Year : 2022

Contemplative practices rooted in Buddhism and stress: Psychophysiological perspective

Gamaiunova Liudmila

Gamaiunova Liudmila, 2022, Contemplative practices rooted in Buddhism and stress: Psychophysiological perspective

Originally published at : Thesis, University of Lausanne

Posted at the University of Lausanne Open Archive http://serval.unil.ch
Document URN : urn:nbn:ch:serval-BIB_04E45F9F2EE97

UNIL | Université de Lausanne

FACULTÉ DE THÉOLOGIE ET DE SCIENCES DES RELIGIONS (FTSR)

INSTITUT DE SCIENCES SOCIALES DES RELIGIONS (ISSR)

Contemplative practices rooted in Buddhism and stress: Psychophysiological perspective

Thèse de doctorat

Présentée à la
Faculté de théologie et de sciences des religions,
Institut de sciences sociales des religions
de l'Université de Lausanne
pour l'obtention du grade de
Docteur ès sciences des religions
par Liudmila Gamaiunova

Jury

Prof. Pierre-Yves Brandt, directeur de thèse (Université de Lausanne)
Prof. Matthias Kliegel, co-directeur de thèse (Université de Genève)
Prof. Elise Dan-Glauser, experte interne (Université de Lausanne)
Prof. Guido Bondolfi, experte externe (Université de Genève)

Sous la présidence du Prof. Jacques Ehrenfreund

Lausanne 2022

UNIL | Université de Lausanne

FACULTÉ DE THÉOLOGIE ET DE SCIENCES DES RELIGIONS (FTSR)

INSTITUT DE SCIENCES SOCIALES DES RELIGIONS (ISSR)

Contemplative practices rooted in Buddhism and stress: Psychophysiological perspective

Thèse de doctorat

Présentée à la
Faculté de théologie et de sciences des religions,
Institut de sciences sociales des religions
de l'Université de Lausanne
pour l'obtention du grade de
Docteur ès sciences des religions
par Liudmila Gamaiunova

Jury

Prof. Pierre-Yves Brandt, directeur de thèse (Université de Lausanne)
Prof. Matthias Kliegel, co-directeur de thèse (Université de Genève)
Prof. Elise Dan-Glauser, experte interne (Université de Lausanne)
Prof. Guido Bondolfi, experte externe (Université de Genève)

Sous la présidence du Prof. Jacques Ehrenfreund

Lausanne 2022

UNIL | Université de Lausanne
Décanat théologie et sciences des religions
bâtiment Anthropole
CH-1015 Dorigny Lausanne

IMPRIMATUR

Le jury, composé de

Directeur de thèse:	Monsieur Pierre-Yves Brandt	Professeur ordinaire, Université de Lausanne
Co-directeur de thèse:	Monsieur Matthias Kliegel	Professeur titulaire, Université de Genève, Suisse
Membres du jury:	Madame Elise Dan-Glauser	Professeure assistante, Université de Lausanne, Suisse
	Monsieur Guido Bondolfi	Professeur ordinaire, Université de Genève, Suisse

Autorisent l'impression de la thèse de

MADAME LIUDMILA GAMAIUNOVA

Intitulée

Contemplative practices rooted in Buddhism and stress: Psychophysiological perspective

Sans se prononcer sur les opinions du candidat.

La Faculté de théologie et de sciences des religions, conformément à ses usages, ne décerne aucune mention.

Lausanne, le 6 mai 2022

Jacques Ehrenfreund
Doyen de la Faculté de théologie et de sciences des religions

Acknowledgments

There are quite a few people that I would like to thank.

First, my supervisors: Pierre-Yves Brandt, who introduced me to the field of psychology of religion; and Matthias Kliegel, who reinforced my interest in the subject of stress and encouraged me to study and apply psychophysiological methods. I was extremely fortunate to have mentors from these varied areas of expertise.

Elise Dan-Glauser and Guido Bondolfi, for accepting to be a part of the jury and providing me with valuable advice during different stages of my research.

The Stanford Psychophysiology Lab, and in particular, Sylvia Kreibig, for deepening my interest in psychophysiology and teaching me how to conduct a large research project.

Pierre Gallaz and Nicolas Pellerin, for contributing their time and efforts to this project and for numerous thought-provoking discussions.

Hoyang Lu, for introducing me to R programming and appreciating my "mathematical thinking." Tom Citherlet and Dunja Vulliemin, the wonderful research assistants who helped me conduct one of the studies.

My colleagues from the ISSR, Monique Thiévent, for tremendous administrative help; Anaïd Lindemann, for being the best officemate; and Jörg Stolz, for shaping my interest in mixed methodology.

Mind and Life Europe, whose help went beyond financial support. The precious time spent with the contemplative community influenced my thinking about various aspects of research and pedagogy. Cogito Foundation for their generous financial support that made this work possible.

Leonid Tiraspolsky, for teaching me discernment and making me value intellect and wisdom; Oleg Pavlov and Alexandr Selin, for numerous enriching conversations and ideas.

My fellow aikidokas and iaidokas in Ryu Seki Kai dojo, particularly Daniel Brunner, for teaching me the way of budo, and Jean Roger for consistently correcting my French.

Dr. Tomáš Zimmermann, for triggering my late return to academia (my future unemployment is on him!), making me appreciate analytical thinking and supporting several elements of this project, from moving tables before a meditation course to helping with data processing algorithms.

Dr. Hedi Klila and Dr. Fabienne Giulianni for their valuable help to us, non-neurotypical folks.

The friends, acquittances, and enemies I made during my life in Switzerland, Russia, the Czech Republic, Egypt, China, and the US, for shaping my ever-growing interest in contemplative life.

Statement

The presented dissertation consists of six studies reported in separate chapters. All the chapters were composed for this dissertation. I declare that in all the studies, I was responsible for the development of design, data collection and analysis, writing of the articles, incorporating feedback from my co-authors. Papers presented in Chapter 1-4 are in the same form as they were submitted to the respective journals. Papers presented in Chapters 5-6 have not been yet submitted for publication. The presented studies are:

Study 1

Gamaiunova, L., Brandt, P.-Y., Bondolfi, G., & Kliegel, M. (2019). Exploration of psychological mechanisms of the reduced stress response in long-term meditation practitioners. *Psychoneuroendocrinology, 104*, 143-151

Study 2

Gamaiunova, L., Brandt, P.-Y., & Kliegel, M. (2021). Contemplative training and psychological stress: An analysis of first-person accounts. *Mindfulness*, *12*(8), 2034-2049

Study 3

Gamaiunova, L., Brandt, P.-Y., & Kliegel, M. (2016). Meditative insight: Validation of a French version of Ireland's Insight Scale (2012) and exploration of relationships between meditative insight and perceived stress. *Mental Health, Religion & Culture, 19*(8), 883-896

Study 4

Gamaiunova, L., Kreibig, S.D., Dan Glauser, E., Pellerin, N., Brandt, P.-Y., Kliegel, M. (submitted manuscript). Effects of two mindfulness-based interventions on the distinct phases of the stress response across different physiological systems

Study 5

Effects of mindfulness training on the anticipatory cognitive appraisals of challenge and threat

Study 6

Mindfulness training and emotion regulation strategies of acceptance and reappraisal

Abstract

Contemplative practices (CP) rooted in Buddhism went through an important transformation in Western societies in terms of the context, form, and motivation. Regardless of settings, reducing suffering remains a unifying motive for various contemplative approaches. This research project focuses on the association of Buddhism-derived contemplative approaches with psychological stress, which is an important negative contributor to well-being, health, and human flourishing.

The association of CP with stress was assessed across six studies and targeted three areas of investigation: (1) association of CP with psychophysiological and affective responses to stress, (2) psychological mechanisms underlying the effects of CP on stress reduction, and (3) exploration of add-on effects of other-than-mindfulness elements of Buddhist contemplative training. Study 1 assessed psychophysiological stress response in long-term meditation practitioners ($N = 29$) compared to age- and gender-matched non-mediators ($N = 26$); Study 2 complemented these results with analyses of first-person accounts of stress experience in long-term meditators ($N = 25$) compared to matched controls ($N = 20$). Study 3 focused on the association between Buddhist insight and perceived stress in an online survey of meditation practitioners ($N = 206$). Study 4 ($N = 99$) used a randomized controlled approach to investigate stress-buffering effects of eight-week courses based on CP. These included a standard mindfulness-based stress reduction (MBSR) program and a modified version of this program containing an add-on module based on other Buddhist practices. Studies 5 ($N = 99$) and 6 ($N = 99$) expanded this investigation by focusing on psychological mechanisms of stress: cognitive appraisals and emotion regulation respectively.

Overall, the results suggest that CP affect the stress responsivity of multiple physiological systems including the hypothalamic-pituitary axis and both branches of the autonomic nervous system. Furthermore, CP reduce prolonged stress activation,

acting during anticipation and recovery phases of stress. CP impact not only stress-related changes in negative affect but also on positive affect and discrete emotions (such as shame). In terms of psychological mechanisms, CP are more closely associated (in short term practitioners) with challenge than threat appraisal, both on levels of self-report assessment and measures of associated cardiovascular profiles. Emotion regulation strategies of reappraisal and acceptance are both affected by CP, but the relationship with stress reduction depends on the context.

Table of Contents

List of abbreviations

ACTH	Adrenocorticotropic hormone
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
ANS	Autonomic nervous system
AUC	Area under the curve
AUCi	Area under the curve with respect to increase
BCa CI	Bias corrected and accelerated confidence intervals
BMI	Body mass index
BP	Blood pressure
BPM	Beats per minute
BPS model	Biopsychosocial model
CFI	Comparative fit index
CO	Cardiac output
CP	Contemplative practice
CRH	Corticotrophin releasing hormone
DBP	Diastolic blood pressure
ER	Emotion regulation
GFI	Goodnes of fit index
HPA axis	Hypothalamic–pituitary–adrenal axis
HR	Heart rate
HRV	Hear rate variability
IQR	Interquartile range
MANOVA	Multivariate analysis of variance
MAT	Monitor and acceptance theory
MBI	Mindfulness-based intervention
MBSR	Mindfulness-based stress reduction
MBSR-B	Mindfulness-based stress reduction with elements of other Buddhist practices
MCAR	Missing completely at random
MI	Multiple imputation
MICE	Multivariate imputation by chained equation
MN	Meditation-naive (participants)
MP	Meditation practitionners
Msec	Milliseconds
NFI	Normed fit index
NSB	Negative self-beliefs
PEP	Pre-ejection period
PNS	Parasympathetic nervous system
PVN	Paraventricular nucleus
RMSEA	Root mean square error of approximation
RMSSD	Root mean square of successive differences
RR	Respiration rate
RSA	Respiratory sinus arrhythmia
sAA	Salivary alpha-amylase
SAM system	Sympathetic adrenomedullar system
SBP	Systolic blood pressure
SET	Social-evaluative threat
SG-MBI	Second-generation mindfulness-based intervention

SNS	Sympathetic nervous system
TA	Thematic analysis
TLI	Tucker-Lewis index
TPR	Total peripheral resistance
TSST	Trier Social Stress Test
Tukey's HSD	Tukey's honestly significant difference (test)
VAS	Visual Analogue Scale
VP	Vasopressin

Introduction

Contemplative practices originating from Buddhist traditions have showed spectacular adaptation to Western society, with meditation techniques being used in contexts ranging from traditional Buddhist centers to hospitals. Regardless of the context, liberation from suffering is the crucial motivational force behind different types of contemplative endeavors. The large focus of this work is precisely that—the exploration of the association between contemplative practice and psychological stress, a crucial aspect of human suffering.

With stress being understood in psychophysiological terms, the role of cognitive and affective factors in physiological response to distress are difficult to overestimate. As a result, contemplative practices, with their potential of cognitive and affective modulation, attracted the attention of stress researchers. The first clinical program based on mindfulness—one of the main components of different forms of Buddhist contemplative training—primarily targeted stress, as is evident from the name mindfulness-based stress reduction (MBSR) (Kabat-Zinn, 1990; 2003). Although there are growing scientific reports suggesting that there is evidence of the stress-buffering effects of contemplative training, the research domain is still very young and thus full of open questions.

This work's main research agenda—exploration of an association between contemplative training and psychological stress—is enabled through three lines of investigation that have emerged in the empirical literature. (1) First, the effects of contemplative practice on the particularities of psychophysiological stress response in terms of biological systems and affective changes. This aim is primarily rooted in the inconsistencies in scientific reports that use biological markers of stress (Morton et al., 2020). (2) Second, psychological mechanisms associated with the stress-buffering effects of contemplative training, in particular cognitive appraisals and

emotion regulation. Exploration of the mechanisms of contemplative training has been routinely cited as one of the top priorities in the field (Hölzel et al., 2011; Shapiro et al., 2006). (3) Finally, this work responds to the latest developments in the field and addresses the stress-buffering effects of the elements of contemplative training other than mindfulness. This aim is dictated by the appearance of so-called second-generation mindfulness programs, which include other aspects of Buddhist practice in addition to mindfulness, such as compassion and loving kindness, elements of wisdom or ethical training (Van Gordon & Shonin, 2020).

The work is organized in the following manner. This Introduction opens with a historico-conceptual account of contemplative training in the West, followed by a detailed description of the human stress response and the associated psychological mechanisms. It ends with a short overview of the existing literature on contemplative training and stress reduction, the identification of open questions, and the presentation of research aims. The main body of the thesis consists of six empirical chapters. Chapter 1 presents the results of a study that investigates stress response and the associated psychological mechanisms in long-term meditation practitioners. The stress response to an experimental induction of a social-evaluative threat is measured in meditators (N = 29) and compared to age- and gender-matched controls (N = 26). The study explores the association of contemplative training with stress-related changes in biological parameters (e.g., cortisol as a marker of the hypothalamic–pituitary–adrenal (HPA) axis, heart rate variability, as an indicator of activity of the parasympathetic branch of the autonomic nervous system (ANS)). Furthermore, the study focuses on the contemplative practice association with affective responses and explores the role of emotion regulation and cognitive appraisals. Chapter 2 presents qualitative results of the same study, in which narratives of the subjective experience of stress are compared between meditators (N = 25) and non-meditators (N = 20). First-person methodological approach permits to

nuance the findings of the study reported in Chapter 1 and gives new insights on the contemplative practice effects on stress attenuation. Chapter 3 presents the results of a survey in a population of long-term meditators (N = 260), where a component of Buddhist practice beyond mindfulness—a Buddhist insight—is tested as a potential contributor to reduced perceived stress. Chapter 4 focuses on the results of a controlled randomized intervention in meditation-naïve participants (N = 99), which compares the stress buffering effects of two programs—a standard MBSR and a modified version of the program which included other aspects of Buddhist contemplative training. The study utilizes advanced psychophysiological assessments, including the HPA axis, SAM system, and both branches of the ANS. In addition, the physiological stress response is assessed in a way that permits us to address its dynamics and test a hypothesis regarding prolonged stress activation (anticipatory activation and prolonged recovery). Chapter 5 expands these results and is focused on cognitive appraisals and their relation to stress using existing theoretical frameworks. Chapter 6 further expands these results and focuses on the effects of contemplative practice on spontaneous emotion regulation during stress, and emotion regulation effectiveness in response to negative self-beliefs associated with personally salient stressful stimuli. The thesis ends with a general discussion, which summarizes the results, addresses limitations, delineates future directions and outlines potential clinical implications.

Buddhist contemplative practices in the West: historico-contextual underpinnings

"Contemplative practice" is a term that has become prominent in the scientific literature on the subject of meditation only recently and primarily as an attempt to broaden and nuance the description of practices generally referred to as "meditation." There is not yet a general definition of "contemplative practice" and the term is still rather fuzzy, but the discussion around the definition is steadily growing. It has been proposed that contemplative practice should be viewed as an umbrella term that includes various practices usually referred to as "meditation" and related cognative disciplines (Komjathy, 2018). By prominently featuring various religious and philosophical traditions, contemplative practices represent a form of training aimed at the development of awareness, concentration, wisdom, regulatory abilities, and self-regulation, among other skills, and as such, can lead to profound psychological transformation (Davidson & Dahl, 2017). In contrast to "meditation," which is usually perceived as a solitary practice performed in a seated posture, the term "contemplative practice" is more englobing and includes dyadic and group practices as well as practices based on movement and certain artistic endeavors (Komjathy, 2018). Both meditations and contemplative practices can be organized by typology and described as part of the system by which they are supported, which can range from religious, spiritual and hybrid traditions to clinical contexts. In sum, the use of the term "contemplative practice" is more advantageous than "meditation," as it: (1) is broader and allows for the inclusion of practices not generally thought of as "meditation," and (2) is less burdened by the general representation of "meditation," which is usually associated with one particular style or tradition.

Contemplative training has been a part of the vast majority of religious traditions and is represented by an array of practices (e.g., Lectio Divina in the Christian tradition, Sema dance in Sufism, Yoga in the Hindu tradition, mental visualization of the supernatural realms in Kabbalah), just to mention a few (Wachholtz & Austin, 2013). However, the scientific study of contemplative practices and their effects in the fields of psychology, neuroscience and medicine are predominantly done on Buddhism-derived forms of contemplative training. The fact that Buddhism is a religious tradition and that its associated practices have found a certain compatibility with the scientific developments in the abovementioned fields can be explained by a number of historical reasons. In his book "The making of Buddhist modernism," (McMahan, 2008) David McMahan traces the process of the modern transformation of Buddhist meditations back to a larger process in Buddhist modernism by which the focus has shifted from institutions and external authority to one of personal experience. This shift has facilitated the creation of conditions in which a religious practice could be extracted from its original context to be employed for personal development. This process of detraditionalization or recontextualization (Komjathy, 2018) of Buddhist contemplative practice did not start in the West: McMahan (2008) gives the example of S. N. Goenka (1924-2013), a vipassana meditation teacher, who described his teaching as being universal and nonsectarian. However, only in the West—starting with the development of so-called new Buddhism (Coleman, 2002)—has the process of shifting the context, purpose and settings of a practice become instrumental. Even though the new Buddhism was built on the foundations of existing Asian traditions—in particular, Zen Buddhism of East Asia, Vajrayana from Tibet, and the Vipassana movement derived from Theravada Buddhism of South and Southeast Asia (Coleman, 2002)—it had a very distinctive new feature: meditation moved to the center of Buddhist practices. Historically, only a small number of monastics within the Buddhist

tradition had access to contemplative training and carried out serious meditation practice (McMahan, 2008). Moving meditation to the center of new Buddhism laid the foundation for the possibility of its extraction from a traditional setting and its rearticulation as a technique that can be used to attain a pleura of developmental goals, from self-actualization to physical health.

In addition to meditation moving to the center of new Buddhism, a discussion on the subject of secular Buddhism (Batchelor, 2015) created the additional possibility of viewing contemplative practice as easily applicable to different contexts. Secular Buddhism can be described as a praxis-based system that offers a secularized dharma free of the soteriological concerns of ancient Buddhist traditions but still founded on canonical texts (Batchelor, 2012). The possibility of secular Buddhism stems from the historical development of Buddhism throughout the world, as the founding traditions underwent substantial changes while adapting to different geographical, cultural and other unique circumstances.

Finally, certain Western interpretations of Buddhism psychologized the tradition by proposing that Buddhism is neither religion nor philosophy, but primarily a form of psychology due to its focus on perception, emotion, consciousness, and radical concern with the topic of human suffering and its alleviation (Mikulas, 2007). Different forms of Buddhism were discussed in terms of their relationship to psychoanalysis (Fromm, 1959; Suler, 1993), Jungian psychology (Moacanin, 2003; Spiegelman & Miyuki, 1985), behavioral therapy (De Silva, 1984; Mikulas, 1978; Robins, 2002), psychology in general (Aronson, 2004; Wallace & Shapiro, 2006), and neuroscience (Wallace, 2009). It is plausible that the possibility of such a close association with psychology is based on a certain emphasis on empiricism, which characterizes several Buddhist practices.

In sum, the particularities of the development of Buddhism in the West—shifting of meditation to the center of the practice, discussing the possibility of

secular Buddhism, and psychologizing the tradition—created the conditions for Buddhist contemplative practices to spread widely throughout Western societies. However, while meditations were practiced in traditional ways in so-called ethnic Buddhist centers, which were created primarily by immigrants of Asian descent (Coleman, 2002), new Buddhism centers had more freedom to express certain eclecticism and borrow contemplative techniques from various Buddhist traditions or make adaptations to traditional techniques. Regardless of these differences, it is possible to assume that the purpose of the practice remained close to the Buddhist soteriological agenda, i.e., liberation from suffering (Coleman, 2002). Without doubt, it is this inspiration—albeit in a more modest form than attaining nirvana—that propelled Buddhist contemplative practices to a new realm: that of medicine and psychophysiological research.

The origins of medical interest in contemplative practice, however, were not related to Buddhist traditions but rather to Maharashi's Transcendental Meditation, a practice derived from Hinduism and based on mantra repetition. Medical research on this type of meditation was largely aided by the work of Henry Benson, whose influential theory of "relaxation response" (Benson et al., 1974; Benson & Klipper, 1975) laid the foundation for the scientific study of contemplative practices. However, the boom in the research on contemplative practices started with Jon Kabat-Zinn at the University of Massachusetts Medical School, who introduced a clinical program called mindfulness-based stress reduction (MBSR), which was an eight-week program that included weekly meetings with an instructor, daily home exercises and a one-day retreat (Kabat-Zinn, 1990; Kabat-Zinn, 2003). While the program is largely based on contemplative practices derived from Buddhism (in particular, mindfulness meditation), the articulation of MBSR was done in strictly secular terms: mindfulness was presented as a universal quality that goes beyond religion and can survive outside the traditional Buddhist context (Gordon, 2009).

This break from the traditional Buddhist context engendered a vivid discussion about what mindfulness is and whether its essence and application change in a new context (Grossman & Van Dam, 2011; Nilsson & Kazemi, 2016; Siegel et al., 2009). With the success of MBSR, mindfulness was used as the foundation for a number of other clinical programs and psychotherapies, such as mindfulness-based cognitive therapy (MBCT) (Segal et al., 2018), acceptance-based therapies (Forman & Herbert, 2009), and a number of short interventions taught in person or online (Creswell, 2017). Regardless of the length or form of their implementation, those programs had mindfulness—with a certain degree of variability in its definition—at their core. With time, however, scientific interest gradually spread to other elements of Buddhist practice, thus fueling discussion about what some researchers called second-generation mindfulness interventions (Van Gordon & Shonin, 2020), which, in addition to mindfulness, include explicitly spiritual and ethical components and a broader array of contemplative techniques other than mindfulness. These additional elements include compassion and loving-kindness-based contemplative practices (Gilbert, 2009; Gilbert & Procter, 2006; Hofmann et al., 2011; Hutcherson et al., 2008; Neff & Vonk, 2009; Pace et al., 2009); ethical practice (Baer, 2015; Chen & Jordan, 2020; Lomas, 2017) and wisdom-based contemplative approaches, which draw from Buddhist philosophy (Bayot et al., 2020; Mikulas, 1978; Sacamano & Altman, 2016; Shonin et al., 2014; Shonin et al., 2014a, 2014b). The integration of additional techniques is not viewed as opposing mindfulness but rather as introducing the possibility of reinforcing mindfulness practice, thus bringing contemplative training closer to its original application in which various aspects of praxis support each other (Grabovac et al., 2011).

Buddhist contemplative training has gone through an important transformation since the emergence of new Buddhism in the West. Inherent particularities of Buddhist tradition (primarily, its emphasis on empiricism, which is

highly compatible with the scientific paradigm), changes in the status of meditation in new Buddhism (i.e., its emergence as the main practice), and a certain flexibility of Buddhist techniques that allows for their use in different contexts created a pleura of contemplative practices currently being practiced in the West. The practice setting ranges from traditional and ecumenical Buddhist centers to meditation groups with and without association with a Buddhist tradition and clinical settings, where interest has steadily shifted to areas beyond mindfulness techniques.

Stress: physioloigical and psychological correlates

Stress response to a psychological challenge

Stress reduction has become one of the first outcomes in the scientific investigation of contemplative approaches. It is not surprising, taking into consideration the detrimental effects of stress on the development of a number of disorders (O'Connor et al., 2021; Sapolsky, 2007; Seeman et al., 1997; Thoits, 2010), ranging from cardiovascular, gastrointestinal, neuromuscular and respiratory diseases to disturbances in the immune system (Everly & Lating, 2013). The key point in the research that has made stress an important area in the fields of psychology and behavioral medicine is the finding that distress-related physiological changes are caused not only by biogenic stressors (e.g., engendering automatic arousal) but also by psychosocial stressors, which are highly dependent on the cognitive process of the evaluation of environmental stimuli (Folkman & Lazarus, 1984). As a result, external stimuli considered threatening are able to evoke a robust stress response, even though the actual metabolic needs necessary to deal with such challenges are not substantial.

Among psychosocial stimuli, the stressors involving unpredictability and social-evaluative threat (i.e., situation in which others judge one's performance

negatively and there is a threat to one's positive self-image) provoke the largest stress response and thus implicate several physiological systems (Dickerson & Kemeny, 2004). These types of stressors create threats to "social safety" and are more likely to cause severe psychobiological and clinical outcomes (Slavich, 2020) and lead to allostatic load, or the "wear and tear" on the brain and body caused by chronic perturbation of physiological systems implicated in adaptation to environmental challenges (McEwen, 1998b).

From a neurobiological perspective, stress response represents a dynamic, interactive, and multidimensional process (Everly & Lating, 2013). Once an environmental stimulus is perceived as stressful (which depends on a variety of factors including biological predisposition, personality type, personal history, etc.), impulses are projected to the limbic system (in addition to the areas of the neocortex associated with neuromuscular behavior) (Cullinan et al., 1995). Implication of the limbic system leads to visceral activation and an increase in neuromuscular activity (for the details of stress response triggering mechanisms via limbic stress circuits, see Ulrich-Lai & Herman, 2009). The triggered stress response is manifested through three axes: neural, neuroendocrine, and endocrine (Everly & Lating, 2013). The neural axis comprises rapid activation of the neuromuscular nervous system and the autonomic nervous system (ANS), including the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). Maintenance of the initial arousal evoked by the neural axis is assured by the activation of the neuroendocrine axis of the "flight-or-fight" response, which triggers a substantial mobilization of the body to prepare to respond to a challenge (McCarty, 2016). The basis of this behavioral response is the activation of neurons in the hypothalamus and brain stem (Jansen et al., 1995) with neural flow subsequently propelling to the adrenal medulla and resulting in the secretion of catecholamines. The activation of this system—the sympathoadrenomedullary or SAM system—bears effects similar to direct

sympathetic innervation, or generalized adrenergic somatic activity (McCabe & Schneiderman, 1985). Finally, the major response to stress is produced by the activation of the hypothalamic-pituitary-adrenal (HPA) axis and starts with the stimulation of parvocellular neurons of the hypothalamic paraventricular nucleus (PVN) (Herman & Cullinan, 1997) and the subsequent release of the neuropeptides corticotrophin releasing hormone (CRH) and vasopressin (VP). These in turn stimulate pituitary adrenocorticotropic hormone (ACTH) release, which then stimulates glucocorticoid secretion by the adrenal cortex. Cortisol, the main glucocorticoid in humans, helps in mobilizing resources to provide energy to cover the demands presented by environmental challenges and participates in the regulation of other systems, such as SAM and the immune system. Given that stress response is orchestrated by different physiological systems, research in behavioral medicine and psychophysiology engendered a discussion about response specificity based on the premise that certain types of stressors are associated with the activation of a particular system. It has been proposed that novelty, lack of control, or loss/harm appraisals are associated with the activation of the HPA axis. On the other hand, the effort, arousal, or appraisals of challenge primarily affect the SAM system (Dickerson & Kemeny, 2004; Schommer et al., 2003). However, it was also proposed that social-evaluative stressors impact the magnitude, not the pattern, of physiological activation (Bosch et al., 2009).

Together with the physiological activation described above, the stress response is manifested through perceptional changes or psychological reactivity (for example, affective changes). Regardless of the theoretical expectations concerning response system coherence, i.e., coordinated activation of physiological and experiential responses (Mauss et al., 2005), empirical evidence suggests that there is a certain dissociation between physiological and subjective stress responses (Campbell & Ehlert, 2012). While measurements of negative affect have been found to be

unrelated to the HPA axis response and the immune system (Dickerson & Kemeny, 2004; Robles et al., 2009), it has been proposed that self-related emotions (such as shame) are associated with the HPA axis-driven stress response and have specific immunological correlates (Dickerson et al., 2004; Kemeny et al., 2004). While negative emotions have mostly been studied in relation to physiological stress responses, theoretical considerations exist on the stress buffering effects of positive emotions (Folkman, 2008; Fredrickson & Levenson, 1998; Fredrickson et al., 2000). However, the empirical evidence is still very limited.

Stress response is considered an important adaptation that allows rapid energy mobilization to react to environmental demands (Ursin & Eriksen, 2004). However, stress response can lead to detrimental effects (1) when the stress response is accompanied by exaggerated physiological changes, and (2) when the stress response is prolonged. The reactivity hypothesis (Cacioppo et al., 1998) states that individuals with a large physiological response (i.e., showing high stress responsivity) may be at a larger risk of developing a stress-related disease than persons with low stress reactivity. The reactivity hypothesis has received some empirical support, particularly as it relates to the cardiovascular system (Chida & Steptoe, 2010; Lovallo, 2010). However, large reactivity is not the only factor linking stress response with pathological outcomes. The expansion of stress theory proposes that it is not so much reactivity (or not only reactivity) but prolonged physiological stress (in the form of anticipatory responses to stressors, slow recovery from stressors, and recurrent activity related to past stressors) that can lead to the development of stress-related diseases (Brosschot et al., 2005). The expansion of stress theory has led to a number of empirical investigations focused on anticipatory stress and recovery across different physiological systems (Brosschot et al., 2017; Engert et al., 2013; Pulopulos et al., 2020).

Psychological factors of the stress response

The process of cognitive and affective integration determines (to a great extent) the amplitude of autonomic, neuroendocrine, and immune responses to a psychological challenge. Thus, particularities in cognitive-emotional processes partially explain variability in physiological responses to stress (Lovallo & Gerin, 2003). Among the main psychological mediators of the stress response are cognitive appraisals and emotion regulation.

The crucial role of the evaluative process in subsequent responses to psychological stress has received important discussion in the framework of several theories, including the transaction model of stress and coping (Lazarus & Folkman, 1984) and the biopsychosocial theory of challenge and threat (Tomaka et al., 1997). According to the first theory, the process of cognitive appraisals concerns the evaluation of information in terms of its relevance for one's personal well-being (Lazarus & Folkman, 1987) and can be divided into primary appraisals (related to the motivational relevance of what is happening) and represented by the appraisals of threats, challenges, and harm as well as secondary appraisals represented by evaluative judgments about possible actions and coping resources. In empirical investigations, it has been demonstrated that primary anticipatory cognitive appraisals are important determinants of the cortisol stress response in a framework of social-evaluative threat and that the alteration of these appraisals can lead to the attenuation of the stress response (Gaab et al., 2003; Gaab et al., 2005). Similarly, the results of a meta-analysis on the subject of stress-inducing experimental procedures and stress response suggest that tasks appraised as challenging, threatening and uncontrollable were associated with heightened stress responsivity (Dickerson & Kemeny, 2004). Cognitive appraisals were found to be associated with heightened cardiovascular response to stress (Maier et al., 2003) and certain parameters of the immune system (Wirtz et al., 2007). The second theory—the biopsychosocial theory

of challenge and threat (Blascovich, 2008; Tomaka et al., 1997)—used the foundation of the transaction model, in particular the distinction of challenge and threat. However, in the framework of the biopsychosocial theory, challenge and threat are viewed not as separate constructs but as poles of a continuum: challenge arises when resources are equal or outweigh demands; threat arises when demands begin to outweigh resources. These motivational states can be differentiated by specific cardiovascular profiles: increased cardiac output and unchanged or decreased total peripheral resistance to challenge and low cardiac output and increased total peripheral resistance to threat (Tomaka et al., 1993). This biopsychosocial theory of challenge and threat laid the foundation for a number of empirical studies that support its theoretical claims (Blascovich, 2008; Seery, 2011). From the perspective of this theory, cardiovascular arousal *per se* is not detrimental: only motivations in which evaluated individual resources are not sufficient to deal with situational task demands (i.e., threats) and the associated cardiovascular profiles can lead to the development of disease.

Emotion regulation—the process of regulating arousal and emotional expressions according to environmental demands (Thompson, 1994)—represents another psychological process that has the potential to alter or attenuate the stress response. The association between emotion regulation and stress response can be explained by common neural structures involved in both stress and emotion regulation, such as the prefrontal cortex, anterior cingulate cortex, and amygdala (Wang & Saudino, 2011). In empirical investigations, several emotion regulation strategies have been linked to changes in physiological arousal. Suppression, a response-focused emotion regulation strategy consisting of inhibition to regulate emotion (Gross, 1998a), has been consistently linked to enhanced physiological arousal in response to distress (Gross & Levenson, 1997; Harris, 2001; Jentsch & Wolf, 2020; Lam et al., 2009). The habitual use of maladaptive emotion regulation,

such as rumination and catastrophizing, was found to predict an increased affective and reduced cortisol response (Krkovic et al., 2018). The effects of cognitive reappraisal, an emotion regulation strategy consisting of the reframing of an emotional event to alter its emotional impact, are less consistent, with reappraisal enhancing physiological reactivity, having no impact on physiology, or attenuating the response (Egloff et al., 2006; Jamieson et al., 2013; Jamieson et al., 2012; Jentsch & Wolf, 2020; Lam et al., 2009; Steptoe & Vögele, 1986). An emotion regulation strategy of acceptance, which, in comparison to suppression and reappraisal, does not consist of actively changing the experience but rather receiving it nonjudgmentally (Hayes et al., 2011), has also been shown to impact psychophysiological responses to distress (Wojnarowska et al., 2020).

In sum, stress response represents a complex multidimensional process that can be triggered not only by biogenic factors but also by psychosocial factors. The response is manifested through the activation of various physiological systems and through (often uncoordinated) psychological responses. Although adaptive in its nature, stress response might lead to pathological outcomes in cases of exaggerated activation or prolonged reactivity. A number of psychological mechanisms, such as cognitive appraisals and emotion regulation, can at least partially explain the variability in the magnitude and duration of the psychobiological stress response.

Buddhism-derived contemplative practices and stress

In the early days of research on contemplative practices, stress reduction was targeted as one of the main outcomes (Astin, 1997; Goleman & Schwartz, 1976; Peterson & Pbert, 1992). Stress-reducing effects have been found to be associated with some of the traditional forms of contemplative training, for example, vipassana (Szekeres & Wertheim, 2015) and zen meditation (Kushner, 2017; Lo & Wu, 2007), among others. However, most scientific studies have focused on the stress-reducing

effects of clinical programs, such as MBSR. The results of a review (Chiesa & Serretti, 2009) suggest that MBSR has a significant effect on stress reduction compared to nontreatment and can have superior effects to other stress reduction programs with similar design in terms of structure and time involvement. While the results suggesting the effectiveness of Buddhist-derived contemplative practices were encouraging, the main shortcoming consisted in the reliance on the self-report assessment of stress, without including biological markers. The inclusion of physiological assessments significantly improved the understanding of the effects of contemplative approaches to stress reduction. Studies have investigated the effect of contemplative training on stress-related changes in various parameters of the ANS, such as blood pressure, heart rate, heart rate variability (Daubenmier et al., 2019; Manigault et al., 2021; Nijjar et al., 2014; Nyklíček et al., 2013; Shearer et al., 2016) and the HPA axis (Engert et al., 2017; Hoge et al., 2018; Lindsay et al., 2018; Rosenkranz et al., 2016a). However, the results of investigations using biological markers of stress showed inconsistencies. A review summarizing the reported results of the effects of mindfulness programs on stress response concluded that while the effects are robust on the self-report level, the stress-buffering effects on physiological stress response need further investigation (Morton et al., 2020). Another aspect that was not addressed in previous research is the effects of contemplative practice on affective changes: stress studies routinely assess changes in negative affect triggered by a stressful encounter. However, positive affects are based on different motivational substrates, underlined by different brain mechanisms (Cacioppo et al., 1997) and can play a separate role in mitigating the effects of the stress response.

Following the accumulation of scientific reports demonstrating the effectiveness of contemplative training for various health-related outcomes, a number of theoretical frameworks were proposed to explain the pathways through

which these practices lead to salutary effects. The frameworks ranged from neuroscientific frameworks, which delineate the neurobiological pathways of contemplative training (Hölzel et al., 2011; Tang et al., 2015; Vago & David, 2012), to psychological frameworks (Shapiro et al., 2006) and even Buddhist frameworks (Grabovac et al., 2011). Stress reduction in itself was proposed as a mechanism linking contemplative training to positive health outcomes. The stress buffering account (Creswell & Lindsay, 2014) suggests that contemplative training reduces the reactivity of central stress processing regions and, as a result, decreases the peripheral response orchestrated by the SAM and the HPA axis. Although the effects of contemplative training on stress can be explained by direct functional and structural brain changes (Taren et al., 2013; Way et al., 2010), the role of psychological mechanisms in the downregulation of physiological stress responses is not negligible. Both psychological processes delineated earlier—cognitive appraisals and emotion regulation—can be affected by contemplative training.

Emotion regulation has been proposed as one of the most crucial mechanisms underlying the salutary effect of contemplative practice, has been included in most of the abovementioned theoretical frameworks, and was assessed as an outcome in a number of empirical studies (Arch & Craske, 2006; Chambers et al., 2009; Jain et al., 2007; Lutz et al., 2013). On a psychological level, it can be hypothesized that contemplative training affects attentional deployment and, as a consequence, impacts the emotion regulation process, thus leading to higher emotional flexibility (Slutsky et al., 2017).

Regardless of general interest in the association of contemplative practices and emotion regulation, the assessment of contemplative training on the emotion regulation processes related to stress experience is less prevalent. One of the most significant contributions to this domain of study was brought by Monitor and Acceptance Theory (MAT) (Lindsay & Creswell, 2017a), in which acceptance was

proposed as the primary mechanism of the stress-buffering effect of contemplative training, in particular by modifying the relation to monitored experience. This theory received empirical support, as the research results demonstrated that acceptance lowers psychophysiological stress reactivity during acute stress (Lindsay et al., 2018). Another emotion regulation strategy—reappraisal—has been equally proposed as a crucial component of the effects of contemplative training on stress: mindfulness practice was hypothesized to create a broadened state of awareness that facilitates reinterpretation of stressful events, thus leading to reduced stress (Garland et al., 2011). Both strategies—acceptance and reappraisal—represent a valid potential mechanism associated with the stress buffering effects of contemplative training. The fundamental difference of those two strategies, their effectiveness, and their relationship to contemplative training has engendered a scientific discussion and fueled a series of empirical investigations (for a detailed discussion, see Chapter 6).

In line with research exploring the stress buffering effects of contemplative training, cognitive appraisals have received much less attention than emotion regulation. Theoretically, the reduction of threat perception through contemplative training can be associated with: (1) the process of decentering or stepping back from the experience (Bernstein et al., 2015), which might facilitate a more benign appraisal of a situation; (2) benevolent mental states, such as compassion, self-compassion, and loving-kindness, which can reduce threat perception (Neff & Vonk, 2009); and (3) a cognitive schema based on doctrinal elements, which helps to evaluate stressful experiences as less threatening (McIntosh, 1995). Regardless of the existing theoretical foundations, the empirical literature on this subject remains very scarce (for a detailed discussion, see Chapter 5).

