledge about mindfulness among participants.

Concluding Remarks and Recommendations

The findings from the two studies indicated that the mindfulness mechanisms of acceptance-attention, decentering, self-compassion, and nonreactivity can be conceptualized as states. Acceptance-attention, decentering, and nonreactivity improved by the second week of the intervention, suggesting that these mechanisms can be early indicators that the intervention is working as expected. Furthermore, the finding that two weeks might be sufficient to observe initial effects suggests that shorter format might be worthwhile to reap initial benefits for populations for whom a longer time commitment might be a barrier their ability or willingness to participate. The benefits of mindfulness intervention increased steadily over the course of the 8-week intervention providing strong evidence that longer program time (i.e., 8 weeks) can lead to greater improvements in mindfulness mechanisms compared to shorter programs (i.e., 2 weeks). Overall, the present dissertation advances understanding of mindfulness mechanisms as dynamic processes changing in everyday life, and the pattern with which they change in response to a mindfulness intervention. This work has important implications for developing a comprehensive framework that describes the role of each mindfulness mechanism in well-being, and how these mindfulness mechanisms can be effectively targeted in interventions.

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