Finally, the development of second-generation mindfulness approaches has raised the question of whether the stress-buffering effects of contemplative training go beyond mindfulness and whether the effects are similar across various programs.

The research results suggest that programs that go beyond mindfulness and employ other techniques from Buddhist contemplative traditions—for example, compassion—are effective for decreasing physiological activation in response to stress (Pace et al., 2009) and that this type of contemplative training impacts psychophysiological response to stress in a different manner (Engert et al., 2017).

In sum, research on Buddhism-derived contemplative training and stress is still in its infancy. Although the research results consistently suggest that contemplative training is associated with reduced perceived stress, the results showing the effect on physiological markers are still inconsistent. It remains unclear how contemplative training affects different physiological systems, in what way it impacts affective responses to stress, and which psychological mechanisms are associated with the observed effects. The development of second-generation mindfulness programs has raised the question of whether other-than-mindfulness elements of Buddhist training can have additional stress buffering effects.

Research agenda: open questions and aims

The above review delineated a number of open questions in the research on the association between contemplative practices rooted in Buddhism and stress. This thesis targets several of these open areas and thus transforms the main research question—whether contemplative training is associated with reduced stress—into three main lines of investigation.

The first area concerns the effects of contemplative practice on the psychophysiological response to stress. Given that stress response is a complex and multidimensional construct and taking into consideration that affective changes do not always follow physiological changes, open questions that remain to be answered consist in determining which physiological stress response systems are mostly impacted by contemplative training and in what way meditative training impacts

affective response to stress. A related question referring to the psychophysiological stress response concerns its dynamics: very little is known about whether contemplative training affects the magnitude of the stress response or contributes to reducing prolonged reactivity. Studies presented in Chapter 1 and Chapter 4 target these questions.

The second area of investigation focuses on the exploration of psychological mechanisms of the stress-buffering effect of contemplative training. Based on the literature in the domain of stress, the first theoretical considerations, and empirical results from the research on contemplative practices cognitive appraisals and emotion regulation have been targeted as psychological factors that can explain the stress-buffering effects of contemplative training. Studies presented in Chapters 1, 2, 5, and 6 assess this question.

Finally, this work aims to explore whether the stress-buffering effects of contemplative training are enhanced by other-than-mindfulness components of Buddhist practices, such as training in wisdom or ethics. Studies presented in Chapters 3-6 address this question.

On the methodological level, this work adopts a mixed-method approach, allowing to explore the research question using the strengths of multiple research designs and levels of assessment. The study presented in Chapter 1 is observational in design and is conducted in the population of long-term meditation practitioners. The choice of this design is dictated by lack of empirical support for theoretical claims linking contemplative practices and physiological stress response. Long-term practitioners with highly developed contemplative skills represent an ideal population to test for a potential association between contemplative training and psychophysiological changes in the context of stress. Multilevel stress assessment (self-report, HPA axis, ANS) are employed to explore what psychophysiological aspects of stress response are mostly associated with contemplative training. The

study presented in Chapter 2 is run in the same population as the study presented in Chapter 1, but instead of *objective* measures of stress response, it employed qualitative methodology, which permits to explore similarities and differences in the *subjective* stress experience between meditators and non-meditators. This methodological approach allows to triangulate findings of the study presented in Chapter 1 and generate new hypotheses. The study presented in Chapter 3 uses a cross-sectional design. It permitted to have a larger sample size to test a hypothesis that other-than-mindfulness elements of contemplative training (such as Buddhist insight) have a separate effect on perceived stress. The results obtained in the studies presented in Chapters 1-3 provide preliminary evidence for the association between contemplative training and psychophysiological stress, reveal several mechanisms of this association and indicate that elements of training going beyond mindfulness might play a role. To assess causality, studies presented in Chapters 4-6 are based on an interventional design. A randomized control experiment which served as a basis of all three studies permits not only to test the effects of contemplative training on psychophysiological response to stress and explore the mechanisms, but also to test other-than-mindfulness elements of contemplative training. An additional stress-inducing paradigm used in the study of Chapter 6 permits to expand the exploration of mechanisms to new settings.

In sum, a complex mix-method approach allows for a detailed and nuanced exploration of the research question, findings triangulation, and provides with an opportunity to adjust methods over the course of the project.

Chapter 1
Population: long-term meditation practitioners (study $N = 55$)
Focus: association of contemplative training with:

- Physiological and affective response: HPA-axis (cortisol), ANS (HRV), negative affect
- Mechanisms of stress reduction (cognitive appraisals, emotion regulation, self-conscious emotions and cognitions)

Chapter 2
Population: long-term meditation practitioners (study $N = 45$)
Focus: association of contemplative training with:

- Subjective experience of stress (targeting affective experience, cognitive evaluations and regulatory strategies)

Chapter 3
Population: long-term meditation practitioners (study $N = 260$)
Focus: association of contemplative training with:

- Other-than-mindfulness elements of contemplative training (Buddhist insight) and its role in the reduction of perceived stress

Chapter 4
Population: meditation-naïve participants (study $N = 99$)
Focus: 1. Effects of contemplative intervention on:

- Physiological and affective response: HPA-axis (cortisol), SAM system (alpha-amylase), ANS (HRV, PEP), negative and positive affect
- Prolonged stress activation (anticipation and recovery)

2. Other-than-mindfulness elements of contemplative training (exploratory comparison of a standard mindfulness intervention and a mindfulness intervention with other Buddhist practices)

Chapter 5
Population: meditation-naïve participants (study $N = 99$)
Focus: 1. Effects of contemplative intervention on:
Mechanisms of stress reduction (cognitive appraisals, measured via self-report and physiological assessment)

2. Other-than-mindfulness elements of contemplative training (exploratory comparison of a standard mindfulness intervention and a mindfulness intervention with other Buddhist practices)

Chapter 6
Population: meditation-naïve participants (study $N = 99$)
Focus: 1. Effects of contemplative intervention on:
Mechanisms of stress reduction (emotion regulation, measured via self-report and physiological assessment in different contexts)

2. Other-than-mindfulness elements of contemplative training (exploratory comparison of a standard mindfulness intervention and a mindfulness intervention with other Buddhist practices)

Chapter 1. Exploration of psychological mechanisms of the reduced stress response in long-term meditation practitioners

Abstract

Previous research links contemplative practices, such as meditation, with stress reduction. However, little is known about the psychological mechanisms underlying this relationship. This study compares the physiological stress response (reactivity and recovery) measured by changes in salivary cortisol, heart rate, heart rate variability, and the associated stress-related ratings in long-term meditation practitioners ($N = 29$) and age- and sex- matched meditation naïve controls ($N = 26$). The participants were administered the Trier Social Stress Test in its active and placebo versions. The results demonstrated that long-term meditation practitioners had faster cortisol recovery from stress, and experienced less shame and higher self-esteem after the exposure to social-evaluative threat. In addition, long-term meditation practitioners scored higher on adaptive cognitive emotion regulation strategies, such as acceptance and positive reappraisal, and lower on maladaptive ones, such as catastrophizing. The cognitive emotion regulation strategy of acceptance mediated the relationship between meditation practice and cortisol recovery. These results suggest that meditation practice is associated with faster recovery from stress due to the employment of adaptive emotion regulation strategy of acceptance, delineating a pathway underlying the positive effects of meditation on stress.

Introduction

Contemplative training and the stress response

Psychosocial stressors activate a distinct response through the limbic-sensitive "processive" stress pathway (Herman & Cullinan, 1997), leading to physiological changes orchestrated primarily by the hypothalamic–pituitary–adrenal axis (HPA) and the sympathomedullary pathway (SAM). The detrimental effects of repeated stress on neurons (Uno et al., 1989) and the negative relationship between psychological stress and a number of physical and mental conditions (Cohen et al., 2007; Roberts et al., 2017; Sapolsky, 2007) have been well documented.

One of the most promising behavioral approaches aiming to attenuate the stress response is contemplative training, which consists of the use of various practices that originated mostly in eastern religious and spiritual traditions. Contemplative practice (CP) is defined as a form of training enacting a process of self-transformation through self-awareness, self-regulation, self-inquiry, and self-transcendence (Davidson & Dahl, 2017; Vago & David, 2012). One of the most studied types of CPs in the context of stress reduction are Buddhist based meditations, in particular, their clinical applications in the form of mindfulness or compassion cultivating interventions. There is a substantial body of research linking stress reduction with these types of CPs (Carlson et al., 2001; Jain et al., 2007; Shapiro et al., 2008). Yet, the majority of those results should be considered with caution since most of the studies relied only on self-report measures of stress. Far fewer investigations have employed physiological markers of stress, and the results are considerably less coherent; several studies linked CPs with reported physiological changes in response to stress, such as changes in the cardiac parasympathetic and sympathetic response (alpha-amylase) (Arch et al., 2014), adrenocorticotropic hormone (ACTH) (Hoge et al., 2017), blood pressure (Nyklíček et al., 2013), and

cortisol (Rosenkranz et al., 2016a). However, several studies have found no association between CPs and the stress-related changes in physiological variables (Gex-Fabry et al., 2012; Nyklíček et al., 2013; Pace et al., 2009) or even reported the opposite effect, i.e., that contemplative training was associated with an increase in salivary cortisol (Creswell et al., 2014).

An important shortcoming of previous research investigating the relationship between CPs and stress is the accent on the reactivity model of the stress response (Brosschot et al., 2005; Linden et al., 1997). Even though the stress-related negative health outcomes are found to be associated with reactivity to a psychological stressor (Cohen et al., 2002; Matthews et al., 1993), it is important to note the prolonged recovery, which results from a failure to shut off the stress response (McEwen, 1998a). Recovery represents a separate mechanism underlying the pathophysiology related to stress exposure; for example, neuroendocrine recovery is associated with increased immunity (Epel et al., 1998), and diminished vagal rebound (increase in heart rate variability after the stressor) is linked to risk factors for cardiovascular disease (Mezzacappa et al., 2001). Thus, from a conceptual and clinical perspective, it is essential to consider both reactivity to and recovery from a stressor when evaluating approaches designed to lead to stress reduction.

Another crucial but relatively neglected aspect of research on the relationship between CPs and stress is the investigation of the psychological mechanisms that underlie the CPs effects on stress. Most of the abovementioned studies did not make an attempt to relate stress-induced changes in physiological variables to psychological factors associated with the stress response. The paucity of a psychophysiological theory on possible mechanistic pathways represents an important lacuna in existing research on CPs and stress. Thus, considering that longterm CPs shows a more consistent association with psychobiological stress reduction (Engert et al., 2017) than short contemplative training (Creswell et al.,

2014), studies aiming to investigate the mechanisms of the CPs and the stress response association should be conducted in a population of experienced practitioners which was the purpose of the present study.

Psychological factors of the stress response and contemplative training

In recent years, initial attempts of delineating the potential mechanisms of contemplative training effects on behavior and health have been proposed, ranging from neurobiological to traditional Buddhist models (see, e.g., Emavardhana & Tori, 1997; Grabovac et al., 2011; Hölzel et al., 2011; Lindsay & Creswell, 2017a; Shapiro et al., 2006; Vago & David, 2012). However, research on CPs lacks more targeted theoretical models describing the relationship between contemplative training and a specific outcome, such as the stress response. The psychobiological stress response has been previously linked to a number of psychological factors, such as primary cognitive appraisals (Gaab et al., 2005), self-conscious emotions and cognitions (Kemeny et al., 2004), and emotion regulation (Lam et al., 2009; Zoccola et al., 2008). These psychological variables have not been sufficiently explored as potential mechanisms of the CPs effects on stress.

Primary cognitive appraisals

According to the influential stress appraisal theories (e.g., Lazarus & Folkman, 1984), the psychobiological response to stress is partially determined by how the situation is evaluated by a particular individual. It was proposed to differentiate between primary appraisals, representing the evaluation of the relevance of a given situation, and secondary appraisal, focusing on the coping potential of an individual. In the context of social evaluative threat, primary stress appraisals "threat" and "challenge" have been found to be related to the physiological changes in response to stress (Gaab et al., 2003; Gaab et al., 2005; Mayor & Gamaiunova, 2014).

CPs have the potential to alter the appraisal process. One of the skills trained in various CPs is reperceiving (Shapiro et al., 2006), a mechanism that allows the participant to step back and disidentify from current thoughts or affective states and view the experience more objectively. Additional mechanisms include heightened awareness of the present moment and mindful attention (for a discussion, see Epel et al. (2009)). Preliminary empirical evidence suggests the CPs may indeed be associated with attenuated threat appraisal (Weinstein et al., 2009).

Self-conscious emotions and cognitions

Alongside cognitive appraisals, the stress response is associated with affective states (Buchanan et al., 1999). However, this relationship is complex, and defining the affective response in terms of valence and arousal appears to be less useful in studying non-autonomic physiological markers of stress, such as cortisol (Denson et al., 2009). Previous meta-analytical work suggests that general negative affect is poorly correlated with cortisol responses (Dickerson & Kemeny, 2004). The stress response in the context of social evaluation appears to be most related to a particular type of affective state: self-conscious emotions (Leary, 2007; Tracy & Robins, 2004). The social preservation theory (Kemeny et al., 2004) and associated research suggest that self-conscious emotions (shame) and associated cognitions (low self-esteem) are mostly associated with the HPA-axis related physiological changes in response to stress (Dickerson & Kemeny, 2004; Gruenewald et al., 2004; Martens et al., 2008; Pruessner et al., 2005).

CPs have been found to be associated with shame reduction (Goldsmith et al., 2014; Woods & Proeve, 2014) and positive effects on self-esteem (Pepping et al., 2013; Rasmussen & Pidgeon, 2011). Some of the proposed mechanisms behind CPs effects on self-conscious emotion and cognition include self-compassion (Woods & Proeve, 2014), nonjudgement (Rasmussen & Pidgeon, 2011), and reduced self-identification (Brown et al., 2008).

Emotion regulation

Emotion regulation (ER) is the processes by which individuals influence when they have emotions, what type, and how they experience and express them (Gross, 1998b). ER represents another important psychological mechanism associated with the stress response (Sapolsky, 2007). Specific ER strategies (for example, perseverative cognition and rumination) can lead to prolonged physiological activation (Brosschot et al., 2005; Zoccola et al., 2008) or impact stress reactivity (Butler et al., 2006; Egloff et al., 2006). Focuses on the cognitive methods of managing emotionally stimulating information (Garnefski et al., 2001) framework differentiates several distinct ER dimensions: acceptance, self-blame, blaming others, refocus on planning, positive refocusing, positive reappraisal, rumination, catastrophizing, and perspective taking.

The relationship between CPs and cognitive ER strategies has been previously investigated. Here, CPs have been positively linked to the recurrence to acceptance (Lindsay & Creswell, 2017b) and positive reappraisal (Garland et al., 2011; Garland et al., 2009a) and negatively related to catastrophizing (Cassidy et al., 2012), rumination (Deyo et al., 2009), and distraction (Jain et al., 2007). However, the complex association of those ER strategies, CPs and the stress response requires further investigation.

This study

This study addresses several of the open questions in research on the relationship between CPs and the stress response that were identified above. First, the study targeted the dynamics of the stress response, assessing both reactivity to and recovery from a psychological stressor in long-term practitioners of Buddhist meditation (MP) and matched meditation-naive controls (MN). Second, the study investigated group differences in the psychological variables associated with the stress response: primary cognitive appraisals (threat and challenge), self-conscious

emotions (shame) and cognitions (self-esteem), and cognitive emotion regulation strategies. Third, the study explored if psychological variables can explain the relationship between contemplative practice and the stress response.

It was hypothesized that MPs will show less reactivity to and more pronounced recovery from stress expressed than MN through changes in salivary cortisol, heart rate (HR), and heart rate variability (HRV). It was further hypothesized that MPs will feel less threat before the stress, will experience less shame and higher self-esteem after the social-evaluative threat, and will score higher in adaptive cognitive emotion regulation strategies (acceptance, positive reappraisal, perspective taking, positive refocusing) and lower on non-adaptive strategies (rumination, catastrophizing, self-blame, other-blame). The relationship between CPs, psychological variables associated with the stress response, and the physiological stress response, was further explored in secondary mediation analyses. In particular, we predicted that (1) primary cognitive appraisal of threat meditates the relationship between meditation practice and reactivity to stress and that (2) cognitive emotion regulation strategies mediate the relationship between meditation practice and recovery.

Methods and materials

Participants

Participants included 29 long-term meditation practitioners (MP) and 26 age- and gender-matched meditation-naïve (MN) controls. Groups did not differ significantly in descriptive variables, except for the self-reported experience in mental calculation (participants were asked if they have experience in doing mental calculations). Controlling for this variable in the analyses did not change the results.

The MN group was recruited through flyers and announcements in community newspapers, and the MP group was recruited mainly through flyers and emails to local Buddhist meditation centers. The inclusion criteria for MP was the practice of meditation derived from Buddhist traditions for at least 3 years with a regularity of at least 3 h/week. For MN controls, the inclusion criteria consisted of having no primary experience with any kind of meditation. The exclusion criteria for both groups included prior participation in the Trier Social Stress Test, psychiatric diagnosis, medical conditions, use of medication that could interfere with biological markers of the stress response, and use of hormonal contraceptives (Kirschbaum et al., 1995). The protocol was approved by the local ethics committees for research involving humans. Participants' characteristics are presented in Table 2.

Procedures

Participants underwent two laboratory sessions in a counterbalanced order: the stress-inducing Trier Social Stress Test, TSST (Kirschbaum et al., 1993), and a placebo version of this test (Het et al., 2009). After arriving at the lab, the participants were given 10 min to rest before they were led to another room and presented to a panel of two judges (male and female) and a camera. After the standard explanation of the task, participants were led back to the first room and given 10 min to prepare for the task. After the preparation period, the participants were asked to deliver a task in front of an unfriendly committee, a camera and a microphone. The task consisted of a 5-minute speech followed by a 5-minute math task. If participants were silent during the speech, they were asked to continue; if a mistake was made during the arithmetic task, the participants were asked to restart the task. The placebo version of the TSST was performed following a similar protocol and in the same rooms as the TSST but without the stress-inducing parts of the TSST (committee, video camera, and microphone). Participants were instructed to read out loud a magazine

for 5 min and count down from 200 aloud. All the participants were only scheduled for the TSST sessions in the afternoon (Kudielka et al., 2004), and female participants were scheduled for the experimental sessions during the luteal phase of the menstrual cycle (Kirschbaum et al., 1999). The order of the active TSST was counterbalanced in each group. Participants were asked to give subjective ratings of stress during both active and placebo versions of the TSST. During the active version, participants filled out a questionnaire assessing primary cognitive appraisals (anticipation period), state shame, self-esteem, negative affect (right after the stressor), and emotion regulation strategies (during recovery period). A detailed description of the measurements is presented in the next section.

Biological measures

Salivary cortisol. The magnitude of the stress response was measured by changes in salivary cortisol (a marker of the HPA axis activity). Six saliva samples were collected after 10 min of rest (t1), at the end of the task preparation period (t2), right after the tasks (t3), and then 10 min (t4), 20 min (t5), and 30 min (t6) after the task using the Salivette sample device (Sarstedt, Nümbrecht, Germany). After each session, the samples were refrigerated and then sent to a laboratory for free cortisol concentration analysis.

Autonomic nervous system (ANS). Heart rate and heart rate variability parameters served as the markers of autonomic activity. The cardiovascular measurements were continuously collected using a Polar RS800CX cardiac monitor (Polar Electro Ltd., Kempele, Finland) (Nunan et al., 2008) at a sampling rate of 1000 Hz. The recorded R-R series was downloaded using Pro Trainer Polar 5 software. Further data processing was done with the help of Kubios HRV – heart rate variability analysis software (Tarvainen et al., 2014). All signals were corrected with the automated artifact correction filter (low) from Kubios HRV. Two-minute

intervals were created for the rest period (t1), preparation period (t2), task (average of 1 min of speech task and 1 min of math task, t3), right after the task (t4), and then 20 min (t5) and 30 min (t6) after the task. For those intervals, two time-domain indexes were calculated: heart rate (HR), as an index of general sympathetic nervous system arousal, and the root mean square of successive differences (RMSSD), an index of vagus-mediated heart rate variability (Camm et al., 1996). Due to the recording problems, measures from one of the sessions were missing in 7 participants (3 from the MP group, 4 from the MN group); those participants were excluded from the analyses.

Self-report measures

The transactional stress questionnaire (PASA) (Gaab et al., 2005) is a 16-item questionnaire intended to measure the primary stress appraisals of threat and challenge as well as secondary appraisals related to the self-concept of one's own abilities and control expectancy. The State Shame & Guilt Scale (SSGS) (Marschall et al., 1994) is a self-report measure compromised of 15 items. Five items for each of the three subscales measure state-feelings of shame, guilt, and pride. The State Self-Esteem Scale (Heatherton & Polivy, 1991) is a 20-item scale that measures a participant's self-esteem at a given point in time. The Cognitive Emotion Regulation Questionnaire (CERQ) (Garnefski & Kraaij, 2007; Jermann et al., 2006) is a 36-item questionnaire consisting of the following nine conceptually distinct subscales, each consisting of four items referring to what someone thinks after the experience of threatening or stressful life events: self-blame, other- blame, rumination, catastrophizing, putting into perspective, positive refocusing, positive reappraisal, acceptance, and planning. Negative and positive affect-PANAS (Gaudreau et al., 2006; Watson et al., 1988) is a measure of Positive Affect (PA) and Negative Affect (NA), consisting of two 10-items scales. A Visual Analogue Scale (VAS) for

subjective stress is a measurement instrument that tries to measure a characteristic or attitude that is believed to range across a continuum of values and cannot easily be directly measured. The participants were asked to indicate to what point they were stressed at the moment from 0 "not stressed at all" to 10 "very stressed" at 6 points corresponding to the collection of saliva samples.

Analyses

The optimal total sample size of N=53 (effect value of f=0.4, with a significance level set at α=0.05, power 1 - β=.80) was calculated prior to the recruitment using G-Power software (Faul et al., 2007). Group difference in demographics variables was tested using ttests and chi-squares tests. Data were tested for normal distribution using the Kolmogorov-Smirnov and Shapiro-Wilk tests together with the examination of QQ plots. The missing values across the datasets were identified: 16 (2.42%) for cortisol due to insufficient material, 3 (0.52%) for HR and HRV due to the recording problems (final part of the R-R wave missing). Pattern of missing values have been analyzed using little MCAR test, and taking in consideration that the data were missing at random, the expectation maximization technique of imputation was applied (Schafer & Olsen, 1998). Cortisol, HR, RMSSD, and VAS variables were log10 transformed prior to the analyses. Outliers (8 in the cortisol dataset, 17 and 16 for HR and RMSSD datasets respectively) were identified by the boxplots inspection, and analyses were run using datasets with both deleted and winsorized outliers. Analysis of variance (ANOVA) was used for the manipulation tests (placebo vs active TSST) for cortisol, HR, RMSSD, and VAS. Subsequently, 6 time point variables were calculated by subtracting the value of the placebo TSST from the active TSST. Two variables were calculated for cortisol, HR, RMSSD, and VAS: reactivity (highest post-TSST value (t4)-first value (t1) for cortisol, TSST value (t3)-first value (t1) for HR and RMSSD, and pre-TSST (t2) – first value (t1) for VAS; and recovery (highest post-

TSST value (t4)-last values (t6) for cortisol, TSST value (t3) – post-TSST value (t4) for HR and RMSSD, and pre-TSST (t2) – last value (t6) for VAS. Analysis of covariance (ANCOVA) was used to test for the group difference in reactivity/recovery, with age, gender and baseline/peak measure as covariates. Prior to all ANOVA and ANCOVA tests, the assumptions for these tests were checked, and the results were corrected by the Greenhouse-Geisser procedure when the assumption of sphericity was violated. T-tests were used to test for the group differences in psychological variables, and the Holm–Bonferroni method was applied to avoid the problem of multiple comparisons (Holm, 1979). Reported correlation coefficients are the Pearson's r values. Mediation analysis was run with the SPSS macro PROCESS (Hayes, 2012). Analyses were performed using SPSS and R software.

Results

Stress manipulation

Stress manipulation effectively induced psychobiological stress response: results of the factorial ANOVAs (condition: active TSST vs placebo TSST X time: t1 to t6) demonstrated changes in salivary cortisol: $F(1.92, 103.40) = 31.04$, $p < .001$, $\eta p2 = .37$, heart rate (HR): $F(3.68, 173.08) = 18.01$, $p < .001$, $\eta p2 = .28$, heart rate variability (HRV): $F(3.85, 146.35) = 4.07$, $p = .004$, $\eta p2 = 0.10$, and subjective rating of stress (VAS): $F(3.39, 183.02) = 18.83$, $p < .001$, $\eta p2 = .26$ (Fig. 1).

To check if order of the session (active TSST first vs placebo TSST first) had an effect on the psychophysiological changes in the stress response from placebo to active TSST, order was added as a between subject factor. The results of the factorial ANOVAs (condition X time X order) demonstrated that the interaction was not significant for salivary cortisol: $F(1.97, 104.23) = 2.77$, $p = .07$, $\eta p2 = .05$, HR: $F(3.67,$

168.86) = 1.46, p = .22, ηp2 = .03, ηp2 = .04, HRV F(3.93,145.410) = 1.39, p = .24, ηp2 = .04, or VAS: F(3.39,179.301) = 0.88, p = .47, ηp2 = .02.

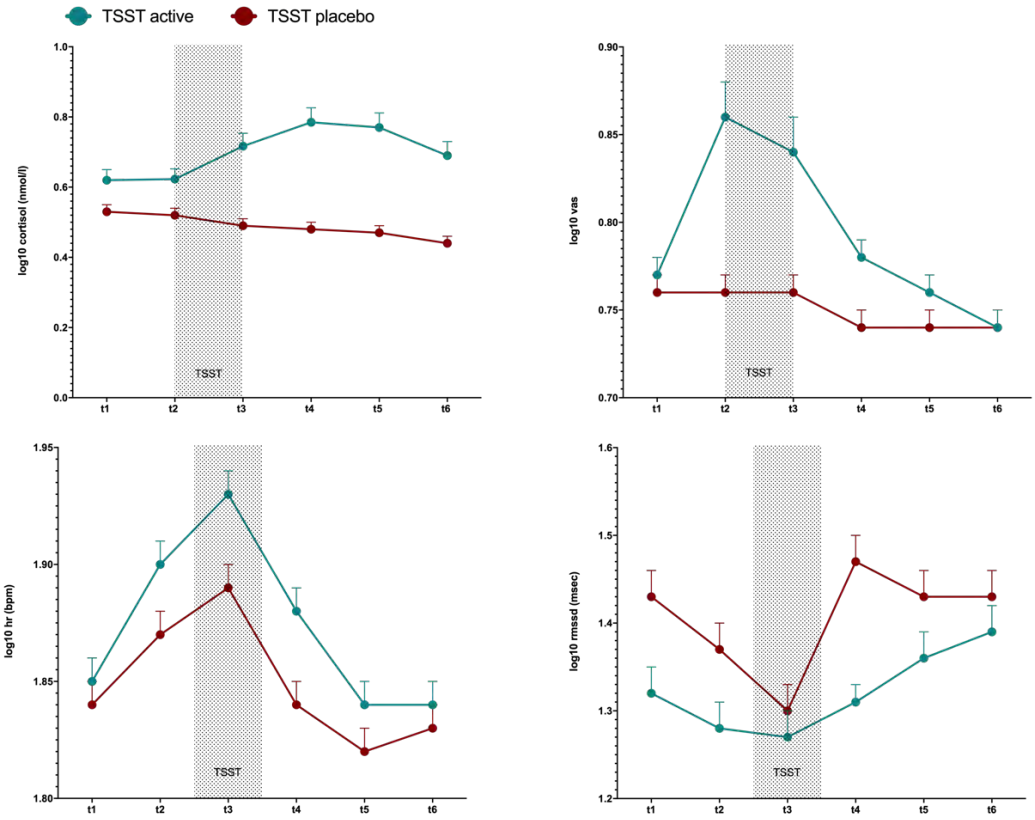


Figure 1. Change in salivary cortisol, subjective measure of stress, heart rate, heart rate variability in active and control versions of the TSST. bpm = beats per minute, msec = milliseconds, rmssd = root mean square of successive differences, vas = visual analogue scale.

Group differences in response to stress

The results of the univariate tests (reactivity or recovery as dependent variable) demonstrated that the groups did not differ in stress reactivity measured by changes in cortisol: F(1, 55) = 1.164, p = .286, ηp2 = .02; HR: F(1, 48) = .463, p = .500, ηp2 = 0.01; HRV: F(1, 47) = .129, p = .721, ηp2 < .01, or VAS: F(1, 55) = .28, p = .594, ηp2 = .01. The group difference was detected only in cortisol recovery F(1, 52) = 18.145, p < .001 (adjusted p = .004), ηp2 = .28 (MP: M = .83, SD = .11; MN: M = .72, SD = .09) (Fig. 2). Recovery measured by changes in HR, HRV and VAS was not different

between the groups: $F(1, 48) = .495$, $p = .495$, ηp2 = .01; $F(1, 45) = 2.763$, $p = .104$, ηp2 = .07; $F(1, 55) = .869$, $p = .356$, ηp2 = .02.

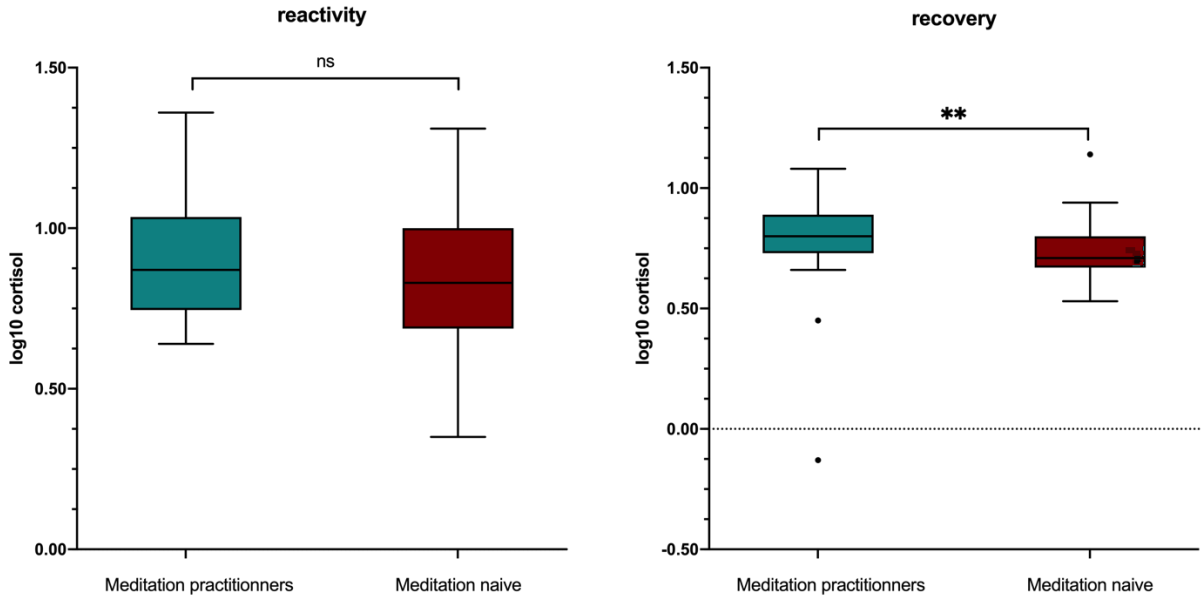


Figure 2. Group differences in the stress response (reactivity and recovery) measured by salivary cortisol. Reactivity is indexed as a change from baseline to t4 (20 minutes after the beginning of the speech task). Recovery is indexed as a change from t4 to t6 (40 minutes after the beginning of the speech task). Age, gender and t1 (baseline measure) for reactivity and t4 for recovery were included as covariates in the model. Winsorizing the outliers did not change the pattern of the results.

Group differences in anticipatory cognitive appraisals, affect, and emotion regulation

After adjusting for multiple comparisons, the group difference remained significant for the post-stressor state shame $t(53) = -3.31$, $p = .009$, $d = 0.61$, state self-esteem $t(53) = 3.14$, $p = .009$, $d = 0.84$, and emotion regulation strategies of catastrophizing $t(53) = -3.20$, $p = .018$, $d = 0.88$, acceptance $t(53) = 4.56$, $p < .001$, $d = 1.24$, and positive reappraisal $t(53) = 4.10$, $p <. 001$, $d = 1.13$. Full tests results can be found in Table 1.

Table 1 Group difference in psychological variables.

Variable	Group/*N*	*M (SD)*	95% BCa[1]	*t* (df)	*p* (adjusted *p*)[2]	*d*
Cognitive appraisals						
Threat	MP/29	2.53 (0.92)	[2.18, 2.90]	*.21*(53)	.838 (.838)	.06
	MN/26	2.47 (1.05)	[2.12, 2.93]			
Challenge	MP/29	4.28 (0.92)	[3.95, 4.60]	*1.69*(53)	.098 (.196)	.52
	MN/26	3.81 (1.13)	[3.40, 4.21]			
Affect						
State shame	MP/29	5.41 (1.09)	[5.09, 5.81]	*-3.31*(53)	.003 (.009)**	.61
	MN/26	6.85 (2.03)	[6.08, 7.64]			
Negative affect	MP/29	25.66 (3.88)	[24.32, 27.06]	*.55* (53)	.586 (.586)	.15
	MN/26	24.95 (5.57)	[22.74, 26.92]			
State self-esteem	MP/29	60.76 (5.32)	[58.92, 62.59]	*3.14*(53)	.003 (.009)**	.84
	MN/26	55.54 (6.97)	[52.40, 58.23]			
Emotion regulation						
Self-blame	MP/29	10.55 (3.13)	[9.34, 11.84]	*.89* (53)	.377 (1.000)	.24
	MN/26	9.82 (2.96)	[8.87, 10.89]			
Other-blame	MP/29	6.87 (1.87)	[6.29, 7.52]	*-2.01*(53)	.050 (.200)	.53
	MN/26	8.23 (3.09)	[7.10, 9.42]			
Rumination	MP/29	12.48 (2.57)	[11.50, 13.48]	*.36*(53)	.718 (1.000)	.10
	MN/26	12.19 (3.26)	[11.00, 13.51]			
Catastrophizing	MP/29	5.21 (1.21)	[4.79, 5.64]	*-3.20*(53)	.003 (.018)*	.88
	MN/26	7.04 (2.69)	[6.08, 7.97]			
Acceptance	MP/29	15.83 (3.28)	[14.64, 17.11]	*4.56*(53)	.000 (<.001)***	1.24
	MN/26	11.88 (3.10)	[10.71, 13.14]			
Positive refocusing	MP/29	8.11 (3.20)	[7.06, 9.17]	*-2.29*(53)	.026 (.130)	.61
	MN/26	10.46 (4.37)	[8.85, 12.30]			
Perspective taking	MP/29	13.38 (3.31)	[12.23, 14.53]	*-.03*(53)	.974 (1.000)	.01
	MN/26	13.41 (3.99)	[11.74, 14.93]			
Positive reappraisal	MP/29	17.48 (1.94)	[16.78, 18.14]	*4.10*(53)	.000 (<.001)***	1.13
	MN/26	13.85 (4.12)	[12.36, 15.43]			

[1] Bootstrap results are based on 1000 bootstrap samples, [2] p-values are adjusted using the Holm-Bonferroni method, [3] *$p < .05$, **$p < .01$, ***$p < .001$

Table 2 Participants' characteristics

	MP *(N = 29)*	**MN *(N = 26)***	**Test statistics (t or χ^2)**	***p***
Age (years)	50.31 ± 10.39	48.23 ± 10.06	t = .75	.46
Sex (M/F)	16/13	14/12	χ^2 = .01	.92
Occupation			χ^2 = 6.47	.17
Student	1	2		
Employed	8	13		
Independent	12	4		
Unemployed	5	6		
Retired	3	1		
Disability	0	0		
Education			χ^2 = 1.89	.76
Primary school	0	0		
Secondary school	3	2		
Professional school	5	6		
Gymnasium	2	4		
College	14	9		
PhD or equivalent	5	5		
Income (yearly, CHF)	N = 29	N = 23	χ^2 = 10.49	.40
0 – 9 999	5	3		
10 000 – 19 999	6	1		
20 000 - 29 999	3	1		
30 000 - 39 999	1	2		
40 000 - 49 999	3	2		
50 000 - 59 999	2	3		
60 000 - 69 999	2	2		
70 000 - 79 999	1	1		
80 000 - 89 999	1	6		
90 000 - 99 999	1	0		
100 000 or more	4	2		
Public speaking experience (Yes/No)	14/13 (N = 29)	12/12 (N = 24)	χ^2 = .02	.90
Mental calculation experience (Yes/No)	10/18 (N = 28)	15/9 (N = 24)	χ^2 = .01	.05
Smoking (Yes/No)	4/25	6/20	χ^2 = .80	.37
Weight (kg)	67.17 ± 10.66	71.31 ±14.22	t = 1.06	.29
Height (cm)	172.34 ± 8.79	169.54 ± 10.79	t = -1.23	.23

Mediation analysis

For the mediation analysis, the variable that demonstrated group difference was chosen as the outcome variable: cortisol decline (recovery). Group served as the predictor variable. Only the variables associated with both predictor and outcome

variables have been introduced as mediators (Baron and Kenny, 1986). Three variables showed to be associated with both the predictor (X) and outcome (Y) variables: acceptance (X: $r(51) = 0.53$, $p < .001$, Y: $r(51) = .46$, $p = .001$), positive refocusing (X: $r(51) = -0.31$, $p = .022$, Y: $r(51) = -0.32$, $p = .019$), catastrophizing (X: $r(51) = -0.41$, $p = .002$, Y: $r(51) = -0.29$, $p = .035$). Mediation model included three mediators and two covariates: age and gender. Results demonstrated that only acceptance remained associated with both the predictor and the outcome variable ($b = 0.011$, $SE = .005$, $t = 2.168$, $p = .035$). Group was no longer a significant predictor of cortisol recovery after controlling for the mediators, thus supporting mediation hypothesis (Fig. 3). The significance of the indirect effect was tested using bootstrapping procedure. These results demonstrated that the indirect coefficient was significant, $b = .043$, $SE = .022$, 95% BCI = .0097, 0.0970. The mediator (acceptance) could account for almost a half of the total effect PM = .49.

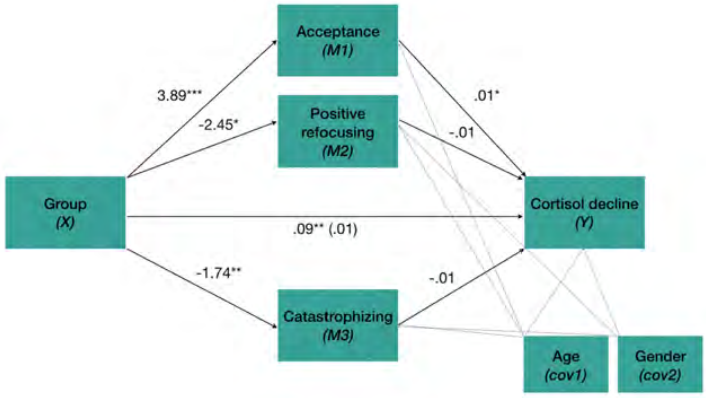


Figure 3. Unstandardized regression coefficients for the relationship between group and cortisol recovery as mediated by cognitive emotion regulation strategies: acceptance, catastrophizing, positive refocusing. The direct effect of group on the cortisol recovery controlling for the mediators is in parenthesis. *$p < .05$, **$p < .01$, ***$p < .001$

Discussion

The results of this study suggest that long-term MP benefit from a more adaptive psychophysiological response to social-evaluative stress than non

meditators. These findings extend the existing evidence linking CPs with a reduced psychobiological response to stress (Engert et al., 2017; Hoge et al., 2017; Rosenkranz et al., 2016b). An important contribution of this study consists of the evaluation of both reactivity to and recovery from stress, with the present results suggesting that contemplative training is particularly related to the recovery phase of the stress response. Those findings nicely dovetail with an earlier study using autonomic nervous system (ANS) markers of the stress response (Goleman & Schwartz, 1976), where CPs were associated with faster recovery from stress but not reactivity. Conceptually, those findings are in line with theories addressing the role of psychological mechanisms of the stress response. For instance, (Brosschot et al., 2005) suggest that prolonged physiological activation expressed in higher anticipatory reactivity and longer recovery is related to perseverative cognition, defined as the repeated or chronic activation of the cognitive representation of stress-related content (Brosschot & Thayer, 2003). It is plausible that contemplative training helps to reduce repeated activation of stress-related content during stress through the use of adaptive ER strategies.

Similarly, preservative cognition affects the anticipatory phase of the stress response; in this study, we measured only reactivity to the task, but possible differences might exist on the level of anticipatory prestress reactivity. It has been proposed that anticipatory endocrine activation has a separate predictive value for psychological health (Engert et al., 2013), and we have preliminary evidence relating CPs with decreased anticipatory stress (Britton et al., 2012; Mayor & Gamaiunova, 2014).

This study was the first to look at the association between CPs and experience of self-conscious emotions and cognition after social-evaluative stress. As predicted, long-term meditators experienced significantly less shame and had higher self-esteem after the stress test. Most importantly, the groups did not differ in negative

affect. The self is complexly involved in the creation of the affective response, but not all affective experiences rely on self, i.e., certain stimuli evoke emotions automatically (Leary, 2003). The stress-inducing protocol used in this study potently evokes general negative affect due to its novelty and unpredictability, which can explain why the groups did not differ in negative affect. Self-conscious emotions, on the other hand, are experienced when actual or ideal self-representation is shattered (Tracy & Robins, 2004), and this type of affective experience is more correlated to the attachment to one's self-representation. CPs rooted in Buddhism often lead to an important change in self-image, where self is seen as less solid and cohesive than before (Epstein, 1988). Those changes in self-representation help to process an ego-threatening experience in a less defensive way (Brown et al., 2008) and have beneficial effects on self-esteem (Rasmussen & Pidgeon, 2011). The results of this study are consistent with empirical evidence from previous research linking CPs and shame (Goldsmith et al., 2014; Woods & Proeve, 2014).

In this study, we further investigated the relationship between CPs and emotion regulation. We assessed group differences in both adaptive and maladaptive cognitive emotion regulation strategies. In line with previous research (Garland et al., 2011), MPs scored higher on positive reappraisal, an ER strategy that permits reconstruction of a stressful event as meaningful or beneficial. However, mindfulness practice is linked to noncognitive processing (Vago & David, 2012), and the association between mindfulness and cognitive reappraisal remains unclear. Taking into consideration that meditators in this study belonged to different traditions and engaged in CPs that go beyond mindfulness, it is possible that certain types of CPs (for example, analytical meditation in the Tibetan tradition) more greatly affect the use of cognitive processing of stressful stimuli. The group difference was equally found in acceptance, a crucial component of several contemplative approaches. Acceptance can be defined as a mental attitude of

nonjudgment and receptivity toward internal and external experiences (Lindsay & Creswell, 2017b). From the set of negative emotion regulation strategies, the group difference was found only in catastrophizing, supporting previous research results linking an important component of contemplative practices, mindfulness, and catastrophizing (Cassidy et al., 2012; de Boer et al., 2014).

A core contribution of our study to the previous research on CPs and stress was testing a mediation model that links CPs and recovery from stress. Our results suggest that CPs affect the stress response only through specific ER strategies. Even though meditators scored higher on reappraisal, this emotion regulation strategy was not a mediator in the relationship between CPs and stress recovery. Reappraisal has been previously found to be positively associated with the ANS changes in response to negative emotions (Mauss et al., 2007), but the association with HPA-axis changes differs (Lam et al., 2009). In this study, only acceptance was found to be a mediator in the CPs and stress response relationship. These findings echo previous results demonstrating that participants instructed to only monitor their experience did not show the same reduction in physiological markers of the stress response as those who also followed acceptance instructions (Lindsay et al., 2018). Similar results were reported in Engert et al. (Engert et al., 2017), where CPs modules that included training of the acceptance attitude resulted in significant physiological stress reduction. Conceptually, it can be concluded that acceptance is efficient in attenuating the perseverative thoughts about a stressor allowing efficient recovery of allostatic systems and reducing HPA-axis activation after the threat is gone. From the neurobiological perspective, the attenuation of the HPA-axis output can be related to the reduced activity of the amygdala, linked to the HPA-axis through the hypothalamus (Sullivan et al., 2004). Previous research suggests that CPs are associated with increased activity in the brain areas linked to the attenuation of the amygdala (Hölzel et al., 2011; Lieberman et al., 2007).

Contrary to our predictions, we did not find any group differences in the stress-related changes in HR and HRV. It was previously proposed that certain outcomes of CPs (such as equanimity) are associated with more adaptive vagal cardiovascular reactivity (Desbordes et al., 2015). However, research results from the studies assessing this relationship are also inconsistent (Engert et al., 2013; Nyklíček et al., 2013; Shearer et al., 2016). The inconsistencies in findings can be explained by several reasons. First, studies use different indexes of HRV; more assessments using similar protocols and indexes are needed to draw a preliminary conclusion on the CPs effects on the parasympathetic system. Another possible explanation are the different effects of various types of contemplative training on HRV. This idea is supported by previous research in which self-compassion, but not focused attention training, resulted in more adaptive RSA (Arch et al., 2014). A limitation of the present study – a non-homogeneous group of meditators – could be responsible for masking the effects of contemplative training on the HRV. The difference between the HPA axis and ANS-related changes in response to stress echoes previous research results by Engert et al. (2017) who suggest that the discrepancy could be explained by the difference in the reactivity of the HPA and ANS systems, with HPA axis activity being determined by internal evaluation and autonomic activity being a sign of general arousal irrespective of its valence. Buddhism-rooted contemplative training, especially in the settings where meditation is coupled with the study of Buddhist philosophy, targets primarily ego-threateningaspects of stressful experience and less so the arousal.

Contrary to our prediction, no significant group difference was found in primary cognitive appraisals. In this study, we only used a self-report measure of anticipatory cognitive appraisal. Future studies should use physiological markers, such as cardiac output and total peripheral resistance that permit to differentiate between threat and challenge appraisals (Tomaka et al., 1993).

One of the main limitations of the study is its observational design. Taking into consideration that the groups were not randomized to receive a meditation treatment, the recovery effect obtained could in principle be related to the self-selection in engaging in or maintaining CPs. In addition, most of the participants from the meditation group belong to a meditation community, and the effects of possible social support or other factors related to a broader practice framework cannot be excluded. Another limitation is a nonhomogeneity of the meditators group; participants belonged to meditation communities derived from various Buddhist traditions, and existing research suggests that various types of contemplative practices can have different effects on the stress response (Engert et al., 2017). An important limitation of this study that should be taking in consideration while interpreting the results, is its small sample size, which is further reduced due to missing subjects for the ANS data.

In terms of future research, the present study underlines the importance of extending research protocols to disentangling both anticipatory and recovery phases. It will be equally essential to study both ANS and HPA-axis related changes in response to stress, as the two systems are not activated in a similar manner. Further, we propose to continue exploring the psychological mechanisms that underlie the effects of CPs on stress. In particular, we suggest going beyond measures of general negative affect and including the assessment of discrete emotions of both positive and negative valence. Research on ER and CPs also requires further development. We suggest investigating how different types of CP affect choice and the ability to use ER strategies in the context of stress.

Taken together, this study adds important conceptual insights to the existing literature linking CPs with the psychobiological stress response and offers an exploration of the possible mechanisms of this relationship. Specifically, it shows

that emotion regulation strategy of acceptance is a potential mechanism linking long-term CPs and physiological recovery from stress.

Chapter 2. Contemplative Training and Psychological Stress: an Analysis of First-person Accounts

Abstract

Objectives. Several studies have investigated the relationship between contemplative approaches and psychobiological stress response; however, this area of research is still new, the mechanisms of the relationship between the stress response attenuation and contemplative training have not been fully delineated, and little is known about the effects of contemplative practice on the ways psychological stress is experienced. This study aimed to explore the first-person experience of psychological stress in meditation practitioners.

Methods. We conducted short semi-structured interviews with twenty-five meditation practitioners and twenty meditation naïve controls immediately after they had undergone a laboratory task (the Trier Social Stress Test). A mixed-method approach was used to analyze the interviews. Thematic analysis was combined with descriptive statistics of the qualitative information that had been converted to quantitative data.

Results Experiences instantiating main themes were identified as follows: (1) primary experiences encountered, describing the most salient experiences associated with the task; (2) reasons for stress, delineating the analyses of why the task was stressful; (3) affect, dealing with emotional experiences during the task; (4) emotion regulation; and (5) attention allocation describing regulatory strategies employed by the participants. Responses to subjective stress experience in meditation practitioners included use of humor, presence of positive affect, combinations of different types of emotion regulation strategies, and adaptive attention allocation.

Conclusions This study elucidates particularities of meditators' subjective experience of psychological stress, provides new insights on the mechanisms of meditation effect on the stress response, and proposes new directions for research.

Introduction

Contemplative practices (CP) is an umbrella term formind–body approaches aimed at psychological transformation through the training of self-regulation, self-awareness, and self-inquiry (Davidson & Dahl, 2017). A significant proportion of the scientific research on CP has examined Buddhist techniques and the secular approaches derived from them. The results suggest that CP are linked—though often with modest effect sizes—to an improvement in a number of somatic and psychiatric conditions (Grossman et al., 2004).

Much of the research on CP has long been focused on an important contributor to several somatic and psychological conditions: stress. Of particular interest are the studies investigating the relationship between CP and psychological stressors known to evoke the greatest biological response. This type of stress is created by uncontrollable situations characterized by social-evaluative threat and has been shown to create significant biological changes, in both the sympathetic-adrenal-medullary (SAM) axis and the hypothalamic–pituitary–adrenal axis (HPA) (Dickerson & Kemeny, 2004). Such biological changes, especially in the HPA axis, are known to be associated with the onset of stress-related diseases (McEwen, 1998a); thus, the research on CP as potentially effective behavioral approaches for stress reduction is particularly important.

A number of studies on CP and biological stress response have utilized stress-inducing protocols that contain both uncontrollability and social evaluation, such as, for example, the Trier Social Stress Test (TSST) (Kirschbaum et al., 1993). In this task, participants are required to deliver a speech and to perform mental arithmetic in

front of an evaluative audience. Attenuation of the physiological response to this type of psychological stressor has been found in long-term CP practitioners (compared with matched controls) (Gamaiunova et al., 2019; Rosenkranz et al., 2016a), in participants who underwent self-compassion training (Arch et al., 2014), mindfulness-based stress reduction training (Nyklíček et al., 2013), social mental training (Engert et al., 2017), and acceptance-based training (Lindsay et al., 2018). Those results indicate that CP impact the ways in which psychological stressors are processed and consequently affect the biological stress response. However, the results of the above-mentioned studies are not homogeneous. Certain studies reported HPA-axis related changes, but no difference in cardiovascular indexes (Engert et al., 2017; Gamaiunova et al., 2019); others reported hemodynamic changes without cortisol alterations (Nyklíček et al., 2013), or with them (Lindsay et al., 2018). There are several possible explanations for the observed differences in reactivity among various stress systems. For example, specificity of CP approaches and duration of contemplative training can both affect underlying mechanisms of the stress reduction. Stress response is linked to several cognitive, affective, and behavioral mechanisms, and we still have limited knowledge about which ones are mostly affected by contemplative training.

Besides an incomplete understanding of how CP affect the stress response, research in this area suffers from another shortcoming: the investigations have been focused on the measurement of stress experience through so-called third-person objective methodologies (Varela & Shear, 1999), such as, for example, biological markers of stress response. However, lived experiences equally include the first-person dimension, or the subjective experience, as an important realm of scientific examination (Varela & Shear, 1999). Limiting the research paradigm to third-person methods has its disadvantages. For instance, certain occurring phenomena can be overlooked by researchers due to the focus on hypothesis testing rather than on

hypothesis generation (Johnson & Onwuegbuzie, 2004) or overreliance on the existing theoretical models. Overcoming this shortcoming is particularly crucial in any new area of research, where theories have not been fully elaborated.

Taking into consideration that the research on CP and stress response is still in its infancy and is full of open questions, complementing physiological assessments with qualitative methods represents an advantage. An example of such approaches is mix-method designs, the fundamental principle of which consists in collecting multiple data with the aid of various approaches and methods (Johnson & Turner, 2003). The combination of qualitative and quantitative research methods allows to expand knowledge by reaching additional aims, such as triangulation (the convergence of results from various methods), complementarity (elaboration and clarification of the results acquired with one methodology by the results from the other method), initiation (the identification of contradictions), and development and expansion (informing a method using the results from another method and expansion of the range of research) (Greene et al., 1989). Due to the large number of open questions, the above-mentioned design strategies could be particularly relevant to research projects investigating biological response to psychological stressors. Research designs can be enriched by the inclusion of qualitative assessment methods, including phenomenological approaches that seek to describe the meaning of lived experience, discourse analysis examining the use of language, and grounded theory that aims at developing an explanatory theory of studies processes (Starks & Brown Trinidad, 2007).

First-person approaches have already been proposed as an important method in the study of CP (Petitmengin et al., 2019). Qualitative assessments have been previously implemented to study various facets of meditative experience (Ataria et al., 2015; Lindahl & Britton, 2019; Przyrembel & Singer, 2018; Sparby, 2018) and the ways in which CP affect the experience of certain medical conditions, such as coping

with seizures (Bauer et al., 2019) or chronic pain (Morone et al., 2008). However, to our knowledge, no previous studies on CP and biological response to psychological stressors have adopted a qualitative approach, and only one study has combined physiological measures and qualitative assessment using the TSST in non-meditators (Vors et al., 2018).

Given the lack of first-person approaches in this area of inquiry, we complemented physiological assessments during stress-inducing protocol (TSST) with semistructured interviews. This paper adds to the previously reported quantitative results addressing stress reactivity in experienced meditators and matched controls (Gamaiunova et al., 2019). In our previous report, we presented the results of objective assessments, such as physiological measures of stress response and self-repot assessments of affect and emotion regulation. We found that long-term meditation practitioners had faster cortisol recovery after psychological stress, experienced less shame and higher self-esteem, and employed more adaptive emotion regulation strategies, such as acceptance and reappraisal (Gamaiunova et al., 2019). The present part of the study was conducted to complement the previously reported data by exploring the subjective experience of being under psychological stress in meditation practitioners and meditation-naïve participants. The aim was twofold: (1) to make a group comparison of the revealed first-person experience of going through a stress-inducing task and (2) to gain additional understanding of group similarities/differences in cognitive, affective, and regulatory processes during psychological stress. The results were expected to clarify and triangulate the findings acquired with physiological and self-report measures, and potentially contribute to the development of theory and/or methodological approaches in the area of research on CP and stress.

Method

Participants

Participants were recruited for a larger study investigating the relationship between long-term meditation practice and psychobiological stress response (Gamaiunova et al., 2019). The meditation practitioner (MP) group included individuals who had been practicing meditation derived from Buddhist traditions, for at least 3 years at a frequency of at least 3 h/week. Meditation types practiced by the participants included zazen (taught in the framework of Soto Zen tradition in a local dojo), vipassana (taught in S.N. Goenka local center and in a non-sectarian vipassana local meditation center), samatha and dzogchen (taught in local Tibetan centers), and mindfulness (taught in secularized meditation courses). Meditation-naïve (MN) control group included individuals who had no prior experience with any form of contemplative practice (participants' characteristics are presented in Table 1). Participants were excluded if they had prior experience performing a similar task, had current psychiatric or somatic conditions, used certain medications, or were women taking hormonal contraceptives. The protocol of this study was approved by the local ethics committee. Fifty-two participants performed the stress task, and 45 were interviewed (25 in the MP group and 20 in the MN group).

Procedures

Participants were administered the TSST, a task known to effectively induce psychological stress (Kirschbaum et al., 1993). After participants arrived at the lab, there was a short 10-min preparation. Then the participants delivered a speech and performed mental arithmetic in front of an unfriendly audience (a man and a woman, wearing white blouses), a camera, and a microphone. The audience did not show any support and prompted participants to continue if they stopped. After the

task had ended, they participated in short interviews, which were recorded for further transcription.

Measures

The interviews were conducted 5 min after the end of the experiment. The interviews had a semi-structured format (Fylan, 2005) and lasted around 15 min each. In the interviews, participants were first asked to freely reconstruct the experience of the task they had just performed. Further, participants were asked to elaborate on the three pre-defined subjects: reasons for stress, emotion regulation/coping, and attention allocation. To evaluate their reasons for stress, participants were asked to analyze why the situation was stressful for them. To evaluate their emotion regulation/coping, participants were asked to recall the strategies they used to deal with the stress. Finally, to evaluate their attention allocation, participants were asked to report where their attention was focused during the task.

Data analyses

Qualitative data were transcribed verbatim with f4 software (audiotranskription, Marburg, Germany) and coded with Nvivo software version 11 for Windows (QSR International, Melbourne, Australia). We used thematic analysis (TA) (Braun & Clarke, 2006) as a method to identify, organize, and describe patterns within data (Braun & Clarke, 2006). As a particular approach, we used a hybrid process of inductive and deductive TA (Fereday & Muir-Cochrane, 2006). The aim of the deductive process was to focus the analysis of stress experience on the particular areas of interest and consisted in using an a priory defined template of themes, reflecting the interview structure (Crabtree & Miller, 1992). The aim of the inductive process was to explore themes emerging from the data, by constructing data-driven

codes (Boyatzis, 1988). Following this approach, the data were first coded using pre-defined template of themes, which reflected the structure of the interviews: (1) primary experiences encountered during the task—free reconstruction of the task experience; (2) affect—description of emotional state during the task; (3) reasons for stress—reports of the participants on why the task was stressful for them; (4) emotion regulation—description of what regulation strategies were used, if any, during the task; (5) attention allocation—reports of the participants on where the focus of attention was during the task. Further, during the second round of coding, induction-driven subcodes emerged inside every high order code. The subcodes of the first code, primary experiences encountered during the task, included subcodes reflecting main features of the lived experience as expressed by the participants during free unguided reconstruction of the task. The second code, affect, included subcodes reflecting positive or negative affect. The third code, reasons for stress, included subcodes inspired by the previous research delineating the characteristics of a stressor capable of eliciting a stress response (Dickerson & Kemeny, 2004). The fourth code, emotion regulation, included subcodes inspired by theories of emotion regulation by Fresco (Fresco et al., 2007), Garnefski and Kraaij (Garnefski & Kraaij, 2007), and (Gross, 1998b). The fifth code, attention allocation, included subcodes reflecting the location of attention as described by the participants. The codebook was revised through the collaborative efforts of two authors (LG and PYB), and the final version was elaborated. Information in the final codebook was presented in the following format: code or subcode, definition, when to use the code or subcode, when not to use the code or subcode, and an example (MacQueen et al., 1998). The final version was used for the main round of coding. The researcher who worked on the first draft of the codebook (LG) had training in psychology of religion, was familiar with varieties of Buddhist contemplative disciplines, and had training in stress psychology and psychophysiology. The second researcher (PYB) had training

in developmental psychology and psychology of religion and was not specializing neither in stress research nor in contemplative studies. The transcripts from both groups were coded together, and the second researcher (PYB) was blind to the group assignment. Two researchers coded part of the data separately (using 10 randomly selected interviews), and the reliability (Cohen's Kappa) and percent of agreement (%) were calculated to determine the level of agreement between coders. A dataset with binary data was created, with "0" representing the presence of a specific code in the interview and "1" the absence of a relevant code.

Results

The agreement between the two coders for a subset of the dataset was 98.75%. Cohen's Kappa (a measure of reliability) for the same subset was 0.75, representing moderate agreement (McHugh, 2012). A description of each theme and subtheme with examples from the interviews and the descriptive statistics are presented below. The group differences for each subtheme are presented in Figs. 1, 2, and 3.

Primary experiences encountered during the task

The theme primary experiences consisted of five sub-themes that emerged from the narratives of the participants, who freely described their experiences during the task (Fig. 1a). Eleven individuals in the MP group (44%) and 4 individuals in the MN group (20%) reported (1) experiencing a sense of challenge and alertness. These participants described the task as positively challenging:

> For the emotions, it was primarily curiosity, I was motivated (…) and (…) and also, I was happy to participate in the test, it was a challenge (participant 21).
>
> I felt that I wanted to do the thing well, like in a challenge (participant 22).

Several participants in both groups reported being in a state readiness and alertness, and having increased energy and enthusiasm:

> …like I say, there was a bit of stress, because I wanted to succeed, but it was positive, it was all energy, well, good stress (participant 3).

> Yes, in a situation like this, where attention is very important, there is vigilance, desire to do the task well, so there is stress (…) (participant 45).

Another theme that emerged in similar proportions in both groups, was the experience oF (2) curiosity. Seven individuals in the MP group (28%) and 2 individuals in the MN group (10%) reported having this experience. Curiosity was mainly associated with the upcoming task:

> To start with, it was a novel experience, so there was a sort of curiosity, and also a pleasure to be able to test myself, to test myself during stress, to see how I would react, so have a small challenge, so (…) (participant 10).

> Well, before there was this kind of [excitement] related to the interest, what they were going to ask me (…) (participant 5).

Descriptions of the stress test experience featured (3) playfulness and humor, but in rather unequal proportions between the groups. Playfulness and humor were experienced by 16 individuals in the MP group (64%) and 1 individual in the MN group (5%). Many participants (mainly, in the MP group) referred to the test as a game, were laughing at their own performance, and reported feeling a sense of general amusement:

> And then, it made me laugh. The drama, the way we

try to be important, it's all cinema, it doesn't exist (participant 17).

It was necessary to make fun of the situation, because it was very painful to restart [the calculation] every time, it was almost comical (participant 6).

It was funny to observe others. What often works for me, it's to turn to humor, to remind myself that it's funny if one [distances themselves], it helps me a lot (participant 18).

Only participants from the MP group (10 [40%]) referred to the (4) temporality of their experience. These participants reported thinking about the time limit of the task and of the impermanence of the current situation:

Every time [that] I am engaged [in] a situation (…) I am stressed, but I immediately remind myself that in any case, it's not gonna last, I just need to enter the situation (participant 18).

Here, in this situation, the only thing that came to my mind was impermanence, the things come and go (participant 9).

The last subtheme of the theme primary experiences, (5) threat and avoidance, emerged only in narratives of participants in the MN group (5 [25%]). Participants recalled wanting to leave the task or finish the experience:

During the task (…) I felt lonely, I wanted it to go fast, as I wanted to be done with it (participant 40).

I had a feeling that I wanted to escape, to get away from here (participant 34).

At the end, I thought that it lasted too long, I thought I

would end by leaving so it stops, as it was unbearable
to be in this uncomfortable situation, I felt very, very
bad (participant 42).

Reasons for stress

The theme reasons for stress consisted of four subthemes (Fig. 1b). The theme and subthemes emerged from the participants reflections on why the experience was stressful. Most of the participants (13 in the MP group [52%] and 14 in the MN group [70%]) reported (1) ego threat as the main cause of their stress. Participants reported fear of being judged or of making a mistake, lowered self-esteem, anxiety related to the attempts to preserve a good image in front of the audience:

For me, it is stressful, because it's the image that we
offer to others, which is (…) we don't want to be ridiculous,
we want to be comfortable (…) so normally
those are not the situations we like, we try to avoid
them (…) (participant 28).

Yes, for me it was the idea of being judged, that someone
will be looking at who I am, they are going to look
at me, film me, observe my gestures, where I look, it's
all going to be analyzed. I am judged, evaluated, it's
very stressful (participant 13).

When I need to repeat the subtractions, there is this
feeling (…) of being empty. One feels a bit (…) inferior.
The fact that I haven't managed the subtractions,
and that I didn't know how to do it, this feeling of
being anxious, stressed (participant 39).

Eight individuals in the MP group (32%) and 6 individuals in the MN group (30%) indicated that the (2) novelty of the situation was a major source of stress. These participants mentioned the lack of experience with this type of task and linked their stress to their unfamiliarity with the task:

> During the task it was more stressful, as I am not used to it (…) I don't usually speak in front of people (…) I am not familiar with it (participant 56).
>
> Very stressful. The situation itself was stressful, I've never been in this type of situation, I work at the same place for 42 years, I am one of old ones who have the same job their whole life, so I've never had an interview (participant 42).

A small percentage of the participants mentioned (3) absence of control (1 individual in the MP group [4%] and 2 individuals in the MN group [10%]) and (4) unpredictability (1 individual in the MN group [5%]) as causes of their stress during the task. These participants commented on their inability to control the time, losing control, and not knowing how much time remained:

> I think that numbers (…) it's stressful, there's time limit (…) it's stressful when there is a limit (participant 48).
>
> I didn't manage to find a good mechanism in the calculations, I didn't feel well, I didn't know where I was, I had to (…) there was this feeling of loosing control. The feeling of anxiety, stress (participant 39).
>
> The presentation is also timed, we have X minutes to talk about a subject, well it destabilizes, I don't know

how much time is left (participant 48).

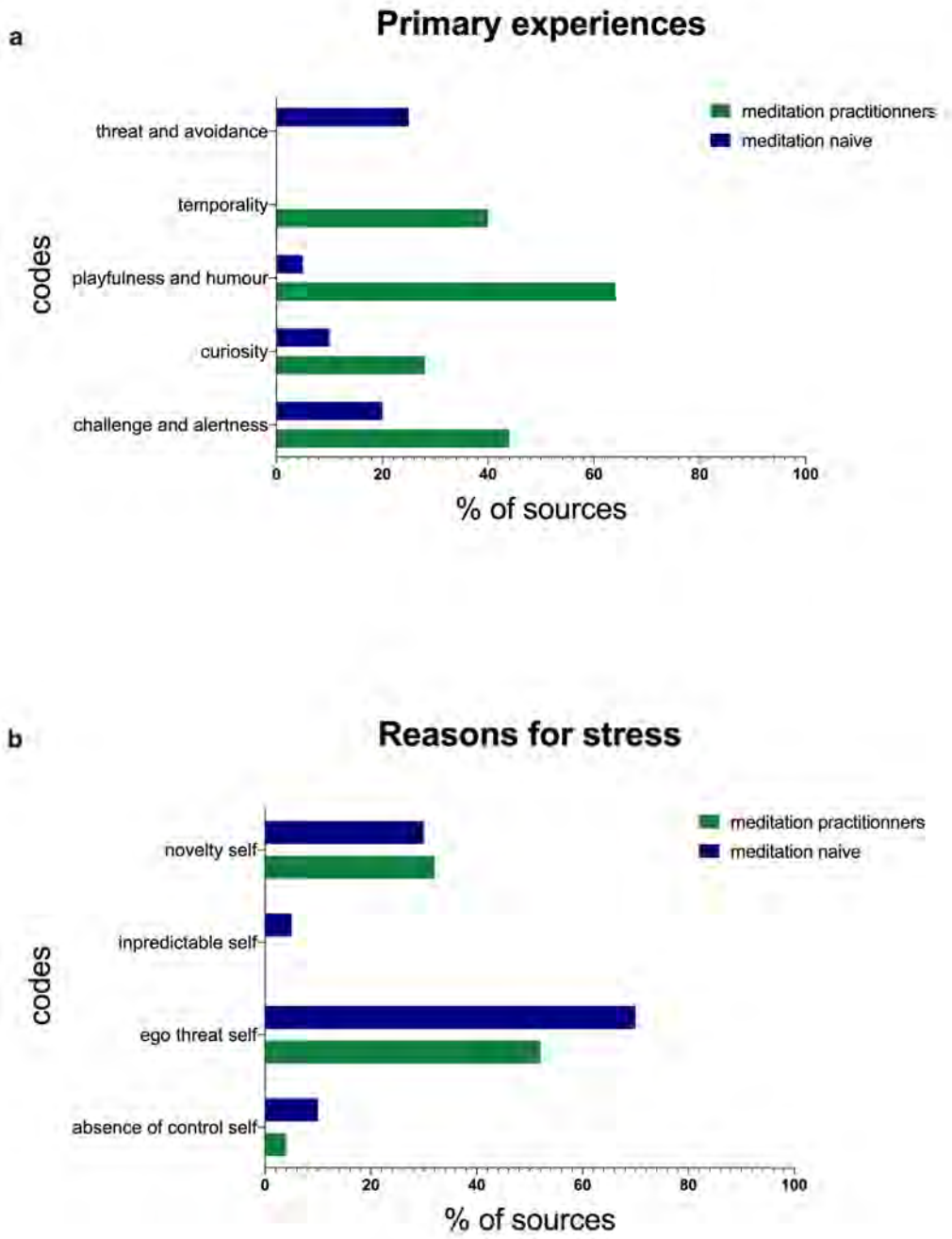


Figure 1. Frequency (%) of sources with the codes reflecting the theme "primary experiences" (a) and "reasons for stress" (b).

Affect

The theme affect consisted of two subthemes that represented affective states experienced during the task (Fig. 2). The first one is (1) negative affect. Seven individuals in the MP group (28%) and 17 individuals in the MN group (85%) reported experiencing negative emotions. The most frequently reported negative

affective experiences in the MP group were nervousness, destabilization, frustration, and tension, and the most frequently reported negative affective experiences in the MN group were stress, anxiety, nervousness, and shame (Fig. 2b-e). Negative affective experiences were primarily related to the actual performance of the task:

> As for the emotions, it was shame, of course. I was very nervous. After the task, I was disappointed in myself concerning this thing, the math (…) (participant 41).

> Just after the task I was very angry with myself, how is it possible that I don't manage, it's not that difficult. So, I was anxious, it was doable, but I panicked, I didn't manage, it was (…) really (…) I was unsatisfied with myself (participant 40).

The second subtheme of affect was (2) positive affect. Fourteen individuals in the MP group (56%) and 3 individuals in the MN group (15%) reported experiencing positive emotions associated with the task. The most frequently reported positive affective experiences in the MP group were delight, curiosity, and interest. In the MN group, positive emotions were reported only four times. The positive affective experiences reported by this group were fun, relaxation, calm, and positivity (Fig. 2). Positive emotions were associated with participation in the task, or with the relief that came after the task had ended:

> As for the emotion (…) enthusiasm, it was a chance to test my presence, I was a bit content (participant 19).

> After, the stress gradually subdued to leave place to something open, interest or even enthusiasm (participant 5).

> After the task I was relieved, content, and even proud,

I've done something, I conquered my fear, I was content (participant 28).

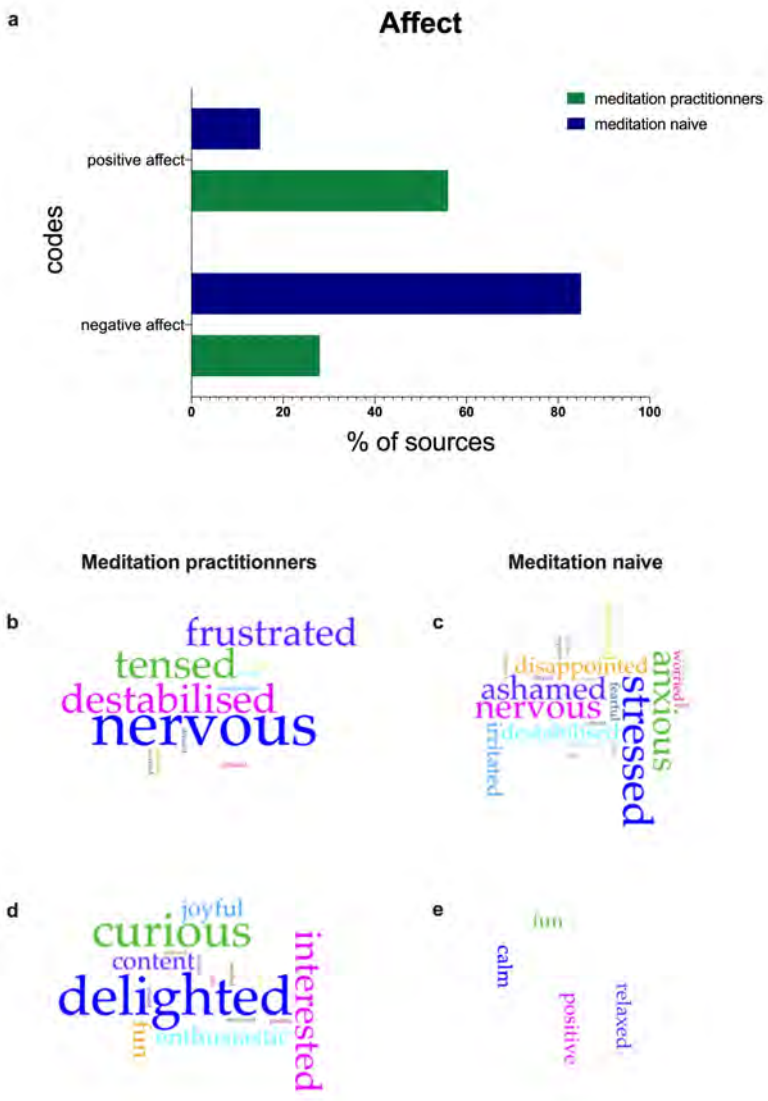


Figure 2. Frequency (%) of sources with the codes reflecting the theme "affect" (a) and word cloud of negative emotions (b-c) and positive emotions (d-e).

Emotion regulation

The theme emotion regulation consisted of nine subthemes (Fig. 3a–b-c). The theme and subthemes emerged from participant descriptions of their attempts to regulate their affective states during the task. Three of the regulatory strategies were reported only by the MP group: (1) acceptance (reported by 13 individuals in the MP group [52%], (2) attention to the body (reported by 15 individuals in the MP group [60%]), and (3) decentering (reported by 10 individuals in the MP group [40%]).

Acceptance was defined as a strategy that involves allowing the experience of emotion without attempting to change it or suppress it:

> When I realized that there was a physiological change in my body, I just looked at my body, trying to stay with this sensation without wanting to change anything, and normally it calms down by itself (participant 10).
>
> I think that advantage is to accept whatever comes, if I like it or not, if I am comfortable or not. If there is stress, well, it is something unpleasant, but it's ok (participant 24).

Attention to the body mainly refers to the attention to breath that participants used as a regulatory strategy. Several participants reported anchoring in their bodies to center themselves during the task:

> For me, it was mainly respiration. When I feel alert, it's there, my breath is quickly engaged, and it changes things rather quickly. When I look at my breath, I manage to better regulate my emotions. When I stay with the breath, it helps me to avoid being carried away by other things (participant 13).
>
> Hmm well (…) it wasn't really conscious, but I do it immediately: feel my respiration, my body, anchoring in the floor, yes, like that. And it happens instantly, without thinking. Yes (…) the connection with my body establishes itself (participant 24).

Decentering involves shifting experiential perspective by "stepping out" of a situation and looking at it "from outside," without being drawn to it. Several participants reported using this strategy to deal with affective changes during the task:

> You can (…) be concerned by the situation: you can be interested, and stuff, but keep it at a distance, understanding that what I feel is false, it's all mental, and it's the biggest liar (laughing). And I try to be an observer. If I am an observer, I am intact. If I am impacted, I am already an actress in this situation. Here, in this situation, I managed to stay an observer (…) and it helped me a lot (participant 17).

> Well, I wasn't too stressed (…), but in this situation (…) it happened almost by itself. I observed my thoughts and my reactions, it was very interesting to make those observations (participant 26).

Four of the emotion regulation strategies were reported only by participants in the MN group: (4) distraction (reported by 1 individual in the MN group [5%]), (5) suppression (reported by 1 individual in the MN group [5%]), and (6) rumination (reported by 8 individuals in the MN group [40%]). Distraction involves generating images of something unrelated to the presented situation in order to neutralize current affective experience. Suppression involves hiding or inhibiting the emotion being experienced. Two participants commented on their attempts to use these strategies during the task:

> I tried to remember all the positive things about myself, all things that went well, people who work with me (participant 40).

I mainly tried to adapt my behavior, so I don't show
my emotions (participant 46).

Rumination is a maladaptive emotion regulation strategy, which involves repetitive focus on negative thoughts. Participants in the MN group commented on their rumination:

After the task I continued to think about what happened
and how it happened (…) yes, there was a light
feeling oF (…) frustration, it's true, I wasn't on top of
the situation according to my criteria (participant 39).

After the task (…) I still continued thinking about it for
ten minutes, because I felt too stupid (participant 50).

The emotion regulation strategy oF (7) catastrophizing was reported by 1 individual in the MP group (4%) and 2 individuals in the MN group (10%). Catastrophizing involves having thoughts that explicitly emphasize the unpleasantness of the experience:

What annoyed me (…) I told myself: "what a fool!", it
was catastrophic, I didn't know how much time it was
going to last, I thought I was going to stay there forever
(participant 35).

It was panic, in my head it was panic, how to explain
(…) panic and void: I can't say anything, think, I can't
(…) yes, just panic (participant 42).

Another emotion regulation strategy, (8) reappraisal, was reported in both groups. Seventeen individuals in the MP group (68%) and 5 individuals in the MN group (25%) used this strategy. Participants described regulating their emotions by trying to reinterpret the current experience. They mentioned reappraising the

situation by thinking of it as a test, reminding themselves that it was not real and telling themselves that they were helping the research:

> It is very useful to have someone who can push your buttons or be in a situation like this when someone tries to push your buttons, because it is the only way to improve (participant 14).
>
> At the beginning I told myself: "Gosh", as I didn't expect it to go this way (…) I was a bit surprised, but I knew it was for a good cause (participant 28).

A number of participants (1 in the MP group [4%] and 12 in the MN group [60%]) reported that they had (9) no emotion regulation strategy. These participants did not know which strategy to use, did not think it would be helpful, or failed to implement one.

> It would have been good to do it, but I could not, I was too focused on the negative aspect of my situation.
>
> I think anything that would relax me could help to organize my thoughts, as they were completely disorganized (participant 34).
>
> I don't think it is possible to get stable, either you feel all right or you don't (participant 36).

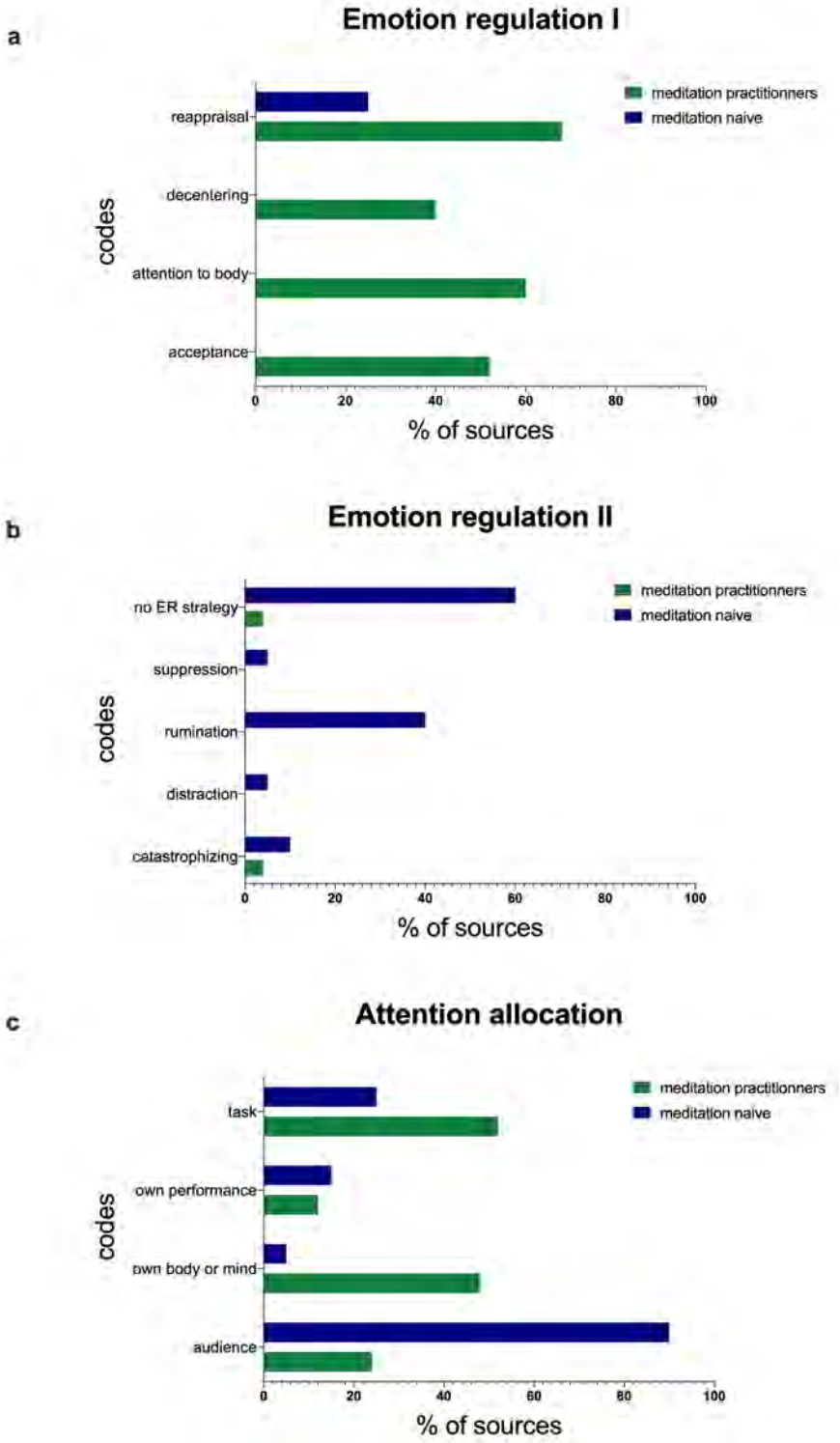


Figure 3. Frequency (%) of sources with the codes reflecting the theme "emotion regulation" (a-b) and "attention allocation" (c).

Attention allocation

The theme attention allocation consisted of four subthemes that emerged from participant responses when asked about the focus of their attention during the task (Fig. 3c). Participants in both groups paid attention to (1) the audience (reported by 6

individuals in the MP group [24%] and 18 individuals in the MN group [90%]). The participants attempted to make sense of the audience's reaction to their performance, to understand the feedback, evoke a reaction, or establish a connection:

> During the presentation I tried to play my role, but after I had to stabilize my attention, but I didn't succeed, because the people were very cold, really very distant (…) it didn't help (…) I found it very destabilizing, as I looked at them quite often. Maybe it's the white coat that gives this effect, I don't know, but it was like a wall in front of you (participant 47).
>
> During the first task I looked at the people, what they were doing, why, I analyzed. What were they searching for, what would they think of me (…) (participant 35).

There was a difference in the percentage of participants who paid attention to their (2) body and mind in the two groups (48% in the MP group [12 individuals] versus 5% in the MN group [1 individual]). Participants who used this strategy reported observing the reactions of their bodies or how affective experiences were unfolding:

> …and also, it was funny to look at my reactions and thoughts. Especially during the math part when I didn't succeed. It's always interesting to observe (participant 6).
>
> (laughing) it was funny to look at my thoughts, at this agitation. I paid attention to what was happening in my head, it was funny (laughing). After so many years of professional life where I was managing… I was nevertheless agitated (laughing). Yes, I observed my reactions,

and also my breath, it often helps (participant 1).

The two groups were similar in the percentage of participants who payed attention to their (3) performance (12% in the MP group [3 individuals] versus 15% in the MN group [3 individuals]) and to the (4) task (52% in the MP group [13 individuals] versus 25% [5 individuals] in the MN group). Participants evaluated their performance and stayed focused on their goals during the task:

I paid attention to my way of speaking as I was criticized
before for being a bit meek and not motivated,
so I tried to look at this (participant 4).

During the task, I don't remember much but I think it
was rather (…) I paid attention to what I was doing,
what I was going through. I tried (…) to concentrate
to do a better job (…) (participant 15).

I tried to pay attention to the task, just to do my best
without thinking about other things (participant 10).

I [paid attention] uniquely on the task, uniquely to do
my best. During the presentation (…) I tried to think
about what I've prepared (…) I didn't think about my
comfort or anything else (…) (participant 22).

The presented above results suggest that meditation practitioners and meditation-naïve participants had both similarities and divergencies in their experiences of going through psychological stress. Both groups recognized why the task was stressful and had a similar ratio of the identified characteristics of the stressor. However, the most salient features of experience reported by the groups differed significantly. Even though both groups experienced challenge and curiosity, the experience of MP was mainly driven by playfulness and understanding of temporality of the experience, while MN participants showed presence of avoidance

and threat. Further differences emerged on the level of affective response to the task: MP showed a very unusual affective profile, reporting more positive than negative affect, while MN had a more common profile of negative affect dominance. The comparison of the emotion regulation strategies employed by the participants showed that MN participants tended to not employ any strategy more often than MP and showed higher rations of negative strategies such as rumination; MP, on the other hand, abundantly used the strategies of acceptance, attention to body, reappraisal, and a meta-strategy of decentering. Finally, the groups deployed their attention in dissimilar ways: MN tended to concentrate mainly on the committee, while MP on the task at hand or body and mind.

Associations among themes

In order to explore possible associations among the emerged themes, we constructed a correlation matrix using the thematic codes with a correlation coefficient equal or greater than 0.4 (Fig. 4). Thirteen themes showed weak to moderate associations. Primary experience "playfulness and humor" showed positive association with attention allocation to body or mind during the task and negative associations with attention allocation to audience and negative affect. Moderate positive association had been identified between the two themes related to the reasons of stress: "unpredictability" and "absence of control." The theme "positive affect" showed positive association with attention allocation to the task and emotion regulation strategy of acceptance, whereas "negative affect" was found to be positively associated with "attention to audience" and negatively to the emotion regulation strategies of acceptance and attention to body. Themes related to adaptive emotion regulation strategies, such as "reappraisal," "attention to body," and "acceptance," showed positive associations.

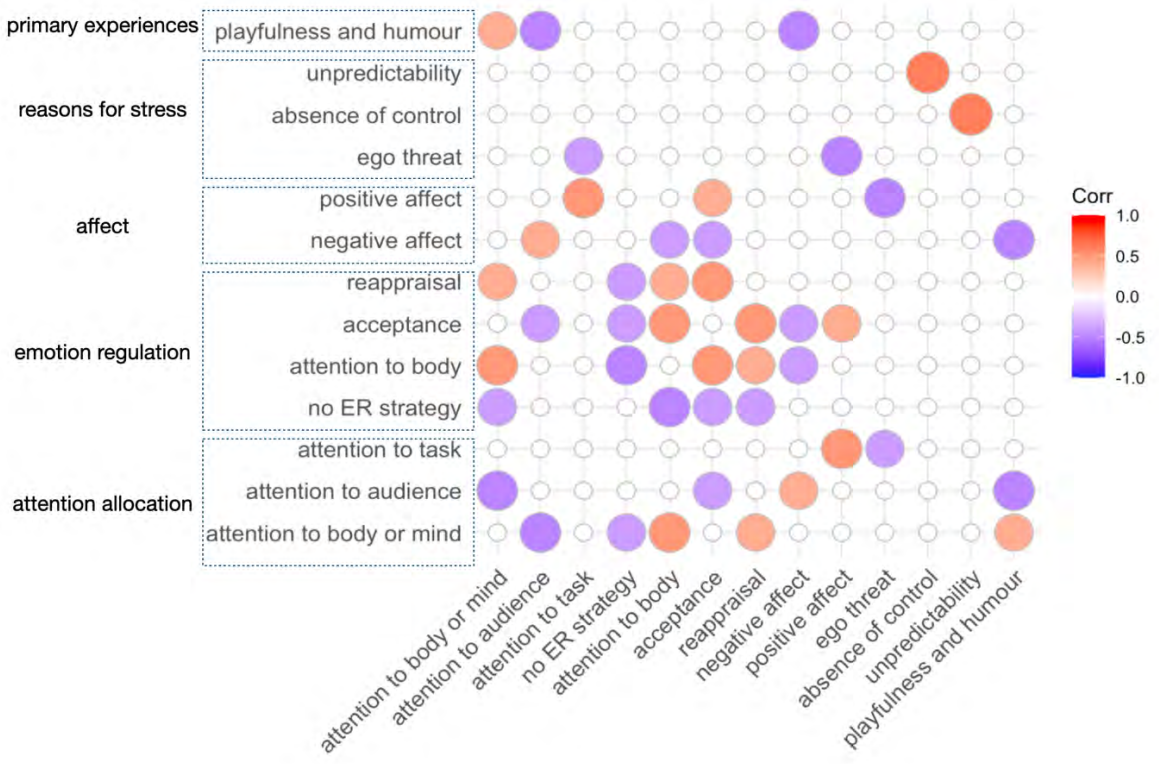


Figure 4. Correlation matrix of the selected themes.

Note. Themes with the correlation coefficient smaller than .40 are not included in the graph.

Discussion

This paper presents the results of qualitative comparisons of the psychological stress experience by long-term meditation practitioners and meditation-naïve participants. Thematic analysis of narratives allowed identification of group similarities and differences in subjective stress experience, as well as in cognitive, affective, and regulatory processes during psychological stress.

The results of our analysis indicate that certain features of subjective experience during a highly controlled stress-inducing task are similar between meditators and meditation-naïve individuals: several participants in both groups reported feeling challenged by the task and had experienced motivation and enthusiasm. However, the experience of threat and avoidance and the desire to leave the experiment was reported only by non-meditators. These findings are in line with previous studies that have suggested contrasting responses to stress: mindfulness, characterized by

awareness, openness, and acceptance of the experience (Bishop et al., 2004), versus experiential avoidance, which refers to attempts to avoid or alter undesired experiences (Hayes & Feldman, 2004). We can hypothesize that meditation practitioners were less inclined to avoid the experience due to higher mindfulness and capacity to be open to any experience. Triangulation with the self-report assessment of similar constructs assessed via questionnaires in the same study (anticipatory cognitive appraisals of challenge and threat) and reported in previous publication (Gamaiunova et al., 2019) revealed convergent and divergent results; in the self-report assessment, the groups did not differ in the experience of feeling challenged or threatened. The observed differences in the reports of challenge and threat may be explained by the timing of the assessment: self-report data were collected prior to the task, and the interviews were conducted after the TSST and referred to the entire duration of the experiment. First, retrospective appraisals could be altered by the process of coping (Lazarus & Folkman, 1984). Second, qualitative data reflected most salient features of their experience, unconstrained by questionnaires items.

Another experiential particularity emerged in the narratives only in the meditation group was the recognition of the temporality of the stressful experience — several participants reported explicit acknowledgement of time-limited nature of the experiment. Even though participants in the MP group did not connect their reasoning to the doctrinal foundations of Buddhist traditions, these types of reports echo the Buddhist notion of impermanence, which suggests that no element of physical matter or concept remains unchanged. Impermanence (annica) is one of the three universal characteristics of existence in Buddhism and is fundamental to all Buddhist schools (Anderson, 2004). Emphasizing temporality of the current experience may serve as a potent regulatory strategy, as it has already been demonstrated in earlier research: the idea of impermanence was used by Sri Lankan

tsunami survivors as a coping strategy (Silva, 2006) and reported as one of the main strategies for coping with stressful situations in American Buddhists (Phillips et al., 2009).

Playfulness and humor, a very unusual type of experience in the framework of social-evaluative stress, emerged as a theme only in the MP group (64% of the MP participants reported this type of experience). Similar to the theme of temporality, this experience has not been explicitly linked by the participants to their contemplative training. However, this type of attitude shows similarities with processes recognized by certain Buddhist traditions: in his analysis of nature and the purpose of humor (using a Zen philosophical approach), Gordon (2010) suggested that our ability to laugh at ourselves is closely connected with dissolving the belief in independent ego that constitutes the core of our being. Once the realization of the illusory nature of the self comes through, it becomes easier to approach difficult experiences with humor. Empirically, mindfulness, a core component of various Buddhist-derived CP, has been found to be positively related to light humor (Hofmann et al., 2020), but the exact nature of this relationship is unclear, and further investigation is needed.

Analyses of the narratives featuring the underlining reasons for being stressed permitted to elucidate cognitive aspects of the stressful experience. The two groups surprisingly did not differ in their explanations of why they perceived the situation as stressful. Ego threat was reported by the majority of participants in both groups. These results are in line with the literature on social-evaluative threat and stress response; the task used in this study (the TSST) simulates the conditions of threat (losing the social self, a psychological state associated with robust psychophysiological stress-related changes) (Gruenewald et al., 2004). The results of our study suggest that this evaluation is explicit. In other words, participants were aware of the relationship between the social-evaluative threat and their stress

experience. Other reasons for stress reported by participants in both groups (i.e., novelty, absence of control, and unpredictability) have also been previously found to be associated with the stress response (Dickerson & Kemeny, 2004).

Exploration of the affective aspects of the experience showed that the MP group reported fewer negative emotions than the MN group. The self-report assessment of affect in our previous study (Gamaiunova et al., 2019) revealed that groups did not differ in general negative affect but experienced more shame. We examined the discrete emotions reported by participants in the interviews and observed that shame was mentioned only by participants in the MN group. It has been proposed (Gruenewald et al., 2004) that certain physiological changes in response to social-evaluative threat (such as changes in the HPA-axis) are specifically tied to self-conscious emotions and cognitions. It can be hypothesized that CP decreases experience of particular type of negative affect: self-conscious emotions, such as shame. We proposed earlier (Gamaiunova et al., 2019) that this might be explained by the fact that Buddhist CP lead to changes in self-image and subsequent decrease of attachment to one's self-representation.

In the present study, we observed that a large percentage of participants in the MP group and a very small percentage of participants in the MN group reported experiencing positive emotions, such as delight, curiosity, and interest during the task. This finding is rather surprising, as the TSST is specifically designed to provoke stress. It can be hypothesized that the positive emotions experienced by the MP group during the task can be explained by an openness to experience fostered by CP. One of the features of mindfulness is the ability to attend to experience with curiosity and detachment, and nonreactive orientation, which helps to invite experiences, even if they are difficult (Creswell, 2017).

Comparison of the narratives related to the theme of emotion regulation revealed that certain adaptive emotion regulation strategies, such as acceptance,

decentering, and attention to the body, were reported exclusively by the MP group. These results are in line with those of previous research that has suggested that the above-mentioned strategies are affected by CP training (Chambers et al., 2009; Fresco et al., 2007; Lindsay & Creswell, 2017a). The emotion regulation strategy of reappraisal, a top-down approach to affect regulation, was not exclusive to the MP group, but was reported by the majority of participants in the MP group. Our results suggest that participants in the MP used both bottom-up (acceptance) and top-down (reappraisal) emotion regulation strategies. These findings can be potentially explained by different levels of CP experience among the participants; previous research has suggested that longer mindfulness practice is associated with bottom-up regulation approaches (Chiesa et al., 2013; Fredrickson, 2002). Participants in the MN group used only one top-down strategy (reappraisal), suggesting that bottom-up regulation strategies are rarely used by individuals without previous CP training. Among the maladaptive emotion regulation strategies, rumination emerged as the most popular approach in the MN group. The absence of reports of rumination in the MP group is congruent with previous research, underlying the association of CP with rumination reduction (Deyo et al., 2009). The majority of participants in the MN group reported not employing any emotion regulation strategy. This finding leads to the question of whether CP effects on stress reduction are associated with emotion regulation efficacy (i.e., how well an emotion regulation strategy is implemented) or rather a widened repertoire of emotion regulation approaches.

Analysis of narratives related to the attention allocation provided us with the insights on the process of attentional deployment during the stressful task. Although a similar number of participants in both groups reported focusing on accomplishing the task and their performance, the majority of participants in the MN group paid attention to the audience, who were the evaluators in the task. These results echo the report of Vors et al. (2018), who investigated phenomenology of the TSST

experience. In that study, the two highest cortisol responders reported that looking at the audience was associated with stress because of the feeling of being judged, and they developed strategies to avoid the experimenters' evaluation by not looking at them. For some participants, paying attention to the audience was associated with the feeling of being rejected. This type of attentional deployment might not have been beneficial, as social rejection has been previously linked to heightened psychophysiological stress response (Blackhart et al., 2007). A large percentage of the participant in the MP group paid attention to their body and mind. Empirically, breath-focused attention has been showed to be associated with decreased negative emotion experience and reduced amygdala activity (Goldin & Gross, 2010), and may represent a beneficial form of attention deployment.

Limitations and future research

The study has a number of limitations. Some of these limitations were previously identified in the first report associated with this project (Gamaiunova et al., 2019). The MP group was not homogenous in terms of Buddhist practice, and different types of CP are known to be associated with different effects. Further, the protocol of the study did not permit long interviews which would help to go deeper in the subjective experience and make a detailed analysis of the associations among the themes.

The results of qualitative studies help generate new hypotheses, create opportunities for new experimental approaches, and suggest methodological improvements. Building on our findings, we propose future directions for the research investigating the relationship between contemplative approaches and stress response. We suggest that more research on the impact of contemplative training on cognitive appraisals is needed. Cognitive appraisals have been found to be associated with stress-associated biological changes, such as cortisol (Gaab et al.,

2005) and heart rate (Mayor & Gamaiunova, 2014), and represent an important psychological mechanism of the stress response initiation (Everly & Lating, 2019). It is important to differentiate between anticipatory and retrospective cognitive appraisals, as they may have different association with stress-related physiological changes (Gaab et al., 2005). Further, studies that explore the effects of CP on appraisals using the framework of the Component Process Model of emotion (Scherer et al., 2001), which postulates that type and intensity of emotion depend on the profile of the appraisal process, should be conducted. An investigation of which appraisal objectives (relevance, implications, coping potential, normal significance) are altered by CP could prove to be informative.

We suggest moving beyond measurements of general negative affect during stress-inducing protocols. Taking into consideration the unexpectedly abundant reports of positive affect during the stress task in the MP group, we suggest adding positive affect measures in similar protocols. Changes in positive affect impact autonomic nervous system (Kreibig, 2010), which may explain why a number of studies on CP and stress show effects on endocrine, but not ANS stress-related physiological changes. Further, in this study, we observed that certain negative emotions, such as shame, are reported only by non-meditators. These results are convergent with those from a self-report assessment conducted in our previous study, where MN participants scored much higher on the post-task measure of state shame. Taking into consideration that specific self-conscious affects and cognitions have been found to be related to cortisol production (Gruenewald et al., 2004) we suggest expanding negative affect measurements to more granular assessments of affective states during stress task (e.g., the Geneva Emotion Wheel; (Scherer, 2005)).

The results of this study suggest that meditation practitioners use both bottom-up and top-down emotion regulation approaches. Future studies on the factors that contribute to the choice of a strategy (e.g., phase of the stress task, ability to

implement the strategy, type of CP) are warranted. In our study, meditation practitioners were found to exhibit particular forms of attentional deployment during social stress.Therefore, future studies should explore this experimentally by, for example, objectively analyzing participant behavior through video recording or using eye-tracking technologies to assess gaze direction.

This study helped to identify novel coping strategies that are potentially related to CP. Use of humor and self-irony has not been previously explored as a strategy for dealing with stress. Exploring this direction has potential; previous research results and theoretical models suggested that coping humor mitigated anxious mood (Moran & Massam, 1999). Furthermore, it was found that self-irony could be protective against self-criticism (Dews et al., 1995) and that perspective-taking humor facilitated recovery from stress (Lefcourt et al., 1995). Humor was found to be related to a more positive self-concept (greater congruence between actual and ideal self), higher self-esteem, and more realistic and flexible standards for evaluating selfworth (Martin et al., 1993). The interrelation between humor and different aspects of self is of particular importance for social stress situations. Future studies on stress and CP that explore the mediation effects of this coping strategy are warranted. We proposed earlier that processing stressful stimuli with detachment and self-irony may be associated with philosophical aspects of Buddhist contemplative training. To test this hypothesis, future studies that include a measure that taps into the wisdom aspect of contemplative training, such as the insight scale (Gamaiunova et al., 2016; Ireland, 2012), Buddhist coping measure (Phillips et al., 2012), and Self-Other Four Immeasurables Scale (Kraus & Sears, 2008), should be conducted.

Chapter 3. Meditative insight: validation of a French version of Ireland's Insight Scale (2012) and exploration of relationships between meditative insight and perceived stress

Abstract

Meditative insight has been defined in previous research as a process of cognitive change based on the understanding through personal experience of the fundamental Buddhist concepts of impermanence, suffering, not-self, and emptiness. It has been proposed that the construct of insight represents an important mechanism in meditative practices, and an instrument for its assessment has recently been proposed. Building on previous findings, this study was designed (1) to test the psychometric properties and perform a validation of a French version of this instrument and (2) to explore the relationship between meditative insight and perceived stress through mediation of irrational beliefs. Self-report data were obtained from a sample of French-speaking meditation practitioners (N = 260). The results confirm the validity and the reliability of the French version of Ireland's Insight Scale (2012), and partially support the hypothesis of the relationship between meditative insight and perceived stress being mediated by irrational beliefs.

Introduction

Meditation is a practice proper to various religious cultures and can be described as a technique involving voluntary control over the body and mind, consequentially impacting different facets of individual's functioning (Wachholtz & Austin, 2013). A large proportion of psychological research on meditation has been implemented on Buddhist practices and on the secular techniques derived from those practices, such as mindfulness-based stress reduction (Kabat-Zinn, 1990). Applications of mindfulness meditation have been studied in relation to anxiety and

depression (Hofmann et al., 2010), pain (Rosenzweig et al., 2010), substance abuse (Brewer et al., 2009), and have among other benefits demonstrated positive effects on well-being (Carmody & Baer, 2008). Most of the studies are based on decontextualised or re-contextualised clinical applications of meditation, and focus primarily on mindfulness, broadly defined as moment-to-moment, non-judgemental awareness (Kabat-Zinn, 1990) as a critical component of the practice. Mindfulness constitutes an important mechanism of meditation effectiveness, but it is not the only factor of meditative practice with the potential to benefit. Buddhist tradition as a "blend of religion, spirituality, and psychology" (Kristeller & Rapgay, 2013, p. 635) has much more to offer to improve the psychological functioning and alleviate suffering. Experiential insight into Buddhist philosophy is a surprisingly understudied factor in meditation research, which requires further investigation.

Meditative insight

Definition

Ireland (Ireland, 2012) defined insight as "an ongoing cumulative process of cognitive change characterised by an experiential sense of understanding and discernment into the nature of all things as being inherently impermanent, without independent self-existence, and through attachment, the cause of suffering" (p. 81). This conceptualisation is based on traditional Buddhist teachings, where the development of wisdom, and thus both intellectual and experiential comprehension of doctrinal tenets is an important step for attaining liberation (Jackson, 2004). Insight consists of grasping through personal experience the three marks of existence, defined as impermanence (Pāli: anicca), suffering (Pāli: dukkha), and not-self (Pāli: anattā) (Pranke, 2004). Thus, gaining insight is not based on a conceptual practice or belief, but on the experiential knowledge obtained through different kinds of Buddhist practices, such as meditation.

In the proposed definition, insight is considered a cumulative cognitive change. This understanding is proper for the Theravada tradition, where gaining wisdom is a gradual development through the classical stages of insight (Goldstein, 2013). In the Zen tradition, on the other hand, insight (satori) is described as a sudden experience, a flash into consciousness (Suzuki, 1991). The unifying feature of insight-wisdom experience in both traditions is the apparent shift in the worldview, or acquisition of a new viewpoint, which further deepens with the practice.

Ireland (Ireland, 2012) underlines an important difference that exists between the mainstream psychological interpretation of insight and the understanding of this concept in Buddhist philosophy. A similar idea is accentuated by Austin (Austin, 2009), who stresses that Buddhist insight should be differentiated from the moment of realisation of a new solution, or an ordinary insight.

Relation to mindfulness

In traditional Buddhist context, both mindfulness (Pāli: sati) and insight-wisdom make part of the Eightfold Noble Path, leading to liberation. But whereas mindfulness practice consists of bringing to mind mental and bodily states and their observation with clear awareness (Gómez, 2004), and as such is not directly linked to doctrinal tenants, insight represents a radical review of reality and is closely linked to Buddhist agenda. According to Bodhi (Bodhi, 2011), mindfulness prevails in the initial stage of the practice, but later a cognitive component is added: a clear comprehension of the nature and qualities of phenomena as defined by the doctrine. A meditator "not only observes phenomena but interprets the presentational field in a way that sets arisen phenomena in a meaningful context" (p. 22). Mindfulness as a state of non-attachment and non-clinging contributes to gradual growth of wisdom (Gunaratana & Gunaratana, 2011).

In psychological research, Ireland (Ireland, 2012) makes a clear distinction between the two concepts, stating that though mindfulness and insight are

overlapping, they still are distinctive constructs. He goes further by providing partial support to the hypothesis that insight mediates the effect of mindfulness on psychological health.

Measurement of insight

The first attempt to capture the experience of insight through self-report was undertaken by Ireland (Ireland, 2012), who developed a four-item measure of insight. This instrument was validated in a large online sample (N = 881) of meditation practitioners in 2012.

Theoretical framework and research context

Conceptually, the author of this questionnaire suggests that insight does not influence psychological health directly, but through a change in the view, which leads to more adaptive functioning (Ireland, 2012). Thus, the next step in research would be to test mediators in the relationship between insight and indicators of psychological health. Stress reduction is one of the most recurrent benefits of meditation practice (Astin, 1997; Shapiro et al., 2008), and theoretically can be linked to a change of view caused by insight. The change of perspective, allowing less rigid perception of others and the world is close to the outcomes of Rational Emotive Behaviour Therapy (REBT) (Ellis, 1962), which has for its aim reduction of irrational beliefs. Drawing on those elaborations, we propose to test a model in which insight is related to perceived stress through the mediation of irrational beliefs.

Insight as a cognitive schema and perceived stress

Perceived stress is usually defined as a degree to which situations in one's life are appraised as stressful (Cohen et al., 1983). The appraisal process can be affected by personal schemas (Clark & Beck, 2011), that represent cognitive structures of knowledge impacting the way in which new information is processed (Fiske & Linville, 1980). Schemas are being constructed for different domains, and can be

modified by experience or cognitive intervention. It is proposed that ideas and beliefs derived from religious sources create influential schemas (McIntosh, 1995), a specific worldview which further impacts the way events are appraised, even in the absence of the environmental bases which construct this schema (Taylor & Crocker, 1981). In this context, insight-wisdom can be described as a specific worldview, a cognitive schema created on the basis of personal experience of the ideas of Buddhist doctrine. As Teasdale and Chaskalson (Teasdale & Chaskalson, 2011) put it, "The new view, or "lens", that embodies this insight, having once been created and used, could be stored as a new schematic mental model in long term implicational memory, ready to be accessed when a thematically similar situation arose in the future." (p. 20).

Cognitive schemas play an important role in the appraisal of stressful events. For example, in a study on Buddhist coping, "right understanding" of the Buddhist concepts of impermanence, suffering, and no-self was mentioned as the main source of coping with stress (Phillips et al., 2009). Olendzki (Olendzki, 2010) outlines the ways in which insight into Buddhist dharma can alter perception of events: getting insight into impermanence facilitates acceptance of change, capturing the notion of suffering helps to encompass distress rather than avoiding it, not clinging to the idea of a stable self gives a possibility to de-centre and thus gain freedom from self-inflicted suffering. Buddhist wisdom offers a radically new worldview, which can be particularly beneficial for stress-related problems.

Irrational beliefs

One of the ways through which an acquisition of the worldview based on insight-wisdom might impact perceived stress is a change in irrational beliefs. The term "irrational beliefs" was introduced by Ellis (1962) to describe beliefs representing rigid demands about the world and oneself. Those beliefs are dysfunctional, linked to poor adjustment (Ellis et al., 2009), emotional distress

(Smith, 1982), and affect stress appraisals (David et al., 2002). REBT, elaborated by Ellis (Ellis & Dryden, 2007), has for its goal reduction of irrational beliefs and elimination of distortions in the view. The same is applied for the process of developing the right view in Buddhism: experiential understanding of Buddhist doctrine is a necessary step towards a non-distorted vision of reality. The similarities between the two approaches were acknowledged by Ellis himself (Ellis et al., 2009), and analysed later by Christopher (Christopher, 2003), who gives a comprehensive comparison between REBT and Buddhist psychology. Irrational beliefs are closely connected with the notion of self, and Buddhism challenges the belief in a rigid and unchangeable core. Acquisition of wisdom-insight modifies the ego system, contributing to the deconstruction of the self (Epstein, 1988), and replacing ego-connected cognitive experiences of grasping with equanimity (Olendzki, 2006).

Present study

The aims of this study were (1) to validate a French version of the Insight Scale (Ireland, 2012) and test its psychometric properties, and (2), for the first time, to test the relationship between insight and perceived stress through mediation of irrational beliefs. We hypothesise that (a) the one-factor model of the questionnaire proposed by Ireland (Ireland, 2012) will be confirmed; that (b) similarly to the original scale, the French version will have high internal consistency and that (c) it will demonstrate construct and criterion validity: insight will be distinct from social desirability and age and close to the concept of mindfulness, insight will increase as a function of length and frequency of meditation practise; insight will predict several indicators of psychological health; (d) the predictive validity of insight will remain significant even after controlling for mindfulness. For our second more conceptual aim we predicted that the relationship between insight and perceived stress will be mediated by irrational beliefs.

Method

Participants and procedure

Two hundred sixty meditation practitioners mostly from France (76.2%) took part in this study (62.7% female). Age of participants ranged between 17 and 78 years (M = 47.69, SD = 11.81). The most represented meditation type was Insight or Vipassana (35.8%), followed by meditation of Hindu tradition (20.4%), and Zazen (18.8%). The majority of participants (60.8%) reported substantial meditation experience (more than 24 months); the most recurrent frequency of meditation practice (29.6%) was 3–4 hours per week. The survey was uploaded onto, and administered by the online survey platform Survey Monkey, and the link was sent by email to meditation centres, as well as promoted online in forums and groups related to meditation. Participants were not given remuneration for their participation, but had a chance to win 200 Swiss francs at the end of the data collection.

Study instruments

The Insight Scale (Ireland, 2012) is a four-item measurement of experience of insight into the Buddhist concepts of impermanence, suffering, not-self, and emptiness. Participants use a five-point scale ranging from 0 (not at all) to 4 (to a great extent) to indicate the extent to which their meditation practice allowed them to experience the insight into "The suffering caused by attachment to phenomena and experiences including the ego/personal identity" (Item1); "The conditional and relative nature of phenomena and experiences including the ego/personal identity" (Item 2); "The impermanent nature of phenomena and experiences including the ego/personal identity" (Item 3); and "The emptiness and/or oneness which

underlies phenomena and experiences including the ego/ personal identity" (Item 4).

In order to accomplish a transcultural validation of the instrument, the instructions for this kind of validation outlined in literature (Sousa & Rojjanasrirat, 2011) were followed. Items of the Insight Scale were translated into French by two bilingual experts, and an initial version was elaborated. Further, the initial French version was back-translated into English and evaluated by two other experts. Discrepancies between the original version and the back-translation were discussed in a meeting organised by the first author, who supervised the translation process. The differences in the translation were slight. The French variant of the measurement was pre-tested by 10 French-speaking meditation practitioners, who were instructed to give comments about the items and instructions.

Meditation experience was measured by the time participants had practiced meditation (in months), and by frequency of meditation per week (in hours).

Mindfulness. The trait mindfulness was measured with the Mindful Attention Awareness Scale (Brown & Ryan, 2003). It is a 15-item instrument for the assessment of dispositional mindfulness. Participants rate the statements in a six-point scale ranging from 1 (almost always) to 6 (almost never).

Well-being was assessed using the five-item World Health Organisation Well-Being Index (Bech et al., 2003), which measures the level of well-being during the last 14 days. Items are scored on a six-point scale ranging from 0 (not present) to 5 (constantly present).

Subjective happiness was assessed with the Subjective Happiness Scale (Lyubomirsky & Lepper, 1999), a four-item measure of global happiness. Items with different response possibilities are scored on a seven-point scale.

Life satisfaction was assessed with the Satisfaction with Life Scale (Diener et al., 1985), a five-item measure of global life satisfaction. Items are rated on a seven-point scale from 1 (strongly disagree) to 7 (strongly agree).

Resilience was measured with the Brief Resilience Scale (Smith et al., 2008), a six-item measure of the ability to bounce back or recover from stress. Item responses range from 1 (strongly disagree) to 5 (strongly agree).

Anxiety and depression were measured with the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983). It is a 14-item measure with seven items corresponding to anxiety, and seven items to depression. Items with different variants of responses are scored from 0 to 3, for example, from 0 (not at all) to 3 (very often).

Perceived stress was measured with the Perceived Stress Scale (Cohen et al., 1983). It is a 10-item measure of the degree to which situations in one's life are appraised as stressful. Items are scored from 0 (never) to 4 (very often).

Irrational Beliefs were assessed with the Belief Scale (Malouff & Schutte, 1986), a 20-item measure of irrationality. The instrument is based on 10 irrational beliefs described by Ellis and Harper (1975). The level of agreement with each belief is rated on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Social desirability responding was measured with the short version of Marlowe–Crowne Social Desirability Scale, elaborated by Strahan and Gerbasi (Strahan & Gerbasi, 1972). The instrument consists of 10 true–false items and measures the tendency to be viewed favorably.

Statistical procedures

Factorial validity of the French version of Insight Scale was performed with Confirmatory Factor Analysis (within the Structural Equation Modeling framework) in SPSS Amos (Arbuckle, 2014), preceded by a check of univariate and multivariate

normality. The internal consistency was measured with the Cronbach, Spearman–Brown, Guttman Split-Half formulas. Convergent and discriminative validity were assessed using partial correlation with unrelated and overlapping constructs. To assess predictive validity, hierarchical multiple regression was performed. Mediation analysis was run with SPSS Process (Hayes, 2012).

Results

Validation of a French version of the Insight Scale (Ireland, 2012)

Preliminary analyses

Missing values (.6%) were computed using expectation – maximisation algorithm. Most variables were not normally distributed (significant Kolmogorov–Smirnov and Shapiro–Wilk for most variables), but the analyses of histograms and normal Q–Q plots suggested that non-normality was not severe. In order to deal with non-normal data, wildly applicable resampling method of bootstrap (Efron & Tibshirani, 1994) was applied. Bias corrected and accelerated confidence intervals (BCa CI) are reported in brackets. Internal consistency of variables and their correlation with insight are presented in Table 1.

Factor structure

Data are required to have multivariate and univariate normality for SEM analyses. Preliminary analyses suggested both univariate and multivariate non-normality. Critical values of skewness for all variables, and of kurtosis for two variables deviated from the cut-off value of 2 (Field, 2009). Value of multivariate kurtosis (Marida's coefficient) was 11.17, which was bigger than the cut-off value of 3 (Yuan et al., 2002) suggesting violation of multivariate normality. Maximum likehood method of estimation is based on the assumption of multivariate normality,

therefore maximum likelihood estimation extraction with Bollen–Stine bootstrapping was employed (Bollen & Stine, 1992).

It is suggested to report several indices of model fit (McDonald & Ho, 2002). The included indices are $\chi 2$: non-significant p value demonstrates good model fit; goodness of fit index: values between 0 and 1, with a value of .80 as a minimum (Cole, 1987); comparative fit index: range from 0 to 1, with larger values indicating better fit; the normed fit index: range between 0 and 1, values of .95 or greater indicating a good model fit; the Tucker–Lewis index: values over .90 or over .95 are considered acceptable (Hu & Bentler, 1999); and the root mean square error of approximation (RMSEA) (should be less than .08, ideally below .05 (Browne & Cudeck, 1993)

The model had good fit indices, except of RMSEA (Table 2), which sometimes rejects valid models in small sample sizes (Hu & Bentler, 1999). Standardised regression weights for four indicators were significant at $p < .001$ (Item1 = .84; Item 2 = .86; Item 3 = .86; Item 4 = .69).

Table 2. Fit index values for one factor model.

Model	Goodness of fit Measures						
	χ^2	*df*	GFI	CFI	NFI	TLI	RMSEA
	11.86[a]	2	0.97	0.98	0.98	0.95	0.14

Note: [a] Bollen-Stine p = 0.6; *df*= degree of freedom; GFI = goodness of fit index; CFI = comparative fit index; NFI = normed fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.

Table 1. Internal consistency of variables and correlations with insight.

	α	pr^a [BCa CI]
Insight	0.88	
Perceived Stress	0.87	– 0.30^{***} [– 0.43, – 0.17]
Anxiety	0.81	– 0.30^{***} [– 0.41, – 0.17]
Depression	0.62	– 0.15^{*} [– 0.26, – 0.14]
Mindfulness	0.89	0.33^{***} [0.19, 0.44]
Well-being	0.88	0.23^{***} [0.10, 0.34]
Life Satisfaction	0.87	0.23^{***} [0.10, 0.36]
Resilience	0.81	0.25^{***} [0.12, 0.36]
Subjective Happiness	0.85	0.24^{***} [0.12, 0.36]
Social Desirability	0.60	– $0.05^{ns,b}$

Note: [a] Partial correlation controlling for social desirability with 95% BCa CI reported in the brackets; [b] simple zero-order correlation. ns = not significant ($p > .05$), * $p < .05$, ** $p < .01$, *** $p < .001$. Bootstrap results are based on 1000 bootstrap samples

Internal consistency

Internal consistency for the four items of Insight Scale was high ($\alpha = .88$, Spearman–Brown = .85, Guttman Split-Half = .85).

Construct validity

Consistent with the findings of Ireland (Ireland, 2012), the construct of insight was distinct from social desirability and age (discriminative validity) and close to the concept of mindfulness (convergent validity). After controlling for meditation experience and frequency of meditation practice, neither age ($r = –.02$, $p = .74$), nor socially desirable responding ($r = –.06$, $p = .3$) correlated with insight, confirming unrelatedness of those constructs. With social desirability being controlled, insight was highly correlated with trait mindfulness $r = .33$, $p < .001$, 95% BCa CI [.19, .44].

Criterion validity

Significant correlation between meditation experience and insight ($r = .34$, $p < .001$, 95% BCa CI [.22. .44]), and frequency of meditation practise and insight ($r = .22$,

$p < .001$, 95% BCa CI [.10, .35]) confirmed hypotheses that insight increases as a function of length and frequency of meditation practise.

Scores of insight predicted several indicators of psychological health. Hierarchical multiple regression was implemented. On the first step demographic variables were included (income, social desirability, age, gender), and on the second step insight. Insight predicted variance in perceived stress, anxiety, depression, well-being, life satisfaction, resilience, and happiness (Table 3(a) and 3(b)). The effect is, however, small: insight accounted for 2–7% of the variance in the outcome variables.

Predictive validity was further investigated by adding mindfulness on the step two in the regression model. Insight and mindfulness are overlapping constructs, but it was hypothesised that insight would account for additional variance in indicators of psychological health, after controlling for mindfulness. Our hypothesis was only partially confirmed: after controlling for mindfulness, insight remained significant predictor of life satisfaction: B = .71, 95% BCa CI [.10, 1.41], $t(259) = 2.26$, $p < .5$, and anxiety: B = –.36, 95% BCa CI [–.73, –.02], t (259) = –2.11, $p < .5$.

Relationship between insight and perceived stress through mediation of irrational beliefs

The hypothesis that the effects of insight on perceived stress is partially mediated by irrational beliefs was confirmed.

To check if the conditions for mediation analysis are fulfilled, regression analyses were conducted to assess each component of the model. Insight was negatively associated with Irrational Beliefs: B = –2.78, 95% BCa CI [–4.26, –1.18], $t(259) = –3.10$, $p < .001$; Irrational Beliefs were positively associated with Perceived Stress: B = .35, 95% BCa CI [.29, .41], $t(259) = 10.45$, $p < .001$; and Insight was negatively associated with Perceived Stress: B = –2.02, 95% BCa CI [–3.04, –1.05], $t(259) = – 4.53$, $p = .001$.

There was a significant indirect effect of Insight on perceived stress: B = –.92, 95% CI [–1.54, –.45]. This represents a medium effect: κ2 = .13 95% CI [.07, .21] (Preacher & Kelley, 2011) (Figure 1).

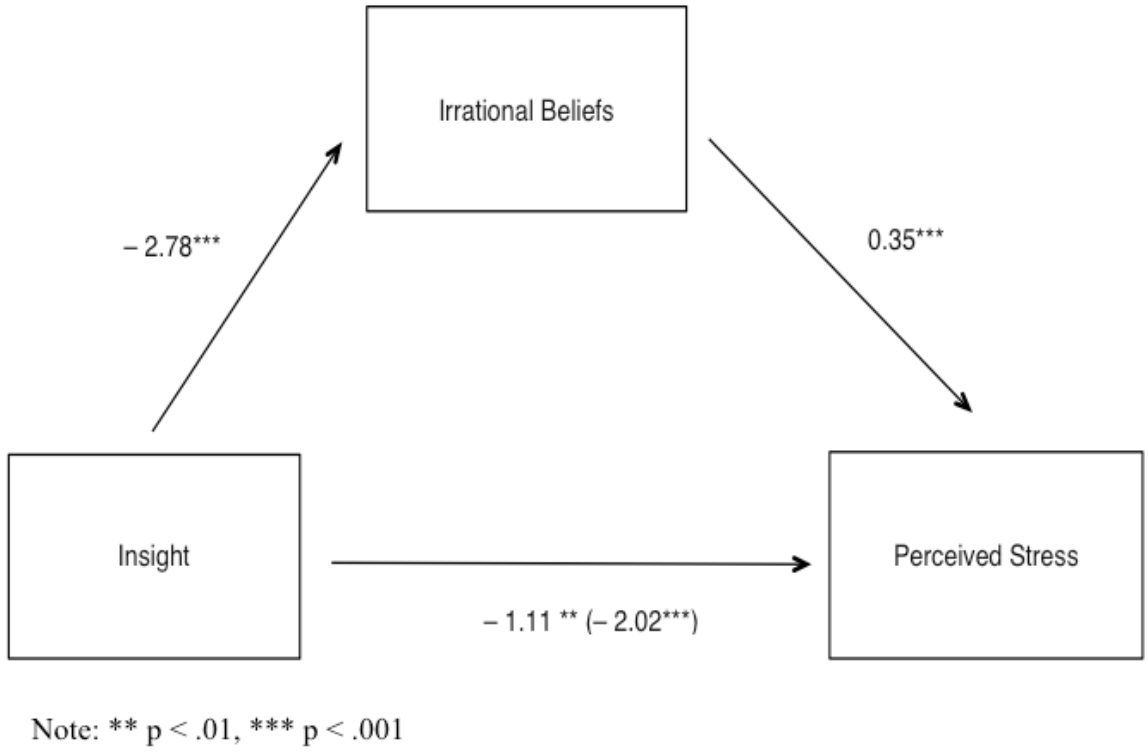


Figure 1. Indirect effect of Insight on Perceived Stress through Irrational Beliefs.

Discussion

In this study, a French version of the Insight Scale has been validated, and the psychometric properties of the translated version have been tested. As hypothesised, a onefactor model was confirmed, and the measure demonstrated high internal consistency. In line with the work of Ireland (Ireland, 2012), the construct of insight has been shown to be distinct from social desirability, and age, and close to mindfulness. It has been demonstrated that insight increases as a function of length and frequency of meditation practise and predicts several indicators of psychological health. We expanded the exploration of the predictive validity of the measurement

by controlling mindfulness in regression analyses, and the results provide preliminary support for the idea that insight brings additional benefits to psychological health. Further, we tested the relationship between insight and perceived stress. Our hypothesis has been partially confirmed: irrational beliefs partially mediated the relationship between insight and perceived stress. Those results provide initial understanding of the ways through which insight impacts psychological health. Together with the work of Ireland (Ireland, 2012), this study provides initial evidence that insight-wisdom represents an additional mechanism of meditation effectiveness and can be captured through self-report. Further directions for the research on meditative insight are outlined below.

Further development of the instrument

Considering the present study, Ireland's (Ireland, 2012) Insight Scale has now demonstrated consistent psychometric properties in two cross-cultural samples. However, the measurement requires further development. First of all, a longer version of the scale is desirable, as every predictor is expressed through only one item. The challenge of such an endeavour will consist in formulating the items in such a way, that they will be closely connected to the Buddhist understanding of constructs of impermanence, suffering, not-self, and emptiness, and will not be confused with the ordinary meanings of those concepts. For example, Buddhist notion of suffering (dukkha) has important semantic differences with the ordinary understanding of the notion expressed by the same word. In addition, items measuring other wisdom-related concepts, such as dependent origination, could be added to the instrument. Secondly, as proposed by the author of the original scale (Ireland, 2012), an attempt should be made to elaborate a version of measurement for use in the population of meditators in clinical settings. But it is important to take into consideration the problems with the measurement of mindfulness, where

elaborated instruments neglected the richness and depth of the Buddhist concept, and as a result lead to significant biases (Grossman et al., 2004; Grossman & Van Dam, 2011).

Insight and stress

Besides its psychometric aim, the present study also revealed some novel conceptual results. Specifically, our data demonstrated that insight is connected to perceived stress through mediation of irrational beliefs. Our mediation hypothesis was partially confirmed, therefore the impact of Buddhist philosophical tenets on perceived stress should be further explored by testing other mediators in the relationship between insight and perceived stress. It is, for example, recommended to explore whether the acquisition of insight alters primary cognitive appraisals and has an impact on the reappraisal process and coping. According to the cognitive models of religious coping (Dull & Skokan, 1995; Newton & McIntosh, 2010), worldviews constructed on the basis of postulates from religious sources can have an impact on the complex process of stress and coping. The next stage of exploration of the relationship between insight and stress may be the use of experimental and longitudinal designs, in which the link between acquisition of insight-wisdom and stress can be causally established.

Acquisition of insight

Together with the development of measurement and exploration of psychological benefits of insight, future research should address the problem of acquisition of insight. The important questions are: whether meditation is a necessary tool for gaining insight into Buddhist truths (not all Buddhist traditions use meditation as a primary technique); whether knowing Buddhist doctrine is essential in the process of developing insight or experience gained through

meditation practice may suffice; which other factors contribute to the process of insight acquisition. Most of those questions can be addressed using a combination of experimental and phenomenological methods, a highly needed approach in the research on contemplative practices.

Table 3 (a). Regression analyses of insight

Predictors	Anxiety		Depression		Perceived Stress	
	ΔR^2	B^a [BCa CI]	ΔR^2	B^a [BCa CI]	ΔR^2	B^a [BCa CI]
Step one	0.13^{***}		0.06^{**}		0.13^{***}	
Age		– 0.03^{ns} [– 0.07, 0.00]		0.00^{ns} [– 0.01, 0.04]		– 0.06^{ns} [– 0.13, 0.02]
Income		– 0.12^{ns} [– 0.27, 0.03]		– 0.18^{*} [– 0.35, – 0.04]		– 0.26^{ns} [– 0.62, 0.07]
Gender[b]		0.90^{*} [0.08, 1.76]		– 0.44^{ns} [– 1.23, 0.31]		1.12^{ns} [– 0.69, 2.85]
SDR[c]		– 0.44^{**} [– 0.63, – 0.25]		– 0.28^{**} [– 0.49, – 0.10]		– 1.03^{***} [–1.42, – 0.60]
Step two	0.07^{***}		0.02^{*}		0.07^{***}	
Insight		– 0.90^{***} [– 1.32, – 0.46]		– 0.41^{*} [– 0.83, 0.01]		– 1.97^{**} [– 3.02, – 1.04]
Total F		12.64^{***}		5.29^{*}		12.34^{***}

Note: [a]Unstandardized Beta with 95% BCa CI reported in the brackets; [b]Gender: 0 = Male, 1 = Female; [c]SDR = Socially Desirable Responding
ns = not significant ($p > .05$), * $p < .05$, ** $p < .01$, *** $p < .001$. Bootstrap results are based on 1000 bootstrap samples.

Table 3 (b). Regression analyses of insight

Predictors	Well-being			Life Satisfaction			Resilience			Happiness		
	ΔR^2	B^a [BCa CI]		ΔR^2	B^a [BCa CI]		ΔR^2	B^a [BCa CI]		ΔR^2	B^a [BCa CI]	
Step one	0.11^{***}			0.03^{ns}			0.06^{***}			0.06^{**}		
Age		0.07^{ns}	[– 0.11, 0.24]		0.02^{ns}	[– 0.07, 0.04]		0.01^{*}	[0.00, 0.01]		0.01^{ns}	[– 0.01, 0.02]
Income		0.40^{ns}	[– 0.35, 1.22]		0.28^{ns}	[– 0.07, 0.04]		0.00^{ns}	[– 0.03, 0.03]		0.01^{ns}	[– 0.05, 0.08]
Gender[b]		– 1.69^{ns}	[– 6.00, 2.53]		0.20^{ns}	[– 1.33, 1.48]		0.10^{ns}	[– 0.08, 0.28]		0.05^{ns}	[– 0.22, 0.35]
SDR[c]		2.31^{***}	[1.45, 3.23]		0.30^{*}	[0.26, 0.55]		0.06^{**}	[0.02, 1.00]		0.14^{***}	[0.08, 0.20]
Step two	0.04^{***}			0.05^{***}			0.06^{***}			0.05^{***}		
Insight		3.23^{**}	[1.29, 5.08]		1.16^{***}	[0.49, 1.87]		0.16^{***}	[0.07, 0.24]		0.28^{***}	[0.13, 0.40]
Total F		8.94^{***}			4.60^{***}			6.73^{***}			6.74^{***}	

Note: [a]Unstandardized Beta with 95% BCa CI reported in the brackets; [b]Gender: 0 = Male, 1 = Female; [c]SDR = Socially Desirable Responding
ns = not significant ($p > .05$), * $p < .05$, ** $p < .01$, *** $p < .001$. Bootstrap results are based on 1000 bootstrap samples.

Chapter 4. Effects of two MBIs on the stress response across different systems

Abstract

Evaluating the effects of mindfulness-based interventions (MBIs) on the stress response requires taking into account several factors, such as 1) effects on various response systems, 2) temporal dynamics of the stress response, and 3) program specificity. This study evaluates the stress-attenuating effects of a standard mindfulness-based stress reduction (MBSR) and a second-generation MBI: MBSR with elements of other Buddhist practices (MBSR-B). Nighty-nine healthy volunteers were randomly assigned to the MBSR, MBSR-B, or waitlist control groups. Their stress response was evaluated with the Trier Social Stress Test. Changes in the activity of the hypothalamic-pituitary-adrenal (HPA) axis, sympathoadrenomedullary system, the autonomic nervous system (ANS), and affect were measured during distinct phases of the task. Compared to waitlist control, the stress-attenuated effects of MBIs were detected across almost all systems and both negative and positive affect, with largest effects for the parasympathetic branch of the ANS. Stress-attenuating effects of MBIs for several outcomes were observed already in the anticipatory phase. Stronger effect sizes for MBSR-B for parasympathetic nervous system and negative affect potentially indicate higher effectiveness of the modified program, though a larger sample size is needed to test these preliminary findings.

Introduction

Psychological stressors rooted in the social environment have become an important focus in stress research (Slavich, 2020). Social threats, characterized by a loss of acceptance, conflict, rejection, exclusion or perceived loss of social status, are particularly important in this framework due to substantial empirical evidence of

their negative impact on neurohormonal, immune, and psychological functioning (Dickerson et al., 2009; Kemeny et al., 2004). These types of stressors are increasingly prevalent in daily life, placing the attenuation of social threat perception among the top priorities in individual interventions aimed at in stress reduction.

In recent years, there has been significant research interest in the stress-buffering effects of mindfulness-based interventions (MBIs)—behavioral approaches based primarily on various types of contemplative training originating in the traditional Buddhist context. Development of mindfulness lies in the center of MBIs and can be broadly defined as a process of attending to the present moment with an open attitude and awareness (Creswell, 2017). Apart from the first and most widely known MBI program designed for clinical purposes (the Mindfulness Based Stress Reduction, MBSR; Kabat-Zinn, (Kabat-Zinn, 1990), a number of other evidence-based MBIs of different lengths and ways of administration are currently used (Creswell, 2017). The main focus of most of the MBIs consists in the development of an ability to mindfully observe bodily sensations and thoughts during formal practice (breathing exercises, body scans, stretching exercises) and in daily life. The evidence of stress-buffering effects of MBIs is substantial (Chiesa & Serretti, 2009), but the vast majority of studies employed only self-report measures of stress. Systematic assessment of the effects of contemplative training on the biological changes associated with stress has only recently started. The relationship between meditation practice and the attenuation of the stress response at the physiological level has been found in observational studies comparing long-term meditation practitioners and matched controls (Gamaiunova et al., 2019; Rosenkranz et al., 2016a). Furthermore, a number of intervention studies have focused on the effects of MBIs on stress-related changes in physiological pathways. A recent report (Morton et al., 2020) systematically reviewed the effects of MBIs on the psychophysiological response to acute stress in a framework of a particular stress-inducing paradigm—

the Trier Social Stress Test (TSST; Kirschbaum et al., 1993)). The test, consisting of delivering a speech and doing a mental arithmetic problem in front of a "judging" committee and a camera, which robustly creates a situation of social threat with possible elements of unpredictability, uncontrollability, perceived social status loss, loss of acceptance, or rejection (Dickerson & Kemeny, 2004). This type of stressor is known for its potential to produce considerable physiological responses evoked by the neural axis, the sympathoadrenomedullary (SAM) system, and the hypothalamic-pituitary-adrenal (HPA) axis. The abovementioned review of selected studies allowed for a preliminary evaluation of whether MBIs can reduce physiological reactivity to social threats. The review demonstrated that the stress-buffering effect of MBIs was observed for HPA-axis activity (3 of 12 studies using cortisol measures), for SAM activity (1 of 3 studies using salivary alpha-amylase [sAA]; 2 of 4 studies using blood pressure), and for the Autonomic Nervous System (ANS) (1 of 4 studies using heart rate variability [HRV], a marker of activity of the parasympathetic nervous system [PNS]). Even though results of a recent study demonstrated an association between dispositional mindfulness and heart rate (HR) response to stress (Beshai et al., 2020), the review did not identify any studies showing the effect of MBIs on HR. Furthermore, none of the selected studies assessed the effects of MBIs on pre-ejection period (PEP), an index of beta-adrenergic influences on the heart (Berntson et al., 2017; Sherwood et al., 1990). The index is important for stress research, as it permits to analyze cardiac changes driven only by the sympathetic system. Concerning the subjective evaluation of stress, 70% of studies showed stress attenuation following MBIs. The review demonstrated that most studies largely overlooked the issue of prolonged stress reactivity, as reflected in anticipatory activation and long recovery (Brosschot et al., 2005). Differences among MBIs (in terms of the content, length, and manner of administration) further confound results. In conclusion, the review showed that the results of the studies

investigating the effects of MBIs on the attenuation of the stress response to social-evaluative threat are inconsistent and largely incomplete. To make research in this area more rigorous and address remaining questions, studies must address 1) effects on various response systems, 2) temporal dynamics of the stress response, and 3) program specificity.

Stress response systems

The stress response is a complex and multidimensional process evoked through cognitive-affective integration and neurological triggering of the activation of several physiological pathways (Everly & Lating, 2013). Physiological changes associated with stress have different etiologies. For example, stress-induced changes in HR might result from increased beta-adrenergic sympathetic drive or from diminished parasympathetic vagal effects on the heart, and those responses are not necessarily coupled (Berntson et al., 1991). Similarly, differential responses to the TSST have been observed across different physiological response systems (Nater et al., 2005; Schommer et al., 2003). Methodological differences among studies complicate direct comparisons of the effects. Considering that we still have a poor understanding of what systems are most affected by MBIs, studies that include measures of different physiological response systems and the use of indices that allow to disentangle different response systems are most informative.

Measures of the subjective (affective) concomitants of the stress response should also be expanded: The majority of studies to date has drawn on measures of affective states with negative valence, as the TSST is expected to provoke negative affect. However, a recent qualitative study exploring the subjective experience of long-term meditation practitioners undergoing the TSST demonstrated that participants in the meditation group reported experiences of positive affect (Gamaiunova, Brandt, & Kliegel, 2021). It has been proposed that two separate

motivational substrates and different brain mechanisms underly negative and positive processes (Cacioppo et al., 1997). Self-report evaluations of stress-induced affective changes in MBI research would benefit from independent unipolar measures of both negative and positive affect.

Temporal dynamics of the stress response

Another crucial issue acknowledged in stress research, but not largely explored in relation to MBIs, are the temporal dynamics of the stress response, in particular prolonged physiological activation. The "reactivity hypothesis," which has dominated research for many years, is based on the assumption that the pathogenic effects of stress are primarily linked to strong and frequent bursts of physiological activation in response to distress. This model has been expanded by incorporating stress-induced physiological activation preceding stress or anticipatory reactivity and prolonged recovery once the stress is over (Brosschot et al., 2005). Both the anticipation of stress and the inability to shut off the stress response are risk factors for allostatic load by driving the output of physiological mediators (McEwen, 1998a). The necessity to differentiate phases of the stress response has been emphasized in relation to both the HPA axis (Engert et al., 2013) and the ANS (Linden et al., 1997). Very few studies investigating the effects of MBIs on the stress response to social threat have addressed this question, especially using physiological measures, but the results suggest that MBIs are an important area for future investigations. The effects of MBIs on stress attenuation during anticipation or recovery were observed for emotional reactivity (Britton et al., 2012), cortisol (Hoge et al., 2018), negative affect (Mayor & Gamaiunova, 2015), and cardiovascular measures (Koerten et al., 2020).

Program specificity

First, the comparison of the effects of different MBIs is a top priority in this area due to the increasing evidence of the differential effects of various contemplative programs (e.g., Engert et al., 2017). The expansion of research on MBIs led to the development of different programs that incorporate, in addition to mindfulness, other aspects of Buddhist practice. So-called second-generation MBIs (SG-MBIs) are mindfulness-based programs that more explicitly integrate elements of a larger Buddhist framework, such as philosophy, the cultivation of adaptive mental states, and/or ethical inquiry (Van Gordon & Shonin, 2020). Enhancing standard MBIs with additional elements of Buddhist practice has the potential to increase the stress-buffering effects of MBIs. Three recent developments are noteworthy in this regard:

A first doctrinal areas dealing with questions of distress is the teaching of three marks of existence. The three marks of existence refer to those realizations that must be cultivated: (1) Impermanence (i.e., *anicca*) recognizes that all (substantial) phenomena change momentarily and will eventually cease. (2) Suffering (i.e., *dukkha*) refers to the understanding that all contaminated phenomena are of the nature of suffering. This understanding includes the acknowledgment of all the sufferings inherent to life (e.g., birth, conflicts, illness, death) and that the craving to obtain certain things and avoid others leads to recurrent dissatisfaction (Dambrun & Ricard, 2011). (3) Not-self (i.e., *anattā*) refers to the realization that all phenomena, including the self, lack selfhood and inherent existence (Van Gordon et al., 2017). It has been proposed that understanding the origins of suffering, the transient nature of phenomena and the concept of not-self might participate in the creation of alternative schematic models, which allow us to perceive the experiences as fleeting and independent of the existing self (Teasdale & Chaskalson, 2011). In the context of social-evaluative stress, this alternative schema has the potential to alter the

cognitive processing of a stressor and reduce fixation on the self-image, which is the key factor in the initiation of psychological stress in this context.

A second important element with the potential to increase the stress-reducing effects of MBIs is represented by the cultivation of the Four Immeasurables (i.e., *brahma-viharas*), referring to a set of four affective states encompassing all living beings as objects (Wallace, 2010). The four states underlying the Four Immeasurables are (1) loving kindness (i.e., *mettā*), the wish for a being to be happy; (2) compassion (i.e., *karuṇā*), the wish for a being to be free from suffering; (3) empathetic joy (i.e., *muditā*), the appreciation of the happiness of others; and (4) equanimity (i.e., *upekkhā*), perceiving others as fundamentally equal, without favor, dislike or disregard toward anyone. Programs, including the cultivation of some of the Four Immeasurables (e.g., compassion) have been tested for their ability to attenuate physiological responses to social stress (Arch et al., 2014; Pace et al., 2009). Further, research results suggest that elements of the Four Immeasurables might be particularly related to stress reduction: Comparing the effects of different types of mental training, Engert et al. (2017) demonstrated that only MBIs based on loving kindness and dyad meditations produced a stress-reducing effect.

A third important aspect of the Buddhist framework is ethics. The Buddhist ethical discipline is to refrain from nonvirtuous actions and to engage in virtuous actions. For example, the practice of the ten virtues consists of refraining from three physical (killing, stealing, sexual misconduct), four verbal (lying, harsh words, slandering, idle gossip) and three mental (malice, covetousness, wrong view) actions (Wallace, 2010). It has been proposed that MBIs would benefit from enhancement with ethical components (Monteiro, 2015). The therapeutic effect is hypothesized to be rooted in the purpose of precepts in Buddhist training: ethical elements are prescribed to benefit not only the recipient but also the sender (Lomas, 2017). Observing certain precepts can reduce the occurrence of negative mental states

induced by unskillful action and potentially attenuate perseverative cognition, directly related to prolonged stress activation (Brosschot et al., 2005).

The present study

This study was designed to test the stress-attenuating effects of MBIs by addressing 1) effects on various response systems, 2) temporal dynamics of the stress response, and 3) program specificity. We aimed to investigate the effects of two MBIs on the psychophysiological stress response over distinct temporal stages of the TSST across multiple response systems: HPA-axis, SAM system, both branches of the ANS (SNS/PNS), and negative and positive affect. To account for the temporal dynamics of the stress response, we chose to distinguish three phases of the test: anticipation, task, and recovery. Cortisol was used as an index of the HPA axis activity (Hellhammer et al., 2009), and sAA as an indicator for SAM system changes (Nater et al., 2005). To differentiate the effects on the sympathetic and parasympathetic branches of the ANS, we assessed pre-ejection period (PEP), a sympathetic measure of ANS influence on heart, quantified as the interval from the depolarization of the heart to the ejection of blood through the aortic valve; and the root mean square successive difference (RMSSD), a time domain measure of heart period variability, relatively independent of respiration rate influences (Berntson et al., 2017; Hill et al., 2009). To assess affective changes, we chose unipolar measures of negative and positive affect. MBIs were a standard MBSR and a second-generation MBI, represented by an MBSR with an additional module including elements of other Buddhist practices (MBSR-B).

We hypothesized that (a) compared to a control group, stress-attenuating effects of MBIs would be found across different stress systems, resulting in reduced cortisol and sAA output, a lower magnitude of sympathetic activation and parasympathetic withdrawal, a lesser increase in negative affect and a lesser decrease in positive affect; (b) the MBIs stress-attenuating effect would manifest

beyond task reactivity, resulting in attenuation of stress response across different systems during anticipation and recovery. Furthermore, we aimed to explore whether the stress-attenuating effects of MBSR-B would be larger than those of MBSR.

Methods

Participants

Recruitment of participants for a stress-reduction course was done in the communities of the Lausanne region and the university campus via flyers, online advertisements in a local newspaper, and a promotional website. Interested individuals (N = 182) filled out an online screening survey. The sample size calculation was based on a fixed effect one-way analysis of variance (ANOVA) to detect any group difference in a given outcome variable. The optimal total sample size of N = 72 (effect value of f = 0.4, with a significance level set at α = .05, power 1 - β = .85) was calculated prior to the recruitment using G-Power (Faul et al., 2009). The following inclusion criteria were set as follows: Age 18–40 years, no prior regular practice of meditation (more than 3 hours/week), good command of French language, ability and desire to participate in the group sessions, comply with home assignments, and participation in a one-day retreat. Exclusion criteria consisted of prior participation in the TSST (volunteers were asked whether they participated in psychological experiments and asked to specify which ones), chronic or acute mental or physical disease, addiction to substances, use of medications that interfere with HPA-axis or ANS functioning, severe obesity (BMI>30), smoking more than five cigarettes per day, pregnancy or lactation, and inability to give consent. Out of 182 interested individuals, 52 did not meet the inclusion criteria, and 31 declined to participate. The resulting sample of 99 participants was randomized into the three

experimental groups. Due to attrition, a sample of 62 participants was included in analyses of physiological data and 65 participants in analyses of self-report data (see Fig. 1 for CONSORT flow chart). The individual characteristics of participants included in the analyses are presented in Table 1.

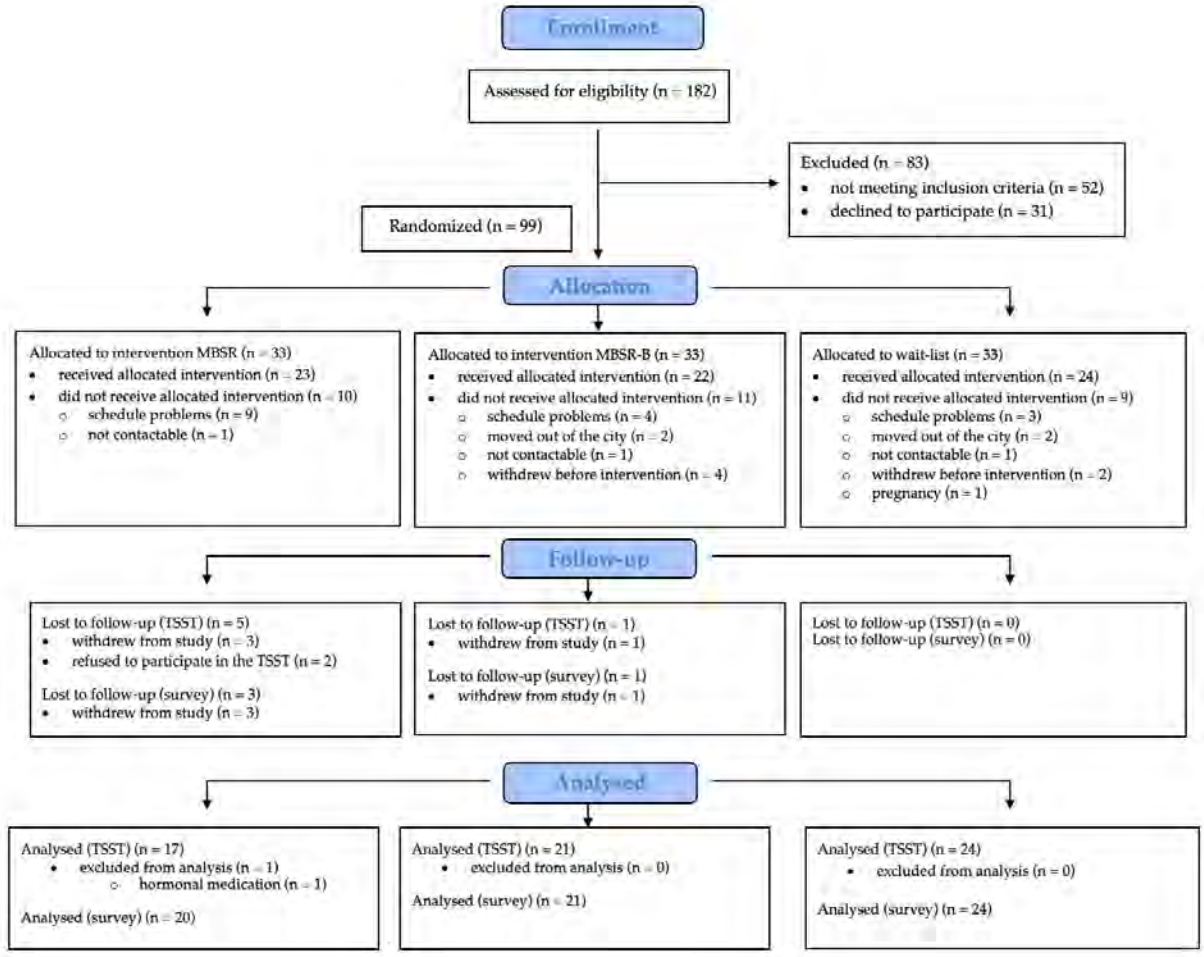


Figure 1. CONSORT flow diagram of participants.

Table 1

Individual characteristics of participants

Individual characteristics	Frequency			χ^2 (*p*)
	MBSR (*N* = 20)	MBSR-B (*N* = 21)	WAITLIST (*N* = 24)	
Sex				81 (.67)
males	6 (30%)	9 (43%)	8 (33%)	
females	14 (70%)	12 (57%)	16 (67%)	
Education				6.64 (.58)
primary school	0	0	0	
secondary school	1 (5%)	0	0	
professional school	2 (10%)	0	2 (8%)	
gymnasium, pedagogical school, school of commerce	1 (5%)	2 (10%)	3 (13%)	
university, polytechnical school, HES	15 (75%)	16 (76%)	18 (75%)	
PhD or other post-grade university degree	1 (5%)	3 (14%)	1 (4%)	
Occupation				12.25 (.06)
student	4 (20%)	8 (38%)	12 (50%)	
paid employment	9 (45%)	10 (48%)	11 (46%)	
self-employed	6 (30%)	1 (5%)	1 (4%)	
unemployed	1 (5%)	2 (9%)	0	
retired	0	0	0	
unable to work (disability)	0	0	0	
Marital status				5.80 (.45)
single	10 (50%)	6 (29%)	12 (50%)	
in a relationship	6 (30%)	11 (52%)	9 (38%)	
married	4 (20%)	4 (19%)	2 (8%)	
divorced	0	0	1 (4%)	
Income (CHF)				.87 (.93)
0-39 999	13 (65%)	12 (57%)	12 (52%)	
40 000 – 79 999	4 (20%)	6 (29%)	7 (31%)	
80 000 – 100 000 and more	3 (15%)	3 (14%)	4 (17%)	
Prefer not to say	0	0	1	
Prior meditation practice				
1 hr/week	1 (5%)	1 (5%)	0	
2 hrs/week	1 (5%)	0	2 (8%)	
Age (years)		*M* (*SD*)		*F* (*p*)
	MBSR	MBSR-B	WAITLIST	
	30.45 (6.14)	28.67 (5.83)	27.21 (4.56)	1.90 (.16)

Procedure

Interested volunteers filled out an online screening survey to determine eligibility. Eligible participants were invited for an in-person visit, where they received additional details on their participation in the study, signed the informed consent, and received a subject ID (assigned sequentially). In order to balance the influence of sex, we performed a stratified randomization (Suresh, 2011): Subjects were assigned to two blocks (male or female), and then simple randomization was performed within each block to assign each participant into one of the three conditions. The randomization plan was created by the first author with the help of an online software (http://www.randomization.com). Enrolled participants were blind to their study condition.

The MBI groups received a link to an online pre-intervention questionnaire two weeks prior to the intervention and were instructed to fill out a printed version of the participant's log daily. After the intervention, participants received a link to an online post-intervention questionnaire and were scheduled for two experimental sessions, the TSST and an emotion regulation task (not presented here). The wait-list control group received the questionnaire link in a similar timeframe.

To account for diurnal variation of cortisol (Labuschagne et al., 2019), the TSST sessions were scheduled between 12 and 16 o'clock; participants were instructed to restrain from caffeine, alcohol, food, and strenuous exercise 2h preceding the session. Female participants were instructed to schedule their sessions during luteal phase of the cycle (Kudielka & Kirschbaum, 2005). On arrival, participants answered questions on their current mood, sleep the previous night, and medication (see Materials). Next, the participant was accompanied to the experimental room and connected to the physiological recording devices (see Materials). The experimenter instructed the participant to sit quietly and relax and left the experimental room for 10 minutes.

To manipulate social-evaluative stress, we used a modified TSST: The anticipation period was increased to 15 minutes in order to assess the pre-performance cortisol stress reactivity (Engert et al., 2013). Two research assistants dressed in white coats and with clipboards entered the room, and the experimenter presented the task. After that, the participant was instructed to fill out questionnaires and was given 15 minutes to prepare for the task. Next, the participant delivered a five-minute speech and performed a five-minute arithmetic task in front of the evaluators and a camera. The evaluators were instructed to maintain a critical attitude and urged the participant to continue if he/she stopped. After the task, the participant was asked to fill out questionnaires and remained connected to the physiological recording devices for 30 more minutes. Taking in consideration that HRV metrics are very sensitive to postural changes (Houtveen et al., 2005), we made a change in the protocol and instructed the participants to remain seated throughout the experiment. Data was collected as followed: Continuously for the ANS measures (time stamps were introduced by the experimenter during the procedure), six saliva samples were taken after the 10-minute rest period, after the anticipation period, in the middle of the task, and 10, 20, and 30 minutes after the task. Subjective rating of the affective stress was collected after rest, anticipation, during the task, after the task, and then 10, 20 and 30 minutes after the task (assessment details are available in Appendix A, Figure A1).

Upon completion of data collection, the experimenter unhooked the participant, took a short interview (not presented here), and completed a full debriefing. The participant was explained the nature of the TSST, presented with the goals of the study, and compensated for their participation.

Materials

Intervention. Participants were randomly assigned to one of three conditions: MBSR, MBSR-B, and wait-list control (WAITLIST). MBSR was administered by an instructor with an official MBSR instructor training (see Instructor). It was composed of a standard program: Eight weekly group sessions (2h30 each), a retreat day during week seven, and guided home practice of 55 minutes per day (Kabat-Zinn, 1990).

The MBSR-B program was a modified version of the MBSR and was designed in collaboration with the MBSR instructor and advanced meditation practitioners in Buddhist traditions. Each week from week one to week six included an additional module targeting a particular concept from broader Buddhist practice: Impermanence (anicca), ethics (sila), loving kindness (metta), compassion (karuna), not-self or disidentification (anatta), and craving (tanna). The introduction of each concept included a short discourse administered during a group session, which was then put into practice during the week through both informal "daily life practices" and a specific meditation practice (except for week one's theme, impermanence, when only the informal practices were used). For example, during week five, not-self was introduced during the group session, and then practiced during the week through 10 minutes of daily, guided formal meditation, as well as informal practices (for instance, being aware of moments of "selfing"). The theme-specific guided meditation and daily life practices were both presented through audio recordings, which could be scheduled by participants (for an overview of the MBSR-B themes, see Apendix A, Table 1).

Instructor. The instructor held Msc in Psychology. His initial training as an MBSR instructor started with Jon Kabatt Zinn's Center for Mindfulness OASIS program (seven-day MBSR with Jon Kabatt Zinn and Saki Santorelli, practicum with Melissa Black and Florence Meleo-Meyer and then Teacher Development Intensive

with the same team). As a part of continuous education, he took part in one workshop a year for ten years, centered upon various aspects and specific methods of mindfulness (between four-seven days per year). He had supervision sessions with Florence Meleo Meyer (seven hours), of Center for Mindfulness and then seven hours with Yuka Nakamura (Center for Mindfulness, Switzerland) which allowed him to be certified as a full member of the Swiss MBSR / MBCT instructors association. He taught more than a hundred eight-week courses over a period of ten years, a few of them within companies or institutions, but most of them for private customers; several dozens all-day silent retreat. He also led about 15 silent meditation retreats for former participants (mostly, three-day long).

Measures.

HPA-axis (cortisol) and SAM system (sAA) stress response. Six saliva samples were collected using Salivate® tubes (Sarstedt Inc.) throughout the experiment. The samples were taken after the rest period at approximately 25 minutes after arrival (pre-TSST), at the end of the 15-minute anticipation period (anticipation), in the middle of the task (task), 10, 20, and 30 minutes after the task (post-task, post-task 2, and post-task 3 respectively). Participants were instructed to place a tube cotton in the mouth, keep it in for a period of two minutes, and return it to the tube without touching it. After the experiment, the tubes were stored in a freezer and shipped in three batches to Dresden, Germany for cortisol and alpha-amylase analyses.

ANS (SNS/PNS) stress response. Electrocardiography and impedance cardiography data were collected continuously throughout the task using a Bionex data acquisition unit from MindWare Technologies (Gahanna, OH) with a sampling rate of 1,000 Hz. Seven spot electrodes were placed on the participant's thorax (Sherwood et al., 1990) and recorded using BioLab software. The data was processed offline using MindWare Technologies IMP 3.1.6 and HRV 3.1.5 analysis software (Gahanna, OH). Segments were inspected by a trained researcher for artifacts and

corrected, if necessary. For the impedance cardiography data, the distance between front electrodes was entered manually into the software and normal R peaks with good corresponding dZ/dt cycles were marked to maintain the expected signal morphology. ANS signals were ensemble averaged using one-minutes epochs, and PEP and RMSSD scores were created as follows: The two last minutes of rest period (pre-TSST), second and third minutes of the anticipation period (anticipation), first minute of speech and first minute of math (task), first two minutes after the task (post-task 1), minutes nine and 10 after the task (post-task 2), and minutes 19 and 20 after the task (post-task 3).

Many forms of contemplative training are associated with changes in breathing (Wielgosz et al., 2016), and the effects of respiration change on stress response can be substantial. Even though RMSSD is considered to be relatively free of respiratory indices (Hill et al., 2009; Tripathi, 2004), we assessed respiration rate (RR), by deriving it from the impedance signal. The scores were created in a similar manner to RMSSD and PEP.

Affective stress response. Negative and positive affect were assessed with a question "How negative/positive are you feeling right now?", with answers on a scale from 0 ("not at all") to 10 ("very much"). The answers were collected after the rest period (pre-TSST), at the end of the anticipation period (anticipation), right after the task (task), and 10, 20, and 30 minutes after the task (post-task 1, post-task 2, and post-task 3, respectively).

Self-report measures.

Individual characteristics. We collected the following individual characteristics: Sex, age, education, current occupation, marital status, and income. Discrete categories are presented in Table 1.

MBSR-B program check. The MBSR-B program contained an additional module, based on a larger Buddhist framework (see Intervention). In order to assess if

participants integrated the materials of the module, we used two measures: (1) the Insight Scale, a validated measure of Buddhist Insight (Gamaiunova et al., 2016; Ireland, 2012), and (2) a questionnaire created based on the content of the module (Buddhist module questionnaire, Appendix A, Table A2). The Insight questionnaire is a short 4-item scale aimed at assessing participants' experiences of insight into the universal characteristics of impermanence, suffering, non-self, and emptiness underlying all phenomena. The instrument was designed to be used in the population of mediators, so the instructions were adapted for use by non-meditators. Cronbach's alpha at pre-test in our sample was .92.

The Buddhist module questionnaire (20 items) focused on three dimensions related to the material taught in the module: First, *wisdom*, containing two items assessing impermanence (e.g., "All things, whether material or mental, are continually changing from moment to moment."), suffering (e.g., "Suffering comes from our afflictive desire to possess and control things."), and non-self (e.g., "There is no permanent and unchanging self, or separate essence in living beings."); second, *brahma-viharas,* containing two items assessing empathetic joy (mudita, e.g., "I appreciate with great joy the success and good fortune of others."), compassion (karuna, e.g., "I have compassion for other beings."), equanimity (upekkha, e.g., "I have an impartial feeling of closeness to all beings, even to strangers and unpleasant people."), and loving kindness (metta, e.g., "I feel love and kindness for all beings."); and third, *right conduct,* containing two items assessing practice of generosity (dana, e.g., "I offer my resources, time and knowledge to others without expecting anything in return."), practice of right speech (samma vaca, e.g., "I engage in trivial conversations, or gossip."), and practice of right action (samma kammanta, e.g., "I intentionally hurt others."). The items were constructed by two authors on the basis of the program content and discussed with advanced Buddhist practitioners.

Internal consistency for the sub scales was acceptable: Cronbach's alpha = .71 for wisdom, .78 for brahma-viharas, and .62 for conduct.

Practice log. Participants were asked to fill out a practice log distributed in paper format before the intervention program. Each week they reported (1) if they participated in a group session; (2) how many minutes they practiced daily; (3) how much effort they put into their practice weekly on a scale from 1 = "no effort" to 10 = "a lot of effort"; and (4) to what extent it was difficult for them to practice on a scale from 1 = "not difficult at all" to 10 "very difficult".

Pre-experimental check. Taking into consideration that both sleep quality and sleep duration can impact experiences of the social environment through alteration of the activity of the HPA axis and SNS (Slavich, 2020), we asked participants to indicate before the TSST session (1) how many hours they slept the night before the experiment and (2) to rate their quality of sleep (from 1 = "very bad" to 5 = "excellent"). To control for the affective state preceding the experiment, participants were asked how they felt at the moment (sleepy, happy, depressed, frustrated, excited), all on a scale from 1 = "not at all" to 5 = "a lot". To account for the previous experiences relating to the task, participants were asked if they had experience in public speaking and mental arithmetic (yes/no).

Analyses

Statistical analyses were performed in R version 4.0.3 Missing values were treated with multiple imputation (MI) method, using R multivariate imputation by chained equation (MICE) package, version 3.9.0 (Buuren & Groothuis-Oudshoorn, 2010). Five imputations were produced with the PMM method using the full predictor matrix. The percentage of the imputed data was 3.6 % for HRV data and 7.3% for the PEP data. All the missing data were caused by a specific instrument failure which, in each occurrence, caused multiple variables to be missing at once. To

test that the data were MCAR (missing completely at random) this specific correlation had to be removed by splitting the data set into several sets containing only a single variable out of the set obtained within a single measurement. Each of these sets was subjected to the Little's MCAR test (implemented in the package naniar 0.6.1) confirming that all the data were MCAR (with the lowest obtained p-value ~ 0.3).

Extreme outliers were identified as values higher than Q3 + 3xIQR or below Q1 – 3xIQR. In the repeated measures analyses of variance (ANOVAs), a Greenhouse-Geisser correction was applied if the assumption of sphericity was violated. To control the Family-Wise Error Rate in multiple testing (several ANOVAs and planned contrasts), we used Holm-Bonferroni approach (Holm, 1979) to adjust the *p*-values while applying the standard alpha level (0.05). Tukey's HSD or Games-Howell (in case of violation of the assumption of equal variance) post hoc tests were used for exploratory analyses of group differences. Analytical procedures for specific variables are outlined below.

Cortisol and alpha-amylase analyses. Salivary cortisol and alpha-amylase data were log10 transformed prior to analyses at the six time points due to significant non-normality. In order to check if different phases of the TSST induced physiological changes across the complete sample, we performed repeated measures ANOVAs. For cortisol, we used pre-TSST, task (mid-task sample reflecting anticipatory reactivity; Engert et al., 2013), and post-task (reflecting reactivity to the task). For alpha-amylase, we used pre-TSST, anticipation, and task (reflecting reactivity to the task).

To compare the effect of training on the TSST-induced changes in salivary cortisol in different periods of the test, we calculated the area under the curve (AUC) with respect to increase (AUCi) for the anticipation, task, and post-task portions of the experiment, using the trapezoid formula (Pruessner et al., 2003). For cortisol, the

anticipation portion of the task is represented by the area from pre-TSST measure to mid-task, and the task portion from pre-TSST to post-task (10 minutes after the end of the TSST). For alpha-amylase, the anticipation portion of the task is represented by the area from pre-TSST measure to end anticipation, and the task portion from pre-TSST to task (measurement in the middle of the TSST). The recovery portion for both outcomes is represented by the area from the post-task to the last measurement (30 minutes after the TSST). To test the training effect on physiological changes, we performed separate multivariate analyses of variance (MANOVAs) for cortisol and alpha-amylase (with anticipation, task, and recovery as dependent variables). In case of a significant MANOVA result, we performed one-way ANOVAs for the respective period (adjusting for multiple testing with the Holm-Bonferroni approach). In case of a significant ANOVA, we continued with planned contrasts, comparing treatment groups to control. Exploratory post-hoc tests were performed to detect any group differences.

ANS analyses. In order to test if different phases of the TSST induced physiological changes across the complete sample, we performed repeated measures ANOVAs. For both PEP and RMSSD, we used pre-TSST, anticipation, and task time points.

To compare the effect of training on the TSST-induced change in PEP and RMSSD in different periods of the test, we calculated relative percent change for physiological variables according to the formula 100*([t2-t1]/t1) for the anticipation, task, and recovery periods of the experiment. The recovery variable for the RMSSD signifies vagal rebound (percent change from pre-test measurement to first two-minutes post-test; (Brigitte M. Kudielka et al., 2004). The post-task variable for PEP signifies change in vascular contractility from pre-test measurement to post-test 3 (minutes 19 and 20 after the task). To test the training effect on physiological changes, we performed separate MANOVAs for PEP and RMSSD (with anticipation,

task, and recovery as dependent variables). In case of a significant MANOVA result, we performed one-way ANOVAs for the respective period (adjusting for multiple testing with the Holm-Bonferroni approach). In case of a significant ANOVA, we continued with planned contrasts, comparing treatment groups to control. Exploratory post-hoc tests were performed to detect any group differences. In order to check for group differences in RR, we computed percent changes as described above and performed a MANOVA for the corresponding variables.

Self-report analyses. Group differences in self-report data were tested using Wilcoxon rank sum test and Kruskal-Wallis test for ordinal data, chi-square tests for categorical variables, and ANOVAs and *t*-tests for continuous variables (in case of violation of homogeneity of variance, robust versions of the tests were applied: Welsh ANOVA or Welsh's *t*-test).

In order to check if different phases of the TSST induced affective changes across the complete sample, we performed repeated measures ANOVAs. We used pre-TSST, anticipation, and task time points.

To compare the effect of training on the TSST-induced changes in negative and positive affect in different periods of the test, we calculated absolute change variables (delta) for the anticipation, task, and recovery periods of the experiment. The recovery variable represents absolute change from task to post-3 measurement (19 and 20 minutes after the task). To test the training effect on affective changes, we performed separate MANOVAs for negative and positive affect (with anticipation, task, and recovery as dependent variables). In case of a significant MANOVA result, we performed one-way ANOVAs for a respective period. In case of a significant ANOVA, we continued with planned contrasts, comparing treatment groups to control. Exploratory post-hoc tests were performed to detect any group differences.

Results

Preliminary analyses

Individual characteristics. The groups did not differ in age, sex, education, occupation, marital status, or income (Table 1).

MBSR-B program check. We used a one-way ANOVA to test the change score from pre to post intervention. MBSR and MBSR-B showed both a larger pre-post increase in Buddhist Insight (measured by the IS) than WAITLIST, but the difference did not reach significance: $F(2, 62) = 0.47$, $p = .63$, $\eta^2_G = .02$ (descriptive statistics are available in Table 2).

Table 2

Group scores changes in Buddhist Insight, wisdom, brahma-viharas, and right conduct

Scale	*M* (*SD*)						Cronbach's α [a]
	MBSR (*N* = 20)		MBSR-B (*N* = 21)		WAITLIST (*N* = 24)		
	pre-test	post-test	pre-test	post-test	pre-test	post-test	
Insight Scale Buddhist module questionnaire	1.89 (1.19)	2.25 (1.09)	2.16 (.94)	2.38 (.64)	1.58 (1.24)	1.63 (1.25)	.92
Wisdom	41.80 (9.83)	42.75 (91.16)	41.62 (7.78)	45.10 (7.16)	41.04 (9.32)	39.54 (8.98)	.71
Brahma viharas	52.55 (11.48)	58.75 (10.30)	52.05 (11.14)	59 (9.40)	56.08 (9.42)	50.71 (12)	.78
Right conduct	49.90 (6.55)	49.10 (7.35)	47.43 (4.96)	49.24 (5.70)	48.79 (6.07)	46.21 (5.37)	.62

Note. [a] Cronbach's alpha at pre-test.

Similarly, both MBSR and MBSR-B showed a pre-post increase in wisdom (greater for the MBSR-B group), while WAITLIST demonstrated a slight decrease. However, the ANOVA test did not reach statistical significance: $F(2, 62) = 2.58$, $p = .08$, $\eta 2_G = .08$ (descriptive statistics are available in Table 2). Regardless the non-significant omnibus test, we ran post-hoc group comparisons in order to explore the effect sizes of group differences. The difference in wisdom scores change between MBSR-B and WAITLIST showed moderate effect size and almost reached statistical significance: $t(35.21) = -2.29$, $p = .03$ (adjusted $p = .06$), $d = 0.69$, the difference between MBSR and WAITLIST showed small effect size: $t(34.72) = -1.16$, $p = .24$, $d = 0.36$. The group difference in *brahmaviharas* change score was statistically significant: $F(2, 62) = 9.10$, $p < .001$, $\eta 2_G = .24$, with MBSR showing greater increase than WAITLIST: $t(38.08) = -3.88$, $p < .001$ (adjusted $p < .001$), $d = 1.18$, as well as MBSR-B showing greater increase than WAITLIST, $t(25.06) = -3.90$, $p < .001$ (adjusted $p < .001$), $d = 1.17$. The group difference in right conduct score change was equally statistically significant: $F(2, 62) = 4.40$, $p = .02$, $\eta 2_G = .12$, but only MBSR-B differed from WAITLIST, $t(39.05) = -2.85$, $p = .007$ (adjusted $p = .01$), $d = .84$.

Practice log. We ran a Wilcoxon rank sum test to determine if the groups differed in the number of weekly sessions attended, and a Student *t*-test to determine if the groups differed in minutes practiced during the course, as well as self-reported difficulty and effort. The median in MBSR was 6 (IQR = 1.25) and in MBSR-B 6 (IQR = 2). The Wilcoxon test showed that the difference was not significant: $W = 220$, $p < .80$, effect size $r = 0.04$. Similarly, groups did not differ in minutes of practice during the course: MBSR ($M = 1503.20$, $SD = 379.94$), MBSR-B ($M = 1704.70$, $SD = 448.87$), $t(39) = -1.55$, $p = .13$, $d = -.48$; effort put into practice: MBSR ($M = 6.24$, $SD = 1.54$), MBSR-B ($M = 6.50$, $SD = .99$), $t(39) = -0.26$, $p = .79$, $d = -.08$; or difficulty of practice: MBSR ($M = 6.23$, $SD = 1.53$), MBSR-B ($M = 6.38$, $SD = 1.62$), $t(39) = -0.29$, $p = .77$, $d = -.09$.

Pre-experimental check. We conducted Kruskal-Wallis tests to determine if there were differences among groups in the number of hours of sleep, perceived sleep quality, and mood. Groups did not differ in the number of hours slept before the experiment: MBSR (*Mdn* = 7), MBSR-B (*Mdn* = 8), and control (*Mdn* = 7), $\chi^2(2) = 1.41$, $p = .49$, $\eta^2[H] = -.01$; perceived quality of sleep: MBSR (*Mdn* = 4), MBSR-B (*Mdn* = 4), and control (*Mdn* = 4) $\chi^2(2) = 2.18$, $p = .34$, $\eta^2[H] < .01$. Similarly, no group difference was detected in affective state before the experiment, with participants reporting comparable levels oF (1) sleepiness: MBSR (*Mdn* = 2), MBSR-B (*Mdn* = 2), and WAITLIST (*Mdn* = 2), $\chi^2(2) = 4.15$, $p = .13$, $\eta^2[H] = .04$; (2) happiness: MBSR (*Mdn* = 3), MBSR-B (*Mdn* = 3), and WAITLIST (*Mdn* = 4) $\chi^2(2) = 3.14$, $p = .21$, $\eta^2[H] = .02$; (3) depression: MBSR (*Mdn* = 2), MBSR-B (*Mdn* = 1), and WAITLIST (*Mdn* = 1) $\chi^2(2) = 4.88$, $p = .09$, $\eta^2[H] = .05$; (4) frustration: MBSR (*Mdn* = 2), MBSR-B (*Mdn* = 1), and WAITLIST (*Mdn* = 1) $\chi^2(2) = 3.92$, $p = .14$, $\eta^2[H] = .03$; and (5) excitement: MBSR (*Mdn* = 2), MBSR-B (*Mdn* = 2), and WAITLIST (*Mdn* = 3) $\chi^2(2) = 1.72$, $p = .42$, $\eta^2[H] < .01$.

A chi-square test for association was conducted among groups to check for differences in the experience of doing public speaking and mental arithmetic. No statistically significant association was found for public speaking: $\chi^2(2) = .19$, $p = .91$ or for arithmetic: $\chi^2(2) = 0.87$, $p = .65$.

Stress induction. To test whether the TSST successfully induced psychobiological changes, we ran repeated-measures ANOVAs followed by post-hoc comparisons with Holm-Bonferroni corrections for the corresponding outcomes, as described in the Analyses section.

The TSST elicited statistically significant changes in salivary cortisol over time, $F(1.46, 89.02) = 11.46$, $p < .001$, $\eta^2_G = .04$. Post-hoc comparisons showed that cortisol significantly increased from pre-TSST ($M = 0.57$, $SD = 0.23$) to anticipation ($M = 0.63$, $SD = 0.28$), $p = .01$, $d = .27$; and from pre-TSST to task ($M = 0.71$, $SD = 0.32$), $p < .001$, $d = .51$ (Figure 2A).

Similarly, the TSST led to statistically significant changes in the sAA over time, $F(2, 124) = 16.60$, $p < .001$, $\eta^2_G = .03$. Post-hoc comparisons revealed that alpha-amylase significantly increased from pre-TSST ($M = 2.03$, $SD = 0.35$) to anticipation ($M = 2.14$, $SD = 0.37$), $p < .001$, $d = .31$; and from pre-TSST to task ($M = 2.16$, $SD = 0.37$), $p < .001$, $d = .36$ (Figure 2B).

The TSST lead to a statistically significant decrease in PEP: $F(1.8, 110.05) = 64.01$, $p < .0001$, $\eta^2_G = .21$, showing a decrease in PEP from pre-TSST ($M = 107.11$, $SD = 11.79$) to anticipation ($M = 99.46$, $SD = 14.16$), $p < .0001$, $d = .59$; and from pre-TSST to task ($M = 89.98$, $SD = 15.18$), $p < .0001$, $d = 1.26$ (Figure 2C).

Similarly, the TSST lead to reduced RMSSD over time, $F(1.35, 82.17) = 16.99$, $p < .0001$, $\eta^2_G = .07$. Post-hoc comparisons showed that RMSSD significantly decreased from pre-TSST ($M = 40.57$, $SD = 120.88$) to anticipation ($M = 36.05$, $SD = 16.12$), $p < .001$, $d = .24$; and from pre-TSST to task ($M = 29.06$, $SD = 13.60$), $p < .0001$, $d = .65$ (Figure 2D).

Affective state also changed as a result of stress induction. Negative affect increased from pre-TSST ($M = 2.19$, $SD = 2.16$) to anticipation ($M = 3.61$, $SD = 2.60$), $p < .0001$, $d = .59$; and from pre-TSST to task ($M = 3.48$, $SD = 2.67$), $p = .004$, $d = .53$; $F(2, 122) = 11.98$, $p < .001$, $\eta^2_G = .06$. Positive affect decreased from pre-TSST ($M = 6.58$, $SD = 1.90$) to anticipation ($M = 5.75$, $SD = 2.31$), $p < .001$, $d = .39$, and from pre-TSST to task ($M = 4.84$, $SD = 2.75$), $p < .001$, $d = .74$; $F(1.6, 97.79) = 24.99$, $p < .001$, $\eta^2_G = .09$ (Figure 2E/F).

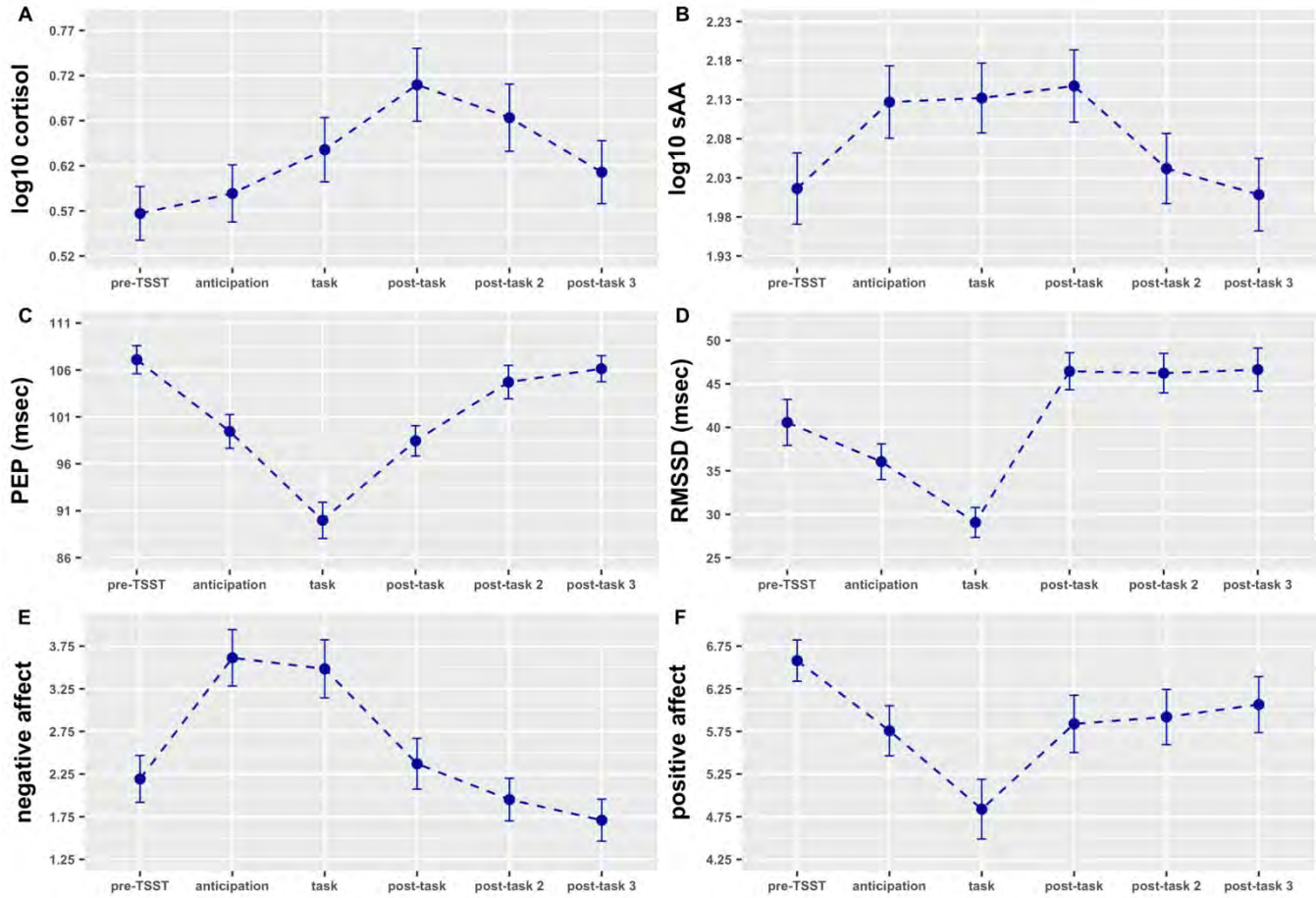


Figure 2. Trier Social Stress Test-related changes in (A) salivary cortisol, (B) sAA, (C) PEP, (D) RMSSD, (E) negative and (F) positive affect. *Note.* sAA = salivary alpha-amylase, PEP = pre-ejection period, RMSSD = root mean square of successive differences, msec = milliseconds.

Main analyses

HPA-axis (salivary cortisol). We performed a one-way MANOVA to determine the effect of MBIs on the TSST-induced changes in salivary cortisol in three periods of the task, indexed by anticipation AUCi, task AUCi, and recovery AUCi. The difference between MBSR, MBSR-B and WAITLIST in dependent variables was statistically significant: $F(6, 112) = 2.34$, $p = .04$, Wilks' $\Lambda = .79$. Follow-up univariate ANOVAs showed that statistically significant differences among the groups could be observed only for the AUCi anticipation: $F(2, 57) = 4.69$, $p = .01$ (adjusted $p = .03$), $\eta 2_G = .14$. Post-hoc *t*-tests demonstrated that during anticipation, MBSR had lower cortisol AUCi than WAITLIST: $t(36.76) = 2.61$, $p = .02$ (adjusted $p = .03$), $d = .82$; the

same pattern was observed comparing MBSR-B group and control, $t(42.87) = 2.60$, $p = .01$ (adjusted $p = .03$), $d = .78$ (Table 3, Fig. 3).

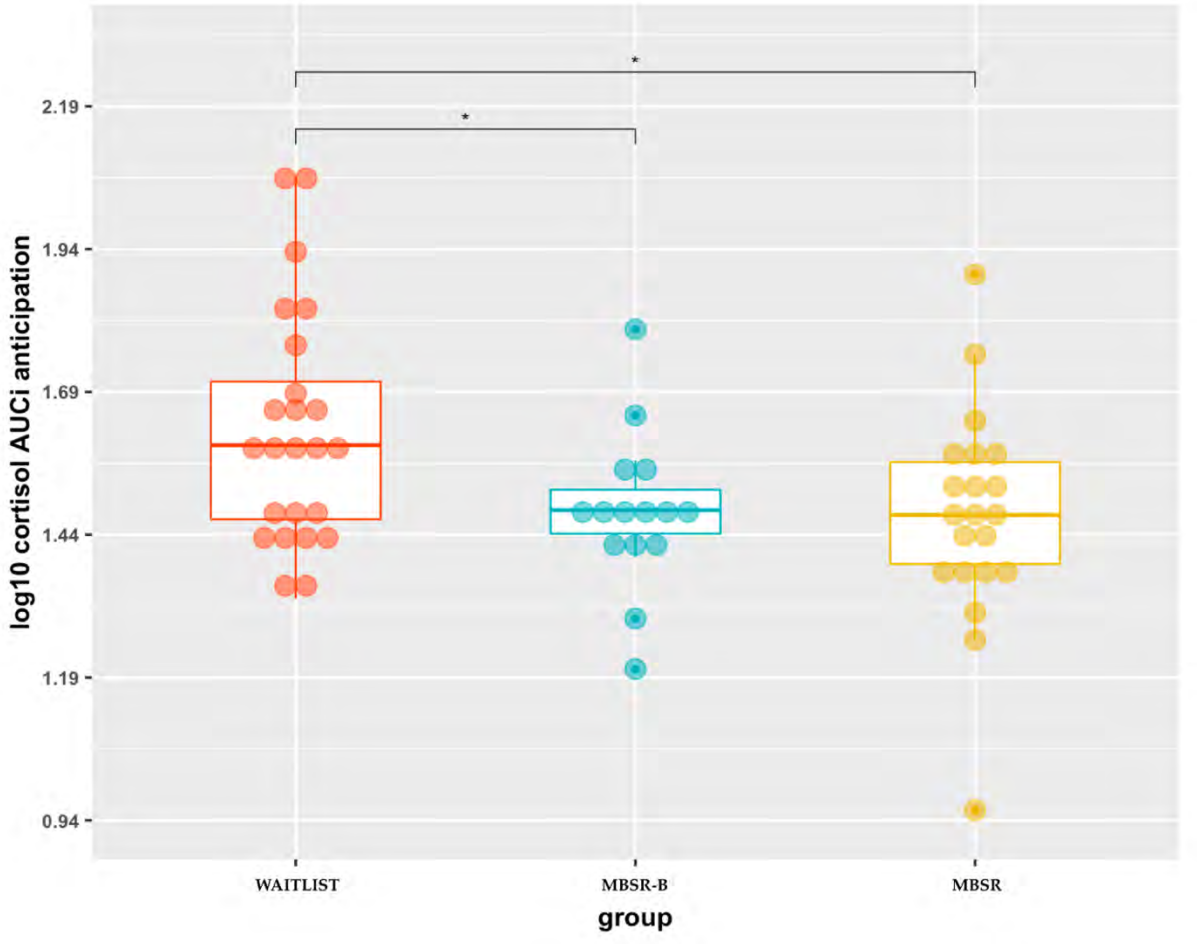


Figure 3. Salivary cortisol AUCi in the anticipation period across three experimental groups. *Note.* AUCi = area under the curve with the respect to increase, WAITLIST = waitlist control group, MBSR = Mindfulness Based Stress Reduction group, MBSR-B = modified Mindfulness Based Stress Reduction group.

SAM system (sAA). We performed a one-way MANOVA to determine the effect of MBI on the TSST-induced changes in SAA in three periods of the task, indexed by anticipation AUCi, task AUCi, and recovery AUCi. The difference between MBSR, MBSR-B, and WAITLIST in dependent variables was not statistically significant, $F(6, 112) = 1.01$, $p = .42$, Wilks' $\Lambda = .90$.

ANS (PEP). We performed a one-way MANOVA to determine the effect of MBIs on the TSST-induced changes in PEP in three phases of the task, indexed by relative percent change from pre-test to anticipation, task, and recovery. The

difference between MBSR, MBSR-B, and WAITLIST in dependent variables was statistically significant, $F(6, 114) = 2.14$, $p = .05$, Wilks' $\Lambda = .81$. Follow-up univariate ANOVAs showed that statistically significant difference between groups could be observed in changes to anticipation $F(2, 59) = 4.69$, $p = .01$ (adjusted $p = .03$), $\eta 2_G = .14$, with MBSR showing lesser relative percent of decrease in PEP than WAITLIST: $t(37.40) = -2.61$, $p = .01$ (adjusted $p = .03$), $d = .82$; the same pattern was observed in MBSR-B, which demonstrated lesser relative percent of decrease in PEP than WAITLIST: $t(40.47) = -2.39$, $p = .02$ (adjusted $p = .03$), $d = .78$. Equally, statistically significant difference between groups could be observed in changes to task $F(2, 59) = 5.17$, $p = .01$ (adjusted $p = .03$), $\eta^2_G = .15$, with MBSR showing lesser relative percent of decrease in PEP than WAITLIST: $t(38.58) = -2.87$, $p = .01$ (adjusted $p = .01$), $d = 0.87$, $d = .82$, as well as MBSR-B showing lesser relative percent of decrease in PEP than WAITLIST: $t(37.20) = -2.37$, $p = .02$ (adjusted $p = .02$), $d = .70$ (Table 3, Fig. 4A). No effect for recovery was observed in either group.

ANS (RMSSD). We performed a one-way MANOVA to determine the effect of mindfulness training on the TSST-induced changes in RMSSD during three phases of the task, indexed by relative percent change in RMSSD from pre-test to anticipation, task, and recovery. The difference between MBSR, MBSR-B and WAITLIST in dependent variables was statistically significant, $F(6, 106) = 2.62$, $p = .02$, Wilks' $\Lambda = .76$. Follow-up univariate ANOVAs showed that statistically significant differences among groups could be observed in changes to all of the three phases. Groups showed statistically significant relative percent decrease in RMSSD from pre-task to anticipation $F(2, 59) = 5.33$, $p = .01$ (adjusted $p = .01$), $\eta 2_G = .15$, with MBSR showing lesser relative percent of decrease in RMSSD than WAITLIST: $t(28.61) = -2.23$, $p = .03$ (adjusted $p = .03$), $d = 0.72$, as well as MBSR-B showing lesser relative percent of decrease in RMSSD than WAITLIST: $t(25.49) = -2.88$, $p = .01$ (adjusted $p = .02$), $d = 0.88$. Equally, statistically significant differences between groups could be observed

in changes to task $F(2, 59) = 7.23$, $p < .01$ (adjusted $p < .01$), $\eta 2_G = .20$, with MBSR showing lesser relative percent of decrease in RMSSD period than WAITLIST: $t(25.71) = -2.56$, $p = .02$ (adjusted $p = .02$), $d = 0.84$, as well as MBSR-B showing lesser relative percent of decrease in RMSSD than WAITLIST: $t(25.06) = -3.41$, $p < .01$ (adjusted $p < .01$), $d = 1.05$. Similarly, group changes were observed in recovery $F(2, 55) = 7.43$, $p < .01$ (adjusted $p < .01$), $\eta^2_G = .21$, but only the MBSR-B group showed a statistically significant difference from the WAITLIST: $t(26.20) = -3.51$, $p < .01$ (adjusted $p < .01$), $d = 1.10$ (Table 3, Fig. 4B). In order to check whether the groups differed in RR, we performed a one-way MANOVA (with relative percent change in RR from pre-test to anticipation, task, and recovery as dependent variables). The difference between MBSR, MBSR-B and WAITLIST in dependent variables was not statistically significant, $F(6, 114) = 0.70$, $p = .65$, Wilks' $\Lambda = .93$.

Affect. We performed a one-way MANOVA to determine the effect of mindfulness training on the TSST-induced changes in negative and positive affect during the three phases of the task, indexed by absolute change from pre-test to anticipation, task, and recovery. The difference between MBSR, MBSR-B, and WAITLIST in dependent variables was statistically significant for both negative affect $F(6, 114) = 2.61$, $p = .02$, Wilks' $\Lambda = .77$ and positive affect $F(6, 112) = 2.36$, $p = .03$, Wilks' $\Lambda = .79$.

Follow-up univariate ANOVAs showed that groups showed a statistically significant difference in increase in negative affect from pre-task to anticipation $F(2, 59) = 4.84$, $p = .01$ (adjusted $p = .02$), $\eta 2_G = .14$, with both MBI groups showing lesser increase in negative affect, but only MBSR-B showing a statistically significant difference with WAITLIST: $t(39.24) = 3.29$, $p < .01$ (adjusted $p < .01$), $d = 0.97$ (Table 3, Fig. 4C). Equally, statistically significant differences between groups could be observed in changes to task $F(2, 59) = 6.82$, $p = .01$, $\eta 2_G = .19$, with MBSR showing lesser increase in negative affect than WAITLIST: $t(38.96) = 3.10$, $p = .02$ (adjusted $p =$

.02), $d = 0.95$, as well as MBSR-B showing lesser increase in negative affect than WAITLIST: $t(37.91) = 2.99$, $p = .01$ (adjusted $p = .01$), $d = 88$ (Table 3, Fig. 4C).

Concerning positive affect, a statistically significant group difference was observed only in changes to the task period: $F(2, 59) = 6.51$, $p = .01$, $\eta 2_G = .18$, with MBSR showing lesser positive affect decrease than WAITLIST: $t(35.91) = -3.01$, $p = .01$ (adjusted $p = .01$), $d = 0.95$, as well as MBSR-B showing lesser positive affect decrease than WAITLIST: $t(42.99) = -3.06$, $p < .01$ (adjusted $p = .01$), $d = 0.91$ (Table 3, Fig. 4D).

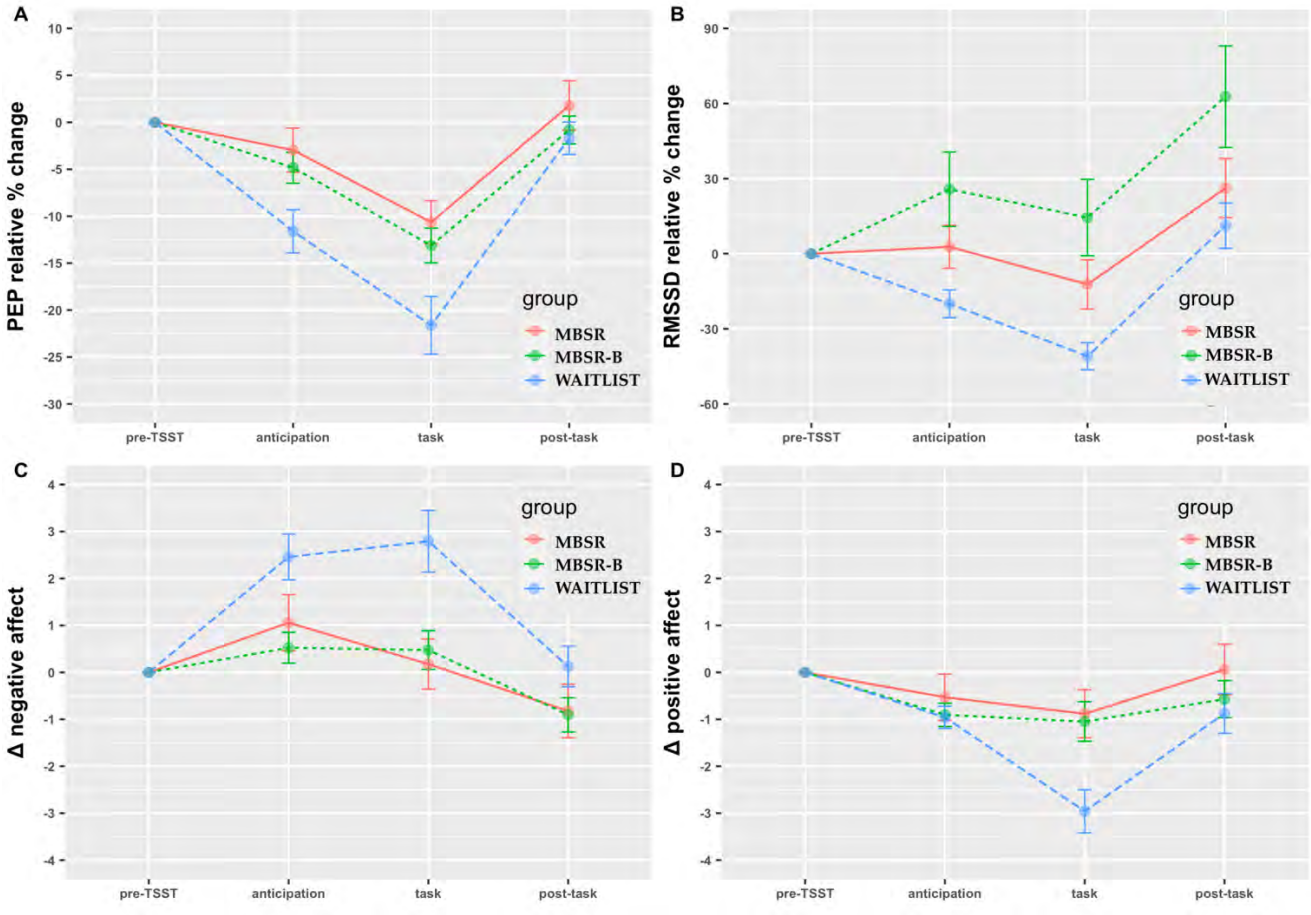


Figure 4. Relative percent change in (A) PEP and (B) RMSSD, absolute change in (C) negative and (D) positive affect across three experimental groups.

Table 3

Descriptive statistics and group differences in outcome variables

Outcome	Group descriptives *M* (*SD*)			MANOVA/ANOVA[a]	Contrasts *p* (adjusted p^a), Cohen's *d*	
	WAITLIST (*N* = 24)	MBSR (*N* = 20)	MBSR-B (*N* = 21)		WAITLIST vs. MBSR	WAITLIST. vs MBSR-B
Salivary cortisol				$F(6, 112) = 2.34, p = .04$, Wilks' $\Lambda = .79$		
log10 cortisol AUCi (anticipation)	1.63 (.21)	1.48 (.14)	1.47 (.19)	$F(2, 57) = 4.69, p = .01(.03), \eta^2_G = .14$	$p = .02$ (.03), $d = 0.82$	$p = .01$ (.03), $d = 0.78$
log10 cortisol AUCi (task)	2.11 (.23)	1.95 (.23)	1.98 (.21)	$F(2, 58) = 2.98, p = .05$ (.10), $\eta^2_G = .09$		
log10 cortisol AUCi (recovery)	1.64 (.18)	1.55 (.18)	1.58 (.18)	$F(2, 58) = 1.24, p = .30, \eta^2_G = .04$		
Alpha-amylase				$F(6, 112) = 1.01, p = .42$, Wilks' $\Lambda = .90$		
log10 amylase AUCi (anticipation)	2.91 (.28)	2.92 (.20)	2.97 (.30)			
log10 cortisol AUCi (task)	3.34 (1.20)	3.71 (.12)	3.68 (.14)			
log10 cortisol AUCi (recovery)	3.22 (.16)	3.22 (.14)	3.27 (.17)			
PEP				$F(6, 114) = 2.14, p = .05$, Wilks' $\Lambda = .81$		
relative percent change (anticipation)	- 11.61 (11.26)	- 2.96 (9.71)	- 4.83 (7.57)	$F(2, 59) = 4.69, p = .01$ (.03), $\eta^2_G = .14$	$p = .01$ (.03), $d = 0.82$	$p = .02$ (.03), $d = 0.71$
relative percent change (task)	- 21.62 (15.03)	- 10.64 (9.46)	- 13.12 (8.51)	$F(2, 59) = 5.17, p = .01$ (03), $\eta^2_G = .15$	$p = .01$ (.01), $d = 0.87$	$p = .02$ (.02), $d = 0.70$
relative percent change (rebound)	- 1.70 (8.42)	1.79 (10.90)	-.82 (6.78)	$F(2, 59) = 0.84, p = .44, \eta^2_G = .03$		
RMSSD				$F(6, 106) = 2.62, p = .02$, Wilks' $\Lambda = .76$		
percent change (anticipation)	- 19.99 (27.11)	2.78 (35.41)	25.78 (35.41)	$F(2, 59) = 5.33, p = .01$ (.01), $\eta^2_G = .15$	$p = .03$ (.03), $d = 0.72$	$p = .01$ (.02), $d = 0.88$
percent change (task)	- 40.91 (26.69)	- 12.22 (40.40)	14.50 (70.01)	$F(2, 59) = 7.23, p < .01$ (< .01), $\eta^2_G = .20$	$p = .02$ (.02), $d = 0.84$	$p < .01$ (< .01), $d = 1.05$
percent change (rebound)	.42 (24.53)	17.12 (31.74)	45.91 (53.08)	$F(2, 55) = 7.43, p < .01$ (< .01), $\eta^2_G = .21$	$p = .09, d = 0.59$	$p < .01$ (< .01), $d = 1.10$
Negative affect				$F(6, 114) = 2.61, p = .02$, Wilks' $\Lambda = .77$		
absolute change (anticipation)	2.46 (2.40)	1.11 (2.46)	.52 (1.50)	$F(2, 59) = 4.84, p = .01$ (.02), $\eta^2_G = .14$	$p = .08, d = 0.58$	$p < .01$ (< .01), $d = 0.97$
absolute change (task)	2.79 (3.22)	0.18 (2.19)	0.48 (1.89)	$F(2, 59) = 6.82, p < .01$ (.01), $\eta^2_G = .19$	$p < .01$ (.01), $d = 0.95$	$p = .01$ (.01), $d = 0.88$
absolute change (recovery)	0.13 (2.11)	-0.82 (2.35)	-0.91 (1.67)	$F(2, 59) = 1.74, p = .18, \eta^2_G = .06$		
Positive affect				$F(6, 112) = 2.36, p = .03$, Wilks' $\Lambda = .79$		
absolute change (anticipation)	- .96 (1.16)	- .53 (2.04)	- .91 (1.14)	$F(2, 59) = .49, p = .62, \eta^2_G = .02$		
absolute change (task)	- 2.96 (2.26)	- .88 (2.12)	- 1.05 (1.94)	$F(2, 59) = 6.51, p < .01$ (.01), η^2_G G = .18	$p = .01$ (.01), $d = 0.95$	$p < .01$ (.01), $d = 0.91$
absolute change (recovery)	-0.65 (1.80)	0.06 (2.21)	-0.57 (1.81)	$F(2, 58) = .76, p = .47, \eta^2_G = .03$		

Note. WAITLIST = waitlist control group, MBSR = Mindfulness Based Stress Reduction, MBSR-B = modified Mindfulness Based Stress Reduction, PEP = pre-ejection period, RMSSD = the root mean square of successive differences. [a]Holm-Bonferroni adjusted *p* values

Exploratory analyses of group differences. In order to explore potential differences across all groups after significant ANOVAs, we performed Tukey's HSD or Games-Howell (in case of violation of the assumption of equal variance) post hoc tests. We did not detect any group differences between MBSR and MBSR-B directly, but in several variables only MBSR-B group (and not MBSR) was significantly different from control in the full pairwise analysis (table 4).

Table 4

Exploratory group comparisons

Outcome	Tukey HSD mean difference (95% confidence interval), *p*		
	WAITLIST vs. MBSR	WAITLIST vs. MBSR-B	MBSR vs. MBSR-B
Salivary cortisol			
log10 cortisol AUCi (anticipation)	0.14 (0, 0.29), .06	.0.15 (0.02, 0.29), .02*	- 0.01 (- 0.16, 0.14), .99
PEP			
relative percent change (anticipation)	- 8.65 (- 16.06, - 1.24), .02*	-6.78 (-13.76, 0.21), .06	- 1.87 (-9.50, 5.75), .83
relative percent change (task)	- 10.98 (-19.89, -2.06), .01*	- 8.50 (-16.90, -0.10), .05*	-2.48 (-11.65, 6.70), .79
relative percent change (rebound)			
RMSSD			
percent change (anticipation)	-22.77 (-48.02, 2.48), .08	-45.77 (-85.26, -6.29), .02*	23.01 (-19.26, 65.27), .39
percent change (task)	-28.70 (-56.58, -0.82), .04*	-55.38 (-95.78, -14.99), .01**	26.68 (-17.86, 71.23), .32
percent change (rebound)	-16.70 (-40.26, 6.85), .20	-45.49 (-77.71, -13.27), .01**	28.79 (-6.31, 63.89), .13
Negative affect			
absolute change (anticipation)	1.40 (-0.24, 3.04), .11	1.93 (0.38, 3.48), .01*	-0.5 (-2.23, 1.15), .73
absolute change (task)	2.62 (.56, 4.67), .01*	2.32 (0.42, 4.21), .01*	.30 (-1.35, 1.95), .90
Positive affect			
absolute change (task)	-2.08 (-3.69, -0.46), .01**	-1.91 (-3.43, -0.39), .01**	-0.17 (-1.82, 1.49), .96

Note. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Discussion

Research on the effects of MBIs on stress requires a comprehensive approach, which takes into consideration several factors. In this study, we tested the effects of MIBs on various stress response systems, addressed temporal dynamics by expanding measurement of the stress response to anticipation and recovery, and explored whether SG-MBI would produce larger stress-attenuating effect. Overall, we found that MBIs produce a stress-attenuating effect in response to social-evaluative threat across multiple physiological and subjective response systems.

Furthermore, this study demonstrated that stress-attenuating effects of MBIs are present already during anticipatory period (and recovery for one of the variables), suggesting effects of contemplative practices on the reduction of prolonged stress reactivity. Finally, we found a preliminary indication that SG-MBIs (represented in this study by a program with an additional module based on Buddhist practices) could have a more pronounced effect on some parameters, such as HRV and negative affect.

Stress response systems. One of the main advantages of this study is its multilevel assessment, which allowed us to test the effects of MBIs on different psychophysiological response systems affected by stress: HPA-axis, SAM, ANS, and affect. The effects of MBIs were observed for the HPA-axis-driven biomarker cortisol, but only in the anticipation period. These results add to the inconclusive literature on the effects of MBIs on the neuroendocrine pathway in response to social-evaluative threat (Morton et al., 2020). Furthermore, previous research (e.g., Engert et al., 2017) reports a discrepancy between the effects of MBIs on the endocrine and autonomic systems that is only partially congruent with our findings. The authors proposed that autonomic activity responds to emotional stimuli of different valences and thus might not be stress specific. However, the results of earlier research suggest that both endocrine and cardiovascular responses are sensitive to social-evaluative threat elements in a stress task (Woody et al., 2018) and that the effects of HPA axis activation could not be completely separated from the effects on sympathetic activation (Bosch et al., 2009) The use of appropriate indices of the ANS, distinguishing the SNS and the PNS, and careful control of experimental conditions (especially posture) would allow to clarify the effect of MBIs on stress-driven ANS changes.

In terms of the ANS, results demonstrated that the effects of MBIs are detectable for both the SNS and the PNS, with larger effect sizes for the PNS. It is an

important finding, taking into consideration that autonomic changes produced by psychological stressors are dependent on individual differences, with some people showing predominant sympathetic activation, vagal withdrawal, or a reciprocal pattern of response (Berntson et al., 1991).

This study is one of the few to investigate the effects of MBIs on PEP, a measure of myocardial contractility that is controlled by beta-adrenergic sympathetic influences on the heart. Previous research has demonstrated that while PEP reactivity is primarily related to effortful active coping, it is very dependent on environmental context changes, such as social-evaluative threat, making this measure most sensitive to the combination of environmental, behavioral, and outcome uncertainty (Kelsey, 2012). Our findings demonstrate that MBIs reduce sympathetic activation in both anticipation and task periods. These findings contradict the results from an earlier report (Daubenmier et al., 2019) where MBI did not result in PEP differences during the TSST, and the authors speculated that mindfulness would not reduce sympathetic activation but would rather facilitate an adaptive responsivity to repeated stress. This discrepancy in the results should be taken with caution because of differences in populations (obese adults vs. healthy volunteers) and types of MBIs.

Even though the attenuation effect of MBIs was found for both branches, the effect was more pronounced for the PNS, as indicated by less vagal withdrawal during anticipatory and task stress for both MBIs and sharper vagal rebound for MBSR-B. HRV is associated with better self-regulation (Thayer & Lane, 2000), and neuroimaging studies suggest that HRV is related to reduced threat perception during social-evaluative threat (Thayer et al., 2012). MBIs have been consistently linked to improved emotion regulation (Chambers et al., 2009); thus, further research should address the effects of MBIs on threat perception during social evaluation tasks and explore whether this psychological mechanism is related to less vagal

withdrawal during stress. While this study showed clear effects of MBIs on HRV, the results of the review on MBIs and psychophysiological responses to social stress (Morton et al., 2020) showed that only one of four studies found an effect of MBIs on HRV. The discrepancies in the results can be related to methodological differences, program characteristics, and metrics corresponding to vagal tone (Christodoulou et al., 2020). Considering that the TSST involves postural changes and that HRV metrics are sensitive to it (Houtveen et al., 2005), it is important to report if this factor was controlled. In this study, participants were not instructed to stand during the TSST, which permitted to avoid physiological changes associated with posture.

On the subjective level, we observed the effects of MBIs on stress-induced changes in both negative and positive affect. MBSR-B showed lesser TSST-induced increase in negative affect during the anticipation period and the task, and MBSR during the task. As for positive affect, both MBIs showed lesser TSST-induced decrease during anticipation and the task. These results are congruent with earlier qualitative research (Gamaiunova, Brandt, & Kliegel, 2021), reporting that meditators unexpectedly experienced various types of positive emotions during the TSST, which is designed to evoke primarily negative affect. Positive affect during stress represents an interesting area of research, resulting in questions such as how positive emotions appear during distressing events and what their stress-buffering role is (Folkman & Moskowitz, 2000). The results of a series of studies (Fredrickson & Levenson, 1998; Fredrickson et al., 2000; Robles et al., 2009) suggest that positive emotions are associated with faster physiological recovery from distress. The mechanisms can be explained by the broaden-and-build theory (Fredrickson & Levenson, 1998; Phillips et al., 2009): In contrast to negative emotions, which narrow individuals' thought–action repertoires, positive emotions broaden those repertoires, allowing a wider than typical range of actions and thoughts. The effects of MBIs on the increase in positive emotions were demonstrated in previous research

(Fredrickson et al., 2017; Geschwind et al., 2011), and our study adds to the literature, suggesting that MBIs lead to a significantly lesser decrease in positive affect in the context of social-evaluative threat.

Temporal dynamics of the stress response. Another important feature of this study is the attempt to differentiate the stress-reducing effects of MBIs during different phases of stress, including both anticipatory activation and recovery. The importance of addressing anticipation and recovery in stress research has been underlined for the HPA axis (Engert et al., 2013; Juster et al., 2012) and the ANS (Brosschot et al., 2005; Linden et al., 1997) due to the idea that prolonged reactivity explains unique variance in psychological health. In addition, anticipatory reactivity before stress might determine the magnitude of response when the stress comes (Pulopulos et al., 2020; Pulopulos et al., 2018).

The results of our study demonstrate that the effects of MBIs on anticipatory stress were detected across almost all physiological systems, leading to attenuated responses of the HPA axis, ANS (SNS/PNS), and negative affect. The effect on recovery was observed in HRV for MBSR-B. These findings suggest that the stress-attenuating effects of MBIs go beyond reducing stress reactivity but also diminish prolonged reactivity related to social-evaluative threat. These results are congruent with previous reports linking contemplative practice with a reduction in prolonged reactivity (Britton et al., 2012; Gamaiunova et al., 2019), but focus on anticipation and recovery in MBIs and stress research is still rare. On the level of mechanism, several theoretical frameworks have been proposed to explain prolonged reactivity in stress, including perseverative cognition (Brosschot et al., 2005) or the generalized unsafety theory of stress (Brosschot et al., 2017). Looking at mechanisms underlying the stress-reducing effects of MBIs during social-evaluative threat can help the field to move forward.

Program specificity. This study aimed to explore the magnitude of effects of two MBIs, a standard MBSR and an SG-MBI (Van Gordon & Shonin, 2020), represented by an MBSR program with an additional module based on elements of Buddhist teachings (MBSR-B). Even though the study did not have sufficient power to make a direct comparison between the two experimental groups, our results demonstrated that, compared with the control, MBSR-B had larger effects on HRV during task phase and recovery. On the subjective level, MBSR-B showed a lesser increase in negative affect in the anticipation period; this effect was not observed when comparing the MBSR and the control group. In addition, the difference between two MBIs demonstrates itself in the results of exploratory pairwise comparisons (of all possible pairs between groups) where only MBSR-B, but not MBSR, shows statistically significant difference from the control group in these variables. Though inconclusive, those results give an indication for potential add-on benefit of a SG-MBI.

Limitations. This study's results are limited as follows: First, our sample size was small. The attrition resulted in the final number of participants being inferior to our a priori sample size estimations. However, regardless of the reduced sample size, effects of MBIs were observed across multiple measures. The small sample size did not permit the direct comparison of the treatment groups, but the estimations of the effects compared to control gave us preliminary indications on the potential add-on effects of SG-MBIs.

Second, measurement of the manipulation of an additional module indicated only partial success. While the pre-post changes in ethics were statistically different from WAITLIST only in the MBSR-B group, the difference in wisdom between those groups fell slightly above the threshold of statistical significance after the appropriate corrections were applied. Although these results can be explained by insufficient statistical power, they may also highlight the challenges inherent in

teaching wisdom in such a short curriculum. Previous research results of studies focused on wisdom development (in non-Buddhist framework) showed small effects with shorter interventions (DeMichelis et al., 2015; Sharma & Dewangan, 2017), and more substantial improvement with semester-long interventions (Bruya & Ardelt, 2018). Regardless this limitation and taking in consideration comparable times of practice in both groups, larger effect for ethics and partially for wisdom in MBSR-B, we can suggest that the effects of MBSR-B were attributable to their participation in the modified intervention.

Third, the training in the MBSR-B group was composed, in addition to standard mindfulness, of distinctive themes (wisdom, brahmaviharas and ethics), which could be further decomposed in separate interventions to explore differential effects of wisdom, ethics, and the four immeasurables. While studies on the distinctive types of training would bring additional insights on the effects of those practices, combined curriculums like ours have their own advantage, as the salutary effects of various types of practices (mindfulness, concentration, ethics, acceptance) are argued to reinforce one another in a feedback loop (Grabovac et al., 2011).

Future directions. Testing the effects of different MBIs separately and in combined curriculums on the stress response to social-evaluative threat is an important priority in the field. As mindfulness was discussed as being a necessary preliminary practice for developing other states, such as compassion or loving-kindness (Hofmann et al., 2011) it remains to be determined how much of mindfulness or concentration training is necessary before starting other types of meditations and if the current terminology (MBIs) is adequate for the programs that have other practices in its core.

Based on the results of this study, we suggest testing more ethics and wisdom-based SG-MBIs, including analytical meditations, a type of contemplative practices which includes systematic investigation and analysis of a particular topic or concept.

Further, the design and implementation of SG-MBIs should address important open questions, such as the ratio of mindfulness and additional practices, the training of intervention providers, and ethical considerations, among others (Baer, 2015; Bayot et al., 2020; Shonin, Van Gordon, et al., 2014a). Development of appropriate measures, able to capture changes in wisdom-related constructs is also of utmost importance.

We suggest further exploration of the effects of MBIs with respect to temporal dynamics, in particular prolonged stress reactivity, including early anticipation and longer recovery. Several theories explaining the potential mechanisms of prolonged stress, such as perseverative cognition, have solid foundations, and the effect of MBIs on stress attenuation through those mechanisms can be experimentally tested.

We suggest, where possible, including measures of different physiological response systems coupled with self-report: Multilevel assessment helps to avoid bias introduced by methodological differences across studies. Furthermore, we suggest increasing methodological rigor in the ANS assessments during the TSST and adequate reporting: The original protocol includes postural changes that have significant effects on cardiovascular indices, which may partially explain the large discrepancies in HRV or PEP across studies. We further suggest accompanying stress measurements by breathing indices, taking into consideration that contemplative practices are associated with altered breathing (Ahani et al., 2014; Wielgosz et al., 2016). Widely used assessment of RR can be enhanced, for example, by exhalation to inhalation ratio which was proposed to be an important modulator of autonomic patterns (Bae et al., 2021).

Conclusions. Regardless of the abovementioned limitations, this study contributes to the research on the effects of MBIs on the stress response to social-evaluative threat. First, this study demonstrates that the stress-buffering effects are observed across different psychophysiological response systems, but not with the

same magnitude, indicating largest effects for the PNS. Second, this study provides preliminary evidence that a contemplative training has the potential to reduce prolonged stress reactivity, such as anticipatory stress and prolonged recovery. Finally, this study gives preliminary indications that SG-MBIs might have add-on effects on the stress attenuation.

Chapter 5. Effects of mindfulness training on the anticipatory cognitive appraisals of challenge and threat

Abstract

Judgment about a psychological stressor in the form of primary cognitive appraisals of challenge and threat determine not only the magnitude of subsequent stress response but also its physiological profile. Both the transactional model of stress and coping and the biopsychosocial model of challenge and threat emphasize the role of cognitive appraisals as an important psychological mechanism of stress reactivity. Contemplative approaches rooted in Buddhist traditions, primarily mindfulness meditation, have been linked to stress attenuation. However, cognitive mechanisms related to stress reduction could be particularly relevant to a wider variety of contemplative practices such as the development of wisdom, compassion, and ethics. In this study, we evaluated the effects of two contemplative interventions on cognitive appraisals of challenge and threat, and associated physiological profiles in response to social stress. The interventions were a standard mindfulness-based stress reduction (MBSR) program and an elaborate program, which, in addition to mindfulness, included broader Buddhist practices (MBSR-B). Volunteers were assigned to 8-week MBSR, MBSR-B, or control groups, and after completed the Trier Social Stress Test (TSST). Prior to the test, we measured the primary cognitive appraisal of challenge and threat, and the autonomic nervous system measures were collected throughout the task. The results demonstrated no statistically significant difference in the level of threat and challenge among the groups but a higher score of challenge than threat in the MBSR-B group. At the physiological level, MBSR-B showed a cardiovascular profile associated with challenge (i.e., a larger increase in cardiac output and smaller increase in total peripheral resistance). The results

suggest that contemplative approaches employing additional Buddhist practices foster higher challenge than threat appraisal.

Introduction

The detrimental effects of stress on health are well documented (O'Connor et al., 2021). Psychological stressors, especially of social nature, evoke robust activation of different physiological systems, often exceeding current somatic and metabolic demands. In terms of pathophysiology, an exaggerated stress response creates a strain on the cardiovascular system (Obrist, 2012) and can lead to allostatic load (McEwen, 1998a). The amplitude of psychological strain is determined by cognitive interpretation of the stressor as either threatening or challenging, which can be evaluated based on the level of primary appraisals (Folkman & Lazarus, 1984). This cognitive evaluation is likely to determine the magnitude of psychophysiological stress response. However, the magnitude of stress response and the particularity of physiological activation have important implications. According to the biopsychosocial (BPS) model of challenge and threat (Tomaka et al., 1993), cognitive evaluation of a stressor results in a specific physiological profile, representing a more or less adaptive response to psychological stress.

Mindfulness-based interventions (MBIs), behavioral approaches based on Buddhist practices, have been linked to stress attenuation in the context of social stressors (Morton et al., 2020). Considering that stress response initiation is caused largely by cognitive mechanisms such as an evaluation of a situation, it represents a potential mechanism linking contemplative approaches and stress attenuation. These cognitive mechanisms might be particularly pronounced in meditation programs aimed at the development of cognitive insight, purpose, and meaning (Dahl & Davidson, 2019) or the so-called second-generation mindfulness-based interventions (SG-MBIs) (Van Gordon & Shonin, 2020). These contemplative

practices, in addition to mindfulness, engage larger Buddhist practice frameworks and a wider set of traditional techniques. In addition to stress-protecting mechanisms brought about by the cultivation of mindfulness (Creswell & Lindsay, 2014; Vago & David, 2012), SG-MBIs have the potential to engage in religious or spiritual coping, as specific beliefs from religious traditions have been found to be associated with appraisals, coping strategies, and stress-related outcomes (Newton & McIntosh, 2010).

Challenge/threat and stress responses

The biological response to stress results from cognitive interpretation, followed by affective integration and neurological triggering (Everly & Lating, 2013). As such, anticipatory cognitive appraisals represent important psychological stress-related physiological changes concomitant with the potential to determine the magnitude, dynamics, and physiological profile of the stress response. In the context of psychological stressors including social-evaluative threat (SET), primary cognitive appraisals of challenge and threat have received the most attention. The appraisal of threat, characterized by the anticipated loss of social self-esteem and rejection, is clearly distinguished from the appraisal of challenge, which consists of recognizing the potential for gain or growth in stressful situations (Folkman & Lazarus, 1984). The results of empirical investigations demonstrated that in the context of SET, primary cognitive appraisals robustly predicted the hypothalamic-pituitary-adrenal (HPA) axis reactivity (Gaab et al., 2005) and showed an effect on the heart rate (Mayor & Gamaiunova, 2014).

The idea that cognitive evaluations determine stress-related physiological changes has been based on the BPS model of challenge and threat (Blascovich & Tomaka, 1996; Tomaka et al., 1993). However, in the framework of BPS, challenge and threat deviate from the definitions proposed in earlier work (Folkman &

Lazarus, 1984) and are conceptualized in terms of the motivation states of approach (challenge) and withdrawal (threat). According to this model, motivated performance with task engagement gives rise to a state of challenge if the evaluated resources are equal to or greater than the demands, or to the state of threat, when demands are greater than resources. These two states can be differentiated by cardiovascular measures, especially the cardiac output (CO), which reflects the amount of blood pumped from the heart each minute, and the total peripheral resistance (TPR), a measure of the resistance to blood flow throughout the circulatory system. During challenge, arteries dilate, resulting in relatively higher CO and lower TPR than during threat, when the constriction of arteries results in less blood being pumped from the heart (Seery, 2011). The physiological pattern associated with challenge represents a more adaptive response to stress, as it enables the response to metabolic demands to occur in a speedy manner (Tomaka et al., 1993); conversely, increased vascular resistance, which characterizes the threat response, impedes the delivery of oxygenated blood to the periphery and brain. The state of threat has important health implications, creating a strain on the immune and cardiovascular systems due to increased arterial constriction (Blascovich, 2008), and is theorized to affect cellular aging (Epel et al., 2009).

Mindfulness-based interventions

MBI is an umbrella term for behavioral programs based on contemplative practices (CP) originating in various religious and spiritual traditions (primarily rooted in Buddhism). These programs come in a variety of forms and have as a core the cultivation of mindfulness, broadly defined as a process of openly attending, with awareness, to one's present moment experience (Creswell, 2017). In addition to programs aimed primarily at the cultivation of mindfulness, SG-MBIs have emerged and are represented by programs that add other elements of Buddhist contemplative

disciplines, such as the cultivation of ethical and empathic awareness (loving-kindness and compassion meditation) and the development of wisdom (e.g., analytical types of meditation) (Van Gordon & Shonin, 2020).

Stress reduction has become an important health-related target outcome of the earliest MBIs, such as mindfulness-based stress reduction (MBSR) (Kabat-Zinn, 2013). Even though research results are still inconclusive, current empirical evidence suggests that MBIs might help to reduce the stress response in the context of psychological stressors with social-evaluative components, and the effects were observed for the immune, cardiovascular, and neuroendocrine systems (Morton et al., 2020). Program specificity tends to play an important role, with certain types of MBIs being more efficient than others (Engert et al., 2017; Lindsay et al., 2018). Several theoretical frameworks have been proposed to delineate the neurobiological mechanisms of MBIs and CP (Tang et al., 2015; Vago & David, 2012). The mindfulness stress buffering account (Creswell & Lindsay, 2014) focuses primarily on the stress-attenuating effects of MBIs and proposes to differentiate a "tow-down" regulatory pathway, which activates prefrontal regulatory regions and reduces the activity of stress processing regions, and a "bottom-up" reduced reactivity pathway, which helps to modulate the activation of stress-processing regions (for example, MBIs can directly modulate stress processing via an increase in the activity of the parasympathetic nervous system).

The neurobiological mechanisms of MBIs are tightly intertwined with psychological mechanisms. Emotion regulation strategies, especially acceptance and reappraisal, have been mostly studied as a potential mechanism of the stress-buffering effects of MBIs (Gamaiunova et al., 2019; Garland et al., 2011; Lindsay et al., 2018). Anticipatory cognitive appraisals have received much less attention and have not been sufficiently tested as potential mechanisms of the effects of MBIs. However, at the theoretical level, several components of contemplative training may

impact the cognitive evaluation of a stressful situation. First, MBIs of all types foster the development of decentering, a capacity to shift the experiential perspective from within onto that experience (Bernstein et al., 2015). Distancing from internal experience and the ability to observe the contents of thoughts can lead to a different primary appraisal or facilitate rapid reappraisal (Astin, 1997; Bernstein et al., 2015). Second, MBIs, and to a larger degree, SG-MBIs, cultivate the development of compassion, self-compassion, and benevolent attitude towards others, which are theorized to reduce threat perception through development of a sense of self-worth independent of external evaluation or approval (Neff & Vonk, 2009), and reduce proneness to self-conscious cognitions, such as self-criticism (Gilbert & Procter, 2006). Such changes in the relationship mode of stressful transactions may help reduce threat perception in subsequent stressful encounters. Third, SG-MBIs, which include doctrinal or philosophical components in the training (in the form of discourses, analytical meditations, etc.) can foster creation of a cognitive schema, a mental representation that includes organized knowledge and relational configuration of a particular domain. This cognitive lens can impact the ways in which a stressful event is appraised (McIntosh, 1995; Newton & McIntosh, 2010). For example, the understanding of traditional Buddhist notion of non-self (i.e., anata) leads to the understanding that all phenomena, including the self, do not possess inherent existence (Van Gordon et al., 2017). The interiorization of this notion can lead to changes in self-concept, where the self is seen as a mental construction, and less effort is mobilized for its protection or enhancement (Ryan & Brown, 2003). In the context of SET, it might be an important factor for changes in threat evaluation, where the distress is primarily generated by the fear of losing a positive self-image. As such, reduction of self-concern through MBIs represents a potent mechanism of stress-attenuating effects. At the empirical level, worldviews from religious traditions were previously found to impact physiological reactivity to stress (Schnell

et al., 2020), suggesting the implication of the cognitive appraisal process as conceptualized in the transactional model (Koenig & Cohen, 2002). Religious stimuli have also been previously found to influence cardiovascular responses to motivated performance situations (Weisbuch-Remington et al., 2005), suggesting that the challenge/threat cardiovascular profile in stress response can be affected by elements of a religious system. In summary, several possible mechanisms present in contemplative training can alter the primary evaluation of psychological stressors.

At the empirical level, only a few studies have investigated the relationship between contemplative training and primary cognitive appraisals of challenge and threat, and the results are not homogeneous. In a study investigating the psychological mechanisms of long-term meditation practice and stress response, no significant association was found between contemplative training and anticipatory appraisals of challenge and threat (Gamaiunova et al., 2019). However, in a longitudinal study, mindfulness was found to be associated with reduced threat appraisal (Weinstein et al., 2009). In the framework of the biopsychosocial model of challenge and threat, the effects of MBI on the cardiovascular profiles during social stress have been investigated in a randomized controlled trial of a mindfulness-based weight loss intervention (Daubenmier et al., 2019). The results suggested that mindfulness training increased challenge-related appraisals and resulted in cardiovascular reactivity associated with challenges. Another study investigated the effects of awareness manipulation and a brief acceptance training on the cardiovascular stress responses (social-evaluative cold pressor test) underlying challenges and threats (Manigault et al., 2021). The results demonstrated that the combination of enhanced awareness and acceptance training was significantly associated with a higher CO and lower TPR, indicating greater challenge and lesser threat.

Considering that cognitive evaluation represents a potential mechanism of contemplative training effects on the stress response and that this question is relatively unexplored, further research is needed. This study presents a secondary analysis of a randomized controlled experiment investigating the effects of two MBIs on the psychophysiological response to social-evaluative stress (Chapter 4). The effects of a standard MBSR and an MBSR-B, a SG-MBI (which included an additional module based on other Buddhist practices) were evaluated after an eight-week intervention, and the stress response was measured across different physiological systems (HPA axis, ANS). The results demonstrated that MBIs reduced the magnitude of stress response across different physiological systems, resulting in lesser sympathetic activation, lesser vagal withdrawal, and smaller changes in cortisol, with slightly higher effects of a SG-MBI.

The focus of this study was to explore the effects of MBIs on cognitive appraisals and associated cardiovascular profiles. The first aim was to test whether MBIs affected anticipatory cognitive appraisals of challenge and threat measured by self-report. We hypothesized that in comparison to the control group, MBI groups will show lower threat appraisal scores and higher challenge appraisal scores, with a larger effect for MBSR-B. The second aim was to test whether MBI groups result in physiological profiles associated with challenge appraisal; that is, an increase in CO and a decrease in TPR. We hypothesized that MBI groups will show cardiovascular profiles that are associated with challenge.

Method

Participants

We recruited participants for a larger study on stress reduction in the community of the Lausanne region and the university campus via flyers, online

advertisements in a local paper, and a promotional website. The optimal total sample size of 72 participants (effect value of f = 0.4, with a significance level set at α = 0.05, power 1 - β = 0.85) was determined prior to recruitment using the G-Power software (Faul et al., 2007). The inclusion criteria were as follows: age 18–40 years; no prior regular practice of meditation (more than 3 hours/week); a good mastery of the French language; and the ability and desire to participate in the group sessions, do home assignments, and participate in a one-day retreat. The exclusion criteria were prior participation in the TSST, chronic or acute mental or physical disease, addiction to substances, use of medications that interfere with the HPA axis or ANS functioning, severe obesity (BMI>30), smoking more than five cigarettes per day, pregnancy or lactation, and inability to give consent. Out of 182 interested individuals, 52 did not meet the inclusion criteria, 31 declined to participate, and a sample of 99 participants was randomized into the three experimental groups. Due to attrition, a sample of 65 participants was included in the analysis of self-report data and 62 in the analysis of the physiological assessments (see Chapter 4 for the CONSORT flow chart).

Procedure

Eligible participants were scheduled for the first visit, during which they received additional details on their participation in the study, signed the informed consent form, received a subject ID (assigned sequentially), and were randomized into one of the three conditions, stratifying for sex. The enrolled participants were blinded to their study condition. After 8 weeks of intervention (or the wait of in the wait-list control condition), participants were scheduled to undergo a laboratory TSST session. They were asked to avoid caffeine, alcohol, food, and strenuous exercise 2 h before the session. On arrival, participants went through a pre-experimental check by answering the questions on their current mood, sleep the

previous night, medication, and were connected to the physiological recording device (see Materials).

For social stress manipulation, we used the TSST with a modification: the anticipation period was increased to 15 minutes to assess the pre-performance stress reactivity for the larger study (Chapter 4). Two confederates dressed in white coats and with clipboards entered the room and presented the task. Then, the participant was instructed to fill out questionnaires (see Materials) and was given 15 minutes to prepare for the task. Then, the participant delivered a 5-minute speech and performed a 5-minute arithmetic task in front of the evaluators who maintained a critical attitude and used a camera. After the task, the participant was asked to fill out questionnaires (not presented here) and remained attached to the physiological device for 30 minutes. The data were collected as follows: continuously for the impedance measures (time stamps were introduced by the experimenter during the procedure) and periodically for blood pressure. In addition, we collected six saliva samples (not presented here). After the experiment, participants were fully debriefed.

Materials

Intervention: Participants were randomly assigned to one of three conditions: MBSR, MBSR-B, and wait-list control. MBSR was a standard protocol administered by a certified instructor comprising seven weekly group sessions (2 h each), a retreat day during week 7, and home practice for 55 minutes a day (Kabat-Zinn, 1990).

The MBSR-B program was designed based on MBSR in collaboration with the MBSR instructor and advanced meditation practitioners in Buddhist traditions. The MBSR-B program followed the same outline as the standard MBSR. In addition, each week focused on a particular concept from a broader Buddhist practice: week 1 concentrated on impermanence, week 2 on ethical aspects, week 3 on loving-

kindness, week 4 on compassion, week 5 on the notion of not-self, week 6 on craving, and week 7 on a choice of topics introduced earlier. The introduction of the concept included a short discourse administered during the group session, audio instructions on how to apply the teachings informally in daily life and guided meditation on the topic that should be listened to at home. For example, for the "not-self" topic, participants were asked to be aware of the moments of "selfing" during the week versus the moments of mindful activities (for details, see Appendix A, Table A1).

Measures

Cardiovascular measures: Electrocardiography and impedance cardiography data were collected continuously using a Bionex data acquisition unit (MindWare Technologies, Gahanna, OH) at a sampling rate of 1000 Hz. We placed seven spot electrodes on participant's thorax (Sherwood et al., 1990) and recorded the values using the BioLab software. We used the MindWare Technologies IMP 3.1.6 analysis software (Gahanna, OH, USA) offline to inspect each segment for the artifacts. The distance between the front electrodes was manually introduced to the MindWare software. The stroke volume (SV) was calculated offline using the Bernstein equation (Bernstein & Lemmens, 2005). The CO was calculated as SV × HR, while the TPR was calculated as CO/MAP*80, where MAP = mean arterial pressure, calculated as diastolic blood pressure (DBP) + 1/3(systolic blood pressure - DBP). Blood pressure was assessed with a digital automatic blood pressure monitor Omron HEM-907 (Vernon Hills, Illinois, USA), that determines blood pressure by oscillometric measurement. The device has been assessed previously for accuracy and has passed clinical evaluation (White & Anwar, 2001). Blood pressure was measured periodically: three times at the end of the rest period and three times in the middle of the task.

Data reduction. Continuous impedance signals were ensemble-averaged using 1-minute epochs and the scores were assessed as follows: last 2 minutes of the rest period for rest and 1 minute in the middle of the task (mid-task). The blood pressure measurements were averaged as follows: three consecutive measurements for rest and three consecutive measurements for mid-task (Appendix B, Figure B1).

Self-report measures: The transactional stress questionnaire, PASA (Gaab et al., 2005) is a 16-item questionnaire that measures the primary cognitive appraisals of threats and challenges and secondary appraisals (control expectancy and self-concept of one's own abilities). Only the threat and challenge subscales were reported in this study. The threat and challenge subscales consist of four items each, with response options ranging from 1 (completely disagree) to 6 (completely agree). Higher scores indicated higher anticipatory challenges or threats. The value of Cronbach's alpha was 0.79 for threat and 0.80 for challenge.

Analyses

Statistical analyses were performed using R Studio version 1.3.1093. Missing values (7.8% in the physiological variables) were treated with the multiple imputation method using R multivariate imputation through the chained equation package (citation mice: Multivariate Imputation by Chained Equations in R). Extreme outliers were identified as values higher than Q3 + 3 × IQR or below Q1 – 3 × IQR; the analyses were performed with and without these values.

Self-report: As the scores of challenge and threat were not significantly correlated ($r = .14$, $p = 0.29$), we tested for group differences in scores of challenges and threats with two separate univariate analyses of variance (ANOVA), adjusting for multiple testing with the Holm-Bonferroni approach (Holm, 1979). A significant result from the ANOVA test was followed by Tukey's honest significant difference post-hoc test. As an exploratory analysis, we tested for the difference between

challenge in threat scores in each group using separate t-tests. Prior to performing ANOVA, the following assumptions were made: absence of significant univariate outliers, normality, multicollinearity, linearity, homogeneity of variance-covariance, and homogeneity of variance. Prior to performing the Student's t-tests, the following assumptions were made: normality, homogeneity of variance, and extreme outliers. The following effect size indices were reported: generalized eta squared for ANOVA and Cohen's *d* for t-tests.

Physiological variables task engagement and the associated sympathetic activation are prerequisites for the examination of the CO and TPR as challenge and threat markers. We first tested whether TSST evoked changes in pre-ejection period (PEP), an index of sympathetic activation, in all groups. To test group differences in the changes in CO and TPR, we computed reactivity values (delta), representing the difference between task performance and the pre-stress rest period (Llabre et al., 1991). Further, we tested for group differences in the delta values of CO and TPR using two separate univariate ANOVAs.

Results

Preliminary analysis

The results of the preliminary analysis are reported elsewhere (Chapter 4). A summary of the results can be presented as follows. The groups did not differ significantly in terms of age, sex, education, occupation, marital status, or income. Concerning the practice of the MBIs conditions, the two groups did not differ in terms of the duration of practice (in minutes) in the course or self-reported difficulty and effort. The pre-experimental check did not show any significant differences between the groups in the number of hours of sleep, perceived sleep quality, and mood.

Main analysis

Anticipatory cognitive appraisal (self-report): We performed two univariate ANOVAs to test for group differences in anticipatory cognitive appraisals of challenge and threat. The ANOVA assumptions were met for both threat and challenge (no significant outliers, normal distribution, homogeneity of variance) subscales. No significant group differences were observed for the threat scores: $F(2, 59) = 0.934$, $p = .399$, $\eta 2_G = 0.03$ (Table 1). However, the groups differed in the challenge scores: $F(2, 59) = 5.921$, $p = 0.01$, $\eta 2_G = 0.17$. The MBSR group had a higher challenge score than the control group ($p = 0.03$, Cohen's $d = 0.71$). A significant difference, with a larger effect size, was also observed between the MBSR-B and control groups ($p = .007$, Cohen's $d = 1.12$). No statistically significant differences were found between the meditation groups (Table 1).

As an exploratory analysis, we compared the scores of challenge and threat in each group. The homogeneity of variance assumption was violated for the two groups, and we performed Welsh t-tests. No statistically significant difference was found between challenge and threat in the MBSR group ($t(30.16) = 1.473$, $p = 0.151$, Cohen's $d = 0.51$) or control group ($t(41.18) = -0.797$, $p = 0.43$, Cohen's $d = -0.23$). However, the challenge and threat scores differed significantly in the MBSR-B group ($t(31.06) = 4.091$, $p < 0.001$, Cohen's $d = 1.26$) (Figure 1).

Task-related sympathetic activation: To check if all the three groups demonstrated sympathetic activation as a result of the task, we performed repeated-measures ANOVA for each group, testing for PEP changes from rest to mid-task. PEP significantly decreased in the MBSR group from rest ($M = 104.50$, $SD = 12.21$) to mid-task ($M = 99.59$, $SD = 15.36$; $F(1, 16) = 5.378$, $p = 0.034$, $\eta 2_G = 0.03$); MBSR-B group from rest ($M = 109.98$, $SD = 2.40$) to mid-task ($M = 97.91$, $SD = 12.97$; $F(1, 20) = 37.115$, $p < 0.001$, $\eta 2_G = 0.18$); and control group from rest ($M = 106.19$, $SD = 13.57$) to mid-task ($M = 90.08$, $SD = 14.24$; $F(1, 23) = 39.476$, $p < 0.001$, $\eta 2_G = 0.26$). These results

(increased ventricular contractility) suggested sympathetic activation in all three groups, allowing further analyses of the cardiovascular profiles of challenges and threats.

Cardiac output and total peripheral resistance: To test for group differences in the changes in CO and TPR, we performed univariate ANOVA on the reactivity values (delta), representing the difference between task performance and pre-stress rest. The groups did not show statistically significant differences in either CO reactivity ($F(2, 59) = 0.503$, $p = 0.697$, $\eta 2_G = 0.02$) or TPR reactivity ($F(2, 58) = 0.758$, $p = 0.473$, $\eta 2_G = 0.03$) (Figure 2). We performed exploratory analyses and tested for CO and TPR changes from rest to mid-task in each group. The results revealed that CO showed a statistically significant increase in the MBSR-B group ($F(1, 20) = 4.781$, $p = 0.04$, $\eta 2_G = 0.02$) but not in MBSR ($F(1, 16) = 0.591$, $p = 0.453$, $\eta 2_G = 0.01$) or control ($F(1, 23) = 1.212$, $p = 0.282$, $\eta 2_G = 0.01$) groups (Table 1 shows the descriptive characteristics).

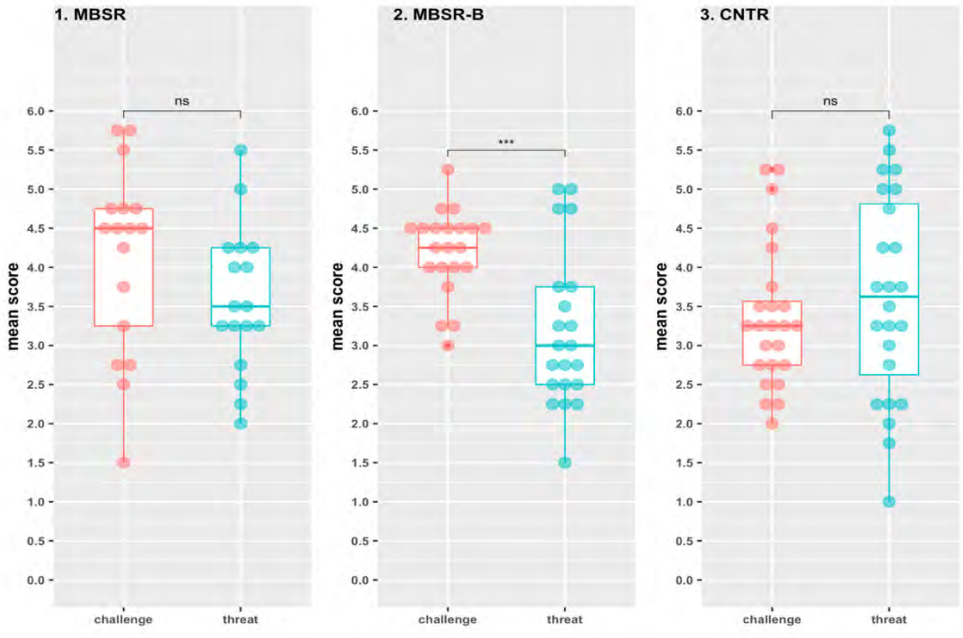


Figure 1. Group differences in cognitive appraisals of challenge and threat.

Table 1

Descriptive statistics and group differences in outcome variables

Outcome	Group descriptives *M* (*SD*)			ANOVA	Contrasts *p* [a], Cohen's *d*	
	CNTR (*N* = 24)	MBSR (*N* = 17)	MBSR-B (*N* = 21)		CNTR vs. MBSR	CNTR. vs MBSR-B
Cardiac output (l/min)						
rest	4.65 (1.94)	3.80 (1.02)	3.82 (1.48)			
mid-task	4.95 (2.12)	3.94 (1.10)	4.33 (2.15)			
reactivity (Δ)	0.30 (1.35)	0.15 (0.78)	0.50 (1.07)	$F(2, 59) = 0.503, p = .697, \eta2_G = .02$		
Total peripheral resistance (dyn·s/cm^{-5})						
rest	1667.73 (731.85)	1724.32 (461.25)	1911.99 (695.62)			
mid-task	1741.54 (727.71)	1851.02 (491.09)	1930.14 (745.04)			
reactivity (Δ)	73.81 (466.95)	126.70 (354.03)	18.15 (388.79)	$F(2, 58) = 0.758, p = .473, \eta2_G = 0.03$		
Anticipatory cognitive appraisals (PASA)						
challenge	3.35 (0.92)	4.12 (1.20)	4.20 (0.55)	$F(2, 59) = 5.921, p = .01, \eta2_G = .17$	$p = .03, d = 0.71$	$p = .007, d = 1.12$
threat	3.62 (1.31)	3.57 (0.93)	3.19 (0.99)	$F(2, 59) = .934, p = .399, \eta2_G = .03$		
In-group differences between challenge and threat	Welsh t-test (*p*, Cohen's *d*)					
	$p = .43, d = -0.23$	$p = .151, d = 0.51$	$p < .001, d = 1.26$			

Note. CNTR = control group, MBSR = Mindfulness Based Stress Reduction, MBSR-B = modified Mindfulness Based Stress Reduction, PASA = The transactional stress questionnaire (Gaab et al., 2005)

[a] Results of Tukey's HSD post hoc tests.

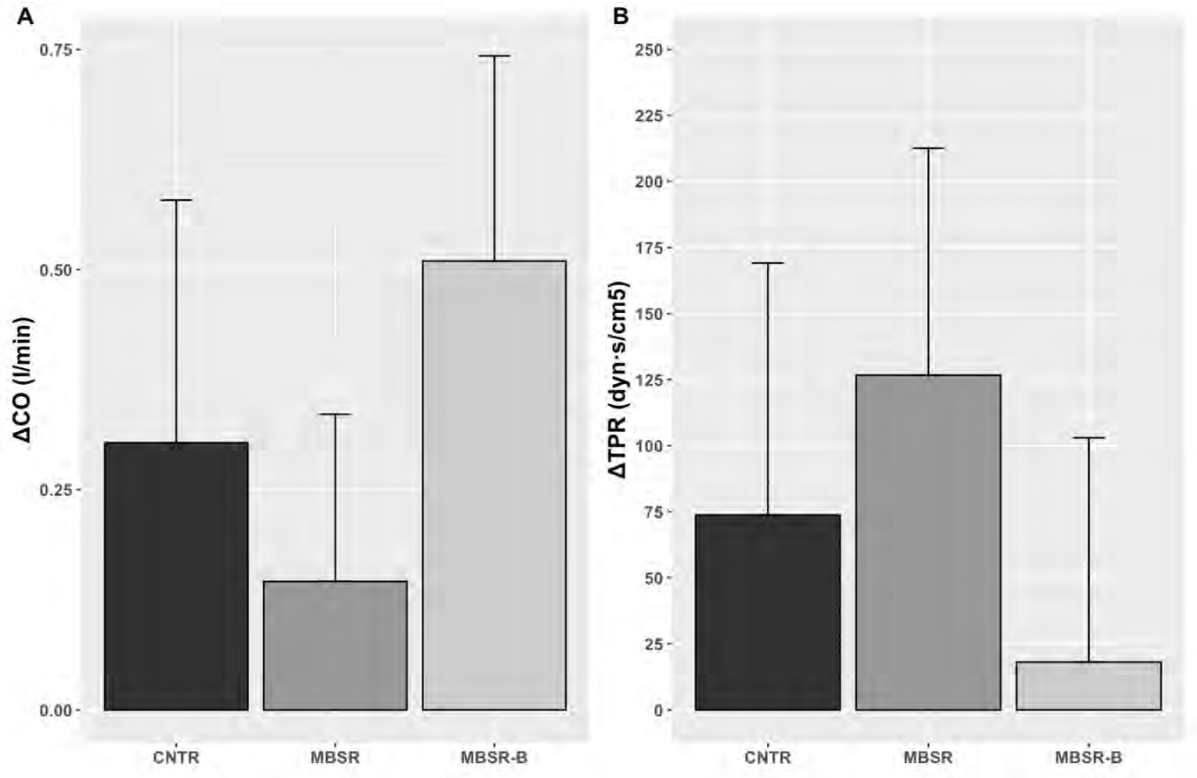


Figure 2. Mean changes in cardiac output and total peripheral resistance

Discussion

In this study, we investigated the effects of two MBIs on the (1) self-reported anticipatory cognitive appraisals of challenge and threat (Folkman & Lazarus, 1984) before a social-evaluative stress task, and (2) cardiovascular profiles of challenge and threat in the framework of the BPS model (Tomaka et al., 1993). The interventions were standard MBSR and MBSR-B (a SG-MBI program). The MBSR-B program had an additional module, which included Buddhist practices for the cultivation of wisdom, ethics, and the four immeasurables. Our findings suggest that MBSR-B was associated with higher in-group challenge scores and showed a more pronounced cardiovascular profile of a challenge as per the BPS model. We offer a potential explanation for our findings, address the study limitations, and propose future directions for research.

The analysis of self-reported data demonstrated that the challenge and threat levels experienced by the participants before the task did not differ significantly

among the experimental groups. However, the comparison of the challenge and threat levels in each group revealed that one of the MBI groups (MBSR-B) demonstrated significantly higher scores of challenge than threat. In the framework of the transactional model of the stress and coping theory (Lazarus & Folkman, 1987), challenge and threat are not conceptualized as mutually exclusive and can occur simultaneously when the event is judged in its potential to bring harm/loss and mastery/gain simultaneously. Our results suggest that while all three groups showed mixed appraisals for challenge and threat, the MBSR-B group's anticipatory appraisal had a stronger challenge component. From a psychophysiological standpoint, these findings can explain non-homogeneous research results in studies evaluating the effects of MBIs on stress-related changes in the ANS (Morton et al., 2020). Challenge is characterized by motivational engagement and the presence of certain positive emotions, such as joy, which are associated with increased beta-adrenergic sympathetic activation (Kreibig, 2010). This may explain why in the effects of MBIs on the ANS stress response attenuation have been found in certain studies (Nyklíček et al., 2013) but not in others (Creswell & Lindsay, 2014; Engert et al., 2017).

Regarding the level of physiological activation in response to stress, our results demonstrated that none of the groups showed physiological profiles associated with a challenge rather than a threat as conceptualized by the BPS model: participants in all three groups demonstrated an increase in CO and, to a smaller degree, in TPR. However, this pattern was more pronounced in the MBSR-B group in which the increase in the CO was statistically significant. It is possible to hypothesize that two other groups demonstrated a bivalent activation of appraisals; however, additional physiological indices would be necessary to confirm this hypothesis (Uphill et al., 2019). It is important to note that in the framework of the BPS model, challenges and threats are considered end states and are determined largely by the perceived

demand/resources ratio. This is different from the transactional model, where challenge and threat refer to perceived potentials for gain and loss, respectively, and are determine by physiological activation (Seery, 2011). However, although challenge is conceptualized differently in these models, SG-MBI showed an association with both.

The question of program specificity in the research on the effects of MBIs on stress has been previously acknowledged, and different types of contemplative training do not impact stress response in the same manner (Engert et al., 2017; Morton et al., 2020). In line with these findings, the results of this study suggest that only an SG-MBI program was associated with higher threat than challenge on the level of self-report and showed cardiovascular profile congruent with challenge. The features of the program, beyond mindfulness (that was present in both groups), that could be associated with challenge rather than threat-oriented cognitive appraisals of stress as conceptualized in the transactional model of stress and the BPS model are as follows. First, the additional module of MBSR-B contained practices aimed at developing an understanding of Buddhist concepts of not-self, origin of suffering, and impermanence and their application to stressful encounters. The possible engagement of these concepts during a stressful encounter represents a form of religious coping in which elements of a traditional doctrine form a cognitive lens (McIntosh, 1995) through which a stressful encounter can be viewed. Buddhist philosophical tenets allow the perception of experiences as fleeting and independent of the existing self, serving as an important antecedent of the cognitive appraisal process (Folkman & Lazarus, 1984). In stress research, this notion is similar to social safety schemas about the self and social world, which are theorized to have a profound impact on physiological stress responses via cognitive evaluation processes (Slavich, 2020). Second, the module included practices involving the development of compassion (focus on the awareness of others' suffering) and

loving-kindness (developing concern for the well-being of others). These practices impact interactional and interpersonal engagement (Hofmann et al., 2011) with the potential to promote social safety (Gilbert, 2009) and increase social connectedness and positivity towards strangers (Hutcherson et al., 2008), thus fostering approach motivational states in social situations. A related skill of self-compassion is the stable feeling of self-worth that is not contingent on particular outcomes (Neff & Vonk, 2009); this represents a potential antecedent of the appraisal process. The results of an empirical investigation suggested an association between self-compassion and the process of stress appraisal (Chishima et al., 2018). In summary, several elements of the additional module may have provided additional stress-protective benefits.

Study limitations and future directions.

This study has several limitations. First, the sample size is small. Second, the additional module consisted of a combination of practices from different meditation families. Future studies on SG-MBIs and cognitive appraisals should address these problems by comparing the effects of interventions from different families, such as constructive, deconstructive, and attentional families (Dahl et al., 2015).

In this study, we focused on primary appraisals. However, the consequences of the cognitive appraisal process for stress response are two-fold: first, primary appraisals directly influence the magnitude of physiological activation in response to stress (Gaab et al., 2005) and physiological response profile (Tomaka et al., 1993); second, primary appraisal processes affect the next step in the transactional process; that is, secondary cognitive appraisals and the choice of coping strategies (Folkman et al., 1986). Consequently, primary cognitive appraisals can have an impact on the magnitude of stress reactivity and the prolonged activation of the stress response due to a reduced sense of control or less efficient coping strategies. Future studies can address not only how MBIs affect primary cognitive appraisals but also the consequent effects on the choice of coping and emotion regulation strategies. The

results of a qualitative study on the stress experience of meditation practitioners suggested that the practice was associated both with the meaning assigned to the stressful event and the strategies chosen to deal with its consequences (Gamaiunova et al., 2021).

The primary cognitive appraisal process is determined by several antecedents, such as beliefs, values, and goal hierarchies. In this regard, it will be particularly fruitful to explore the effects of contemplative approaches aimed at cultivating self-inquiry, spirituality, purpose and meaning (Dahl & Davidson, 2019).

Chapter 6. Mindfulness training and emotion regulation strategies of acceptance and reappraisal

Abstract

Emotion regulation (ER) has been proposed as one of the central mechanisms underlying the effects of mindfulness-based interventions (MBIs). Among particular ER strategies, acceptance and reappraisal have been linked to mindfulness training. However, contextual particularities, such as the type of task or the MBI program specificity, have not been sufficiently evaluated. In this study, we evaluated the effects of two MBIs, a mindfulness-based stress reduction (MBSR) and a modified MBSR that included an additional module based on Buddhist doctrine (MBSR-B) on the ER strategies of reappraisal and acceptance. Nighty-nine participants were randomized to MBSR, MBSR-B or waitlist control. After the course, we assessed: (1) the effectiveness of acceptance and reappraisal in downregulating negative affect and autonomic nervous system (ANS) activation in response to negative self-beliefs (NSBs) associated with self-conscious emotions, and (2) spontaneous choice of acceptance and reappraisal during psychological stress (the Tries Social Stress Test). The results demonstrated that in response to NSBs, both MBIs affected the effectiveness of using acceptance to downregulate negative affect, but only MBSR-B had an impact on the downregulation of negative affect and sympathetic activation using reappraisal. The spontaneous choice of ER strategies during social stress demonstrated that both MBIs were associated with higher acceptance scores, and acceptance was associated with less pronounced sympathetic activation. We conclude that MBIs affect both acceptance and reappraisal, but the effect depends on contextual factors.

Introduction

Mindfulness-based interventions (MBIs), or programs based on Buddhist contemplative practices with mindfulness at their core, have been linked to stress attenuation at both the subjective and physiological levels (Creswell, 2017; Morton et al., 2020). With growing evidence of their potential effectiveness, the exploration of the mechanisms of MBIs' effects has become an important research agenda in this field. This has led to the development of a number of theoretical models that delineate the potential psychological and biological mechanisms of contemplative training (Creswell, 2017; Hölzel et al., 2011; Lindsay & Creswell, 2017a; Tang et al., 2015; Vago & David, 2012). Most of these models suggest that many of the beneficial effects of contemplative training are driven by enhanced emotion regulation (ER), a process of conscious or nonconscious modulation of emotions (Bargh & Williams, 2007; Ochsner & Gross, 2005). Positive effects of mindfulness training on ER have been reported in several studies (Arch & Craske, 2006; Chambers et al., 2009; Jain et al., 2007; Lutz et al., 2013). From the neuroscientific perspective, strengthening prefrontal cognitive control and the subsequent downregulation of activity in regions related to affect processing is proposed as the neurobiological basis of the positive effects of mindfulness on ER (Tang et al., 2015; Vago & David, 2012). Regardless of the overall positive effects of mindfulness on the ER process, its relation to unique ER strategies is still underexplored. Different ER strategies exhibit unique properties in terms of their implementation as well as contextual, physiological and psychological correlates. Two distinct ER strategies in particular—cognitive reappraisal and acceptance—have received much research attention in relation to mindfulness, but it remains unclear whether MBIs affect reappraisal or acceptance ability and choice in the same manner and whether the particularity of a MBI and situational context play a role.

Reappraisal and acceptance

According to a process model of emotion regulation (Gross & John, 2003), reappraisal represents an antecedent-focused strategy, i.e., a strategy that acts in the early stages of the regulatory process, before the full activation of emotional response tendencies and the subsequent physiological and behavioral responses. The essence of reappraisal is the reinterpretation of the meaning of a stimulus in such a way that its emotional impact is modulated. Other definitions of reappraisal as an emotion regulation strategy are present in the literature: in the model of Garnefski & Kraaij (2007), positive reappraisal is associated with creating a positive meaning to the event in terms of personal growth. In the stress literature, reappraisal has been linked to a more adaptive cardiovascular stress response (Jamieson et al., 2013; Jamieson et al., 2012), stress reactivity measured by galvanic skin response (Dandoy & Goldstein, 1990), and stress recovery indexed by changes in heart rate variability (Jentsch & Wolf, 2020). The results of a meta-analysis demonstrated that trait reappraisal was negatively correlated with stress reactivity as measured by cortisol, heart rate, and self-report state anxiety (Carlson et al., 2012). Reappraisal intervention also shows promising effects, although they are observed more on the subjective rather than the physiological levels (Liu et al., 2019). The results of negative emotion elicitation studies show similar results, with reappraisal being associated with more adaptive affective and physiological responses (Gross, 1998a; Mauss et al., 2007).

Acceptance represents an ER strategy, which, in contrast to reappraisal, focuses on the ability to embrace unwanted responses without judgment or desire to alter them (Hofmann & Asmundson, 2008). It has been proposed that acceptance includes elements of both antecedent-focused emotion regulation (in terms of cognitive reinterpretation of the acceptability of emotional experience) and response-focused emotion regulation (in terms of allowing the experience to unfold without a desire to

alter or suppress it) (Liverant et al., 2008). In stress research, acceptance was reported to be effective in reducing subjective stress (Kishita & Shimada, 2011). However, the effects on physiological parameters, such as heart rate or cortisol, have been less consistent (Gloster et al., 2019; Low et al., 2008). Similar to reappraisal, acceptance was reported to reduce negative affect (Kohl et al., 2012) and was associated with a more adaptive physiological response to emotional pictures (Dan-Glauser & Gross, 2015).

The effectiveness of acceptance and reappraisal has been explored in several studies. Both strategies had a similar effect on the startle eyeblink magnitude in response to emotional visual stimuli (Asnaani et al., 2013). A similar pattern of results was observed in a study comparing the effects of both strategies in the context of aversive emotions elicited by film clips; compared to the control condition, both acceptance and reappraisal were associated with less subjective distress, fewer physiological responses and less behavioral avoidance, with the exception of one film clip for which the effect of reappraisal was stronger (Wolgast et al., 2011). In a study investigating neural, behavioral, and autonomic effects of acceptance and reappraisal in the context of ideographic personally salient negative self-beliefs, reappraisal resulted in fewer negative emotions than acceptance but was associated with a higher heart rate and greater recruitment of brain resources (Goldin et al., 2019). Similarly, reappraisal was more effective than acceptance in reducing the subjective anxiety response during impromptu speech, but the effects were comparable at the physiological level (Hofmann et al., 2009). The inconsistent results of the abovementioned studies suggest that future research in this area is needed.

Mindfulness and reappraisal/acceptance

Theoretical considerations on the relationship between mindfulness and ER efforts based on acceptance and reappraisal are not homogenous. Some models emphasize that the mindfulness training fosters the development of equanimity, defined as an even-minded mental state or dispositional tendency toward all experiences or objects, regardless of their origin or their affective valence (Desbordes et al., 2015). Equanimity manifests itself through an intentional attitude of acceptance toward any experience, which results in a willingness to tolerate different experiences regardless of their hedonic tone instead of trying to minimize the negative impact of there experiences (Hadash et al., 2016). According to these models, mindfulness training fosters ER based on the acceptance of aversive emotional experience; a mechanism put it in clear opposition to cognitive reappraisal based on the alteration of the meaning of this experience (Farb et al., 2014). Rather than promoting changes in negative stimuli, acceptance fosters an attitude of tolerance of the experiences, thus reducing reactivity (Lindsay et al., 2018). Other models do not completely exclude the association of mindfulness with active cognitive control over aversive stimuli (Hölzel et al., 2011), which suggests that in addition to bottom-up ER approaches, mindfulness might be associated with the success of purely cognitive ER strategies, such as reappraisal. A study reporting the association of mindfulness with activation in brain regions related to reappraisal supports this idea (Modinos et al., 2010). It has also been proposed that mindfulness training impacts both ER approaches, first acting at the stage of attentional deployment by promoting orientation toward stimuli in an accepting manner, and then affecting each of the emotion regulation stages by increasing the availability and flexibility of cognitive change strategies (Slutsky et al., 2017). A more nuanced approach suggests that mindfulness might be related to cognitive reappraisal at the process rather than the content level, i.e., by changing one's thinking about emotive

perceptions in general rather than about the emotive stimuli themselves (Chambers et al., 2009).

The results of empirical investigations demonstrated that both state mindfulness and MBI-driven pre/post intervention increases in dispositional mindfulness are linked with increases in positive reappraisal (Garland et al., 2011; Garland et al., 2015). This ER strategy was tested as a mechanism of the effects of mindfulness, and reappraisal significantly mediated the associations between mindfulness and depressive symptoms (Desrosiers et al., 2013) and mindfulness and stress (Garland et al., 2011). A similar pattern of MBIs' effects on increases in ER can be observed for acceptance: a recent study reports increases in acceptance as a result of MBSR and its mediating role in increases in well-being (Arlt Mutch et al., 2021). Similar to reappraisal, acceptance has been tested as an explanatory factor of contemplative training. In a randomized controlled trial aimed at dismantling mechanisms of mindfulness interventions by comparing the effects of monitor, monitor + accept and active control trainings, only the group with acceptance was found to be effective at reducing cortisol and blood pressure in response to stress (Lindsay et al., 2018).

Only a few studies have assessed both reappraisal and acceptance in relation to contemplative training. In a study exploring the psychological mechanisms of reduced stress response, meditation practitioners demonstrated higher scores than non-meditators in both reappraisal and acceptance; however, only acceptance mediated the relationship between meditation practice and stress (Gamaiunova et al., 2019). The results of a study investigating the effects of cognitive behavioral group therapy (CBGT) and MBSR on the brain and negative emotion indicators of cognitive reappraisal and acceptance in patients with social anxiety disorder suggest that, similar to CBGT, MBSR enhances both reappraisal and acceptance emotion regulation strategies (Goldin et al., 2021). A study investigating whether emotion

regulation strategies act as mechanisms of MBSR's effectiveness for students at risk of social anxiety reported that acceptance, but not positive reinterpretation, served as a mediator (Ștefan et al., 2018).

In sum, mindfulness training appears to be associated with both acceptance and reappraisal, and both strategies explain some of the beneficial effects of contemplative practices. With an increasing number of mindfulness-based or mindfulness-related programs (Creswell, 2017) and reported evidence of the differential effects of various contemplative approaches (e.g., Engert et al., 2017), an important empirical question is whether different MBIs affect reappraisal and acceptance to a similar extent. While it can be hypothesized that any program containing mindfulness practices would increase acceptance, certain mindfulness-based programs—second-generation MBIs (SG-MBIs)—might be particularly suited to train reappraisal. Those programs, which often place mindfulness at their core, emphasize other elements of Buddhist training, including ethical inquiry, values, philosophy, and the cultivation of adaptive mental states, more explicitly (Van Gordon & Shonin, 2020). Programs containing elements of philosophical inquiry, such as teaching impermanence, suffering, and not-self (Chapter 4), can be hypothesized to create an alternative cognitive schema through which events are interpreted (Newton & McIntosh, 2010). In the context of emotional distress, such a cognitive schema can create the possibility of an alternative interpretation. As such, programs that incorporate philosophical elements can be particularly effective for the development of reappraisal. Another aspect of the relationship between mindfulness and acceptance and reappraisal that needs further investigation is the differentiation between the ability to use a particular ER strategy (for example, in an instructed ER task) and the spontaneous use of the strategy in question (Egloff et al., 2006; Ehring et al., 2010). Empirical evidence on the effects of mindfulness on the spontaneous use of acceptance and reappraisal is largely lacking.

This study

This study aims to test the effects of two MBIs—a standard MBI (MBSR) and a modified MBSR with elements of other Buddhist practices (MBSR-B)—on the ER strategies of reappraisal and acceptance in two experiments. In Experiment I, the aim was to test the effectiveness of acceptance and reappraisal in downregulating negative affect and the autonomic nervous system (ANS) reactivity to negative self-beliefs (NSB) associated with autobiographical salient narratives. In Experiment II, the aim was to test the spontaneous choice of acceptance or reappraisal during a laboratory stressor. We hypothesize that in Experiment I, compared to the control, both MBSR and MBSR-B will show a more effective downregulation of negative affect and physiological arousal in the accepted condition. We further hypothesize that compared to the control and MBSR, MBSR-B will be more effective in reappraisal conditions. In Experiment II, we hypothesize that both groups will have higher scores of acceptance than the control and that MBSR-B will show higher scores of reappraisal than both MBSR and the control.

Experiment I

Method

Participants

For the information on the recruitment and inclusion criteria, please refer to Chapter 4 (Methods section). Exclusion criteria consisted of chronic or acute mental or physical disease, addiction to substances, the use of medications that interfere with ANS functioning, severe obesity (BMI>30), smoking more than five cigarettes per day, pregnancy or lactation, and an inability to give consent. Out of 182 interested individuals, 52 did not meet the inclusion criteria, 31 declined to participate, and the resulting sample of 99 participants was randomized into the

three experimental groups. Due to attrition, a sample of 64 participants was included in the analyses of behavioral data, 63 in the analyses of the HRV assessments, and 62 in the analyses of impedance cardiography due to the exclusion of low-quality data. The individual characteristics of the participants are presented in Chapter 4.

Procedure

For the intervention procedure, refer to Chapter 2 (Methods section).

After the intervention, participants received a link to an online postintervention questionnaire and were scheduled for two experimental sessions: the TSST (Experiment II, presented in the next section) and an emotion regulation (ER) task (Experiment I) in that order. Prior to the ER task, participants provided information about six autobiographical situations in approximately eight sentences, which were associated with increased self-conscious emotion (e.g., shame, embarrassment, humiliation) and five NSBs associated with the situation. In addition, participants were asked to choose six neutral stories from a list of short stories describing mundane tasks or procedures. Before the experiment, participants were asked to refrain from alcohol for twenty-four hours and caffeine and strenuous exercise for two hours. Upon arrival at the lab, participants completed the pre-experimental check (see: Materials). Furthermore, participants were connected to the physiological recording device and underwent training in applying the cues presented in the task (see: Materials). After the training, participants performed a trial run, followed by the task (see: Materials). Physiological readings were taken continuously with Biolab (Mindware Technologies, Gahanna, OH). Time stamps in the signal were introduced automatically through integration with E-Prime software (Psychology Software Tools, Inc., Pittsburgh, Pennsylvania). After the task, participants were disconnected from the physiological recording device and debriefed.

Materials

Intervention

An intervention description is presented earlier (Chapter 4, Methods section).

Autobiographical social situation task

The task was designed on the basis of a previously published work (Goldin et al., 2019; Goldin et al., 2021). Prior to the ER task, participants provided information about six autobiographical situations in one paragraph of approximately eight sentences each, which were associated with increased self-conscious emotions (e.g., shame, embarrassment, humiliation) and, for each story, five NSBs associated with the event (e.g., "I am worthless"; "No one likes me"). Participants indicated how much time elapsed since the event, how much self-conscious emotion they felt during and after the event, and the emotional intensity of NSBs. In addition to negative stories, participants chose from a list of neutral stories describing domestic chores or mundane events.

The task was implemented in E-Prime software (Psychology Software Tools, Inc., Pittsburgh, Pennsylvania) and consisted of six negative blocks, each followed by a neutral block. A negative block (Fig. 1A) presented a negative autobiographical story in eight sentences for a total duration of 24 seconds (i.e., three seconds each sentence). Reading the autobiographical story was included to help the participants to recall the social context and enhance emotional reactivity to NSBs. The story was followed by a three-second rating of negative emotion. Participants were asked "How negative do you fell right now?" (1 = not at all; 5 = very much) and responded by clicking on the arrow key. After that, five NSBs were presented for 12 seconds each and were preceded by the cue "REACT" (for the two first NSBs) and "ACCEPT" or "REINTERPRET" (for the following three NSBs) and followed by a three-second rating of negative emotions. The task contained three negative stories with "ACCEPT" cues and three with "REINTERPET" cues. A neutral block (Fig. 1B)

consisted of a participant-chosen neutral story for a total duration of nine seconds (i.e., three sentences for three seconds each). The story was followed by a three-second rating of negative emotion: participants were asked "How negative do you feel right now?" (1 = not at all; 5 = very much) before giving three neutral statements preceded by the cue "READ" and finally their rating of negative emotions.

Before the task, participants were trained to use the cues. For "READ," participants were asked to simply read the sentences on the screen and keep their eyes on the screen for the entire time. For "REACT," participants were asked to let feelings and thoughts arise as they naturally would, to think how what is written reflects something true about it, and to not try to change the feelings that arise. For "REINTERPRET," participants were asked to think about a negative belief in a way that helps them feel less negative without distracting themselves. Participants were free to choose any alternative interpretation of the event. For "ACCEPT," participants were asked to not fight any arising feelings, observe them with kindness, and not judge whatever their experience was. After a detailed explanation and examples, participants repeated back the instructions and made an attempt on two NSBs for each cue. After the attempt, participants explained what they did and, if necessary, were corrected by the experimenter. After the training, participants underwent a training trial.

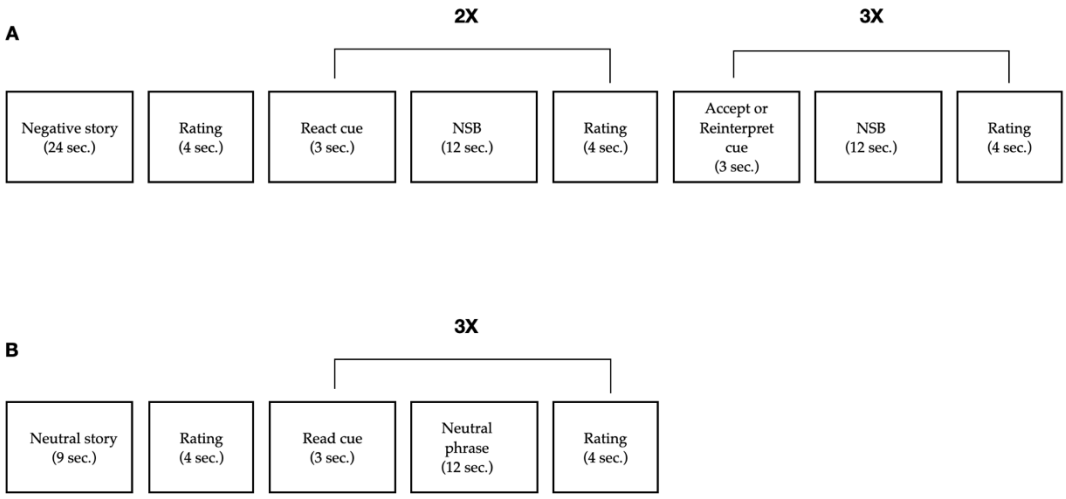


Figure 1. Structure of the task.

Measures

Self-report measures. Individual characteristics, practice log, MBSR-B program check, pre-experimental check. Refer to Chapter 4 (Methods section).

Task-related information. Participants indicated how much time elapsed since the event, how much self-conscious emotion they felt during and after the event (1 = "not at all"; 9 = "a great deal"), and the emotional intensity of the NSBs (on the same scale).

Cardiovascular measures. Electrocardiography and impedance cardiography data were collected continuously throughout the task using a Bionex data acquisition unit from MindWare Technologies (Gahanna, OH) with a sampling rate of 1000 Hz. Seven spot electrodes were placed on the participant's thorax (Sherwood citation 1992) and recorded using BioLab software. The data were processed offline using MindWare Technologies IMP 3.0.10 (check) and HRV 3.0.1 analysis software (Gahanna, OH). Segments were inspected by a trained researcher for artifacts and corrected, if necessary. For the impedance cardiography data, the distance between front electrodes was introduced manually to the software, and we marked normal R peaks with good corresponding dZ/dt cycles to maintain the expected signal

morphology. ANS signals were ensemble averaged over twelve seconds starting from the onset of a negative self belief or a neutral phrase.

Analyses

Group differences in self-report data were tested using the Wilcoxon rank sum and Kruskal–Wallis tests for ordinal data, chi-square tests for categorical variables, and ANOVAs and t tests for continuous variables (to avoid violating homogeneity of variance, robust versions of the tests were applied: Welsh ANOVA and Welsh's t test).

To check whether negative affect, RMSSD and PEP changed from "READ" (baseline condition) to "REACT" similarly in all groups, we performed mixed ANOVAs (Group X condition).

To test whether groups differed in negative affect rating, RMSSD or PEP, we performed three separate (group: MBSR/MBSR-B/WAITLIST) X 3 (condition: REACT/ACCEPT/REFRAME) mixed ANOVAs. The REACT, ACCEPT and REFRAME variables were calculated as delta scores (raw score - READ condition). Mixed ANOVAs were preceded by checking the assumptions for homogeneity of variance, sphericity and homogeneity of covariances. Extreme outliers were identified as values higher than Q3 + 3xIQR or lower than Q1–3xIQR. To control the family-wise error rate in multiple testing, we used the Holm–Bonferroni approach (Holm, 1979) to adjust the p values while applying the standard alpha level (0.05). A significant interaction was followed by tests of simple main effects and simple pairwise comparisons. A nonsignificant interaction was followed by tests of main effects.

Results

Preliminary analyses

Individual characteristics

The groups did not differ in age, sex, education, occupation, marital status or income (Chapter 4, Results section).

Intervention

The groups did not differ in the number of weekly sessions attended, self-report difficulty and effort in practice, or minutes of practice during the course (Chapter 4, Results section). The implementation of the MBSR-B program was partially successful, and MBSR-B participants reported a higher increase in their wisdom and ethical conduct scores than the MBSR and WAITLIST groups (Chapter 4, Results section).

Pre-experimental check

We conducted Kruskal–Wallis tests to determine if there were differences among groups in the number of hours of sleep, perceived sleep quality and mood. The groups did not differ in the number of hours they slept before the experiment: MBSR (*Mdn* = 7), MBSR-B (*Mdn* = 7), and WAITLIST (*Mdn* = 7), $\chi2(2) = 1.65$, $p = .437$, eta2[H] = -.01; no in the perceived quality of sleep: MBSR (*Mdn* = 3), MBSR-B (*Mdn* = 4), and WAITLIST (*Mdn* = 4), $\chi2(2) = 0.91$, $p = .634$, eta2[H] = .02. Similarly, no group difference was detected in affective state before the experiment, with participants reporting the comparable levels oF (1) sleepiness: MBSR (*Mdn* = 2), MBSR-B (*Mdn* = 2), and WAITLIST (*Mdn* = 2), $\chi2(2) = 0.70$, $p = .705$, eta2[H] = - .02; (2) happiness: MBSR (*Mdn* = 3), MBSR-B (*Mdn* = 3), and WAITLIST (*Mdn* = 4), $\chi2(2) = 5.08$, $p = .079$, eta2[H] = .05; (3) depression: MBSR (*Mdn* = 1), MBSR-B (*Mdn* = 1), and WAITLIST (*Mdn* = 1), $\chi2(2) = 0.56$, $p = .757$, eta2[H] = - .02; (4) frustration: MBSR (*Mdn* = 1), MBSR-B (*Mdn* = 2), and WAITLIST (*Mdn* = 1), $\chi2(2) = 2.10$, $p = .351$,

eta2[H] < .01; and (5) excitement: MBSR (*Mdn* = 2), MBSR-B (*Mdn* = 2), and WAITLIST (*Mdn* = 2), $\chi 2(2) = 1.75$, $p = .418$, eta2[H] < .01.

We conducted one-way ANOVAs to test whether the groups differed in years elapsed since the event, their level of self-conscious emotions during and after the event, and the emotional intensity of NSBs. The groups did not differ in any of those variables (Table 1).

Baseline-react difference

Negative affect. There were two extreme outliers that were deleted prior to the analysis. The data were relatively normally distributed for the REACT condition, as assessed by QQ plots. For the READ condition, there was deviation from normality, but as data in the groups demonstrated a similar pattern of positive skew, the test was carried out regardless of the deviation from normality. There was homogeneity of variances ($p > .05$) and covariances ($p > .001$), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively; the assumption of sphericity was met for the two-way interaction (Mauchly's test of sphericity > .05). There was no statistically significant two-way interaction between group and condition ($F(2, 58) = 1.62$, $p = .21$, generalized $\eta 2 = .023$); the main effect of condition was statistically significant ($F(1, 58) = 449.215$, $p < .001$, generalized $\eta 2 = .763$). The negative affect rating was significantly higher in the REACT ($M = 3.16$, $SD = 0.65$) than in the READ ($M = 1.30$, $SD = 0.36$) condition ($p < .001$, $d = 3.54$).

Pre-ejection period. There were no extreme outliers. The data were relatively normally distributed, as assessed by QQ plots. The assumption of homogeneity of variances was not met (Levene's test results: $p = .038$ and .047 for the REACT and READ conditions, respectively), so in addition to parametric ANOVA, we ran a robust mixed ANOVA using trimmed means with the help of the R package WRS2 (version 1.1-2). The results showed a similar pattern as the parametric test reported below. There was homogeneity of covariances ($p > .001$), as assessed by Box's M test,

and the assumption of sphericity was met for the two-way interaction (Mauchly's test of sphericity > .05). There was no statistically significant two-way interaction between group and condition ($F(2, 59) = 0.034$, $p = .9$, generalized $\eta 2 < .001$); the main effect of the condition was statistically significant ($F(1, 59) = 114.189$, $p < .001$, generalized $\eta 2 = .007$). PEP was significantly lower in the REACT ($M = 105.52$, $SD = 10.10$) than in the READ ($M = 104.23$, $SD = 10.11$) condition ($p < .001$, $d = 0.16$).

Heart rate variability. There were no extreme outliers. The data were normally distributed for REACT, as assessed by QQ plots. There was homogeneity of variances ($p > .05$) and covariances ($p > .001$), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively; the assumption of sphericity was met for the two-way interaction (Mauchly's test of sphericity > .05). There was no statistically significant two-way interaction between group and condition ($F(2, 60) = 0.12$, $p = .21$, generalized $\eta 2 < .001$); the main effect of the condition was statistically significant ($F(1, 60) = 10.24$, $p = .002$, generalized $\eta 2 = .007$). RMSSD was significantly lower in the REACT ($M = 38.98$, $SD = 16.38$) than in the READ ($M = 41.76$, $SD = 17.04$) condition ($p < .002$, $d = 0.17$).

Main analyses

Negative affect

There were no extreme outliers. The data were relatively normally distributed, as assessed by QQ plots. There was homogeneity of variances ($p > .05$) and covariances ($p > .001$), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively; the assumption of sphericity was met for the two-way interaction (Mauchly's test of sphericity > .05). There was a statistically significant two-way interaction between group and condition ($F(4, 122) = 4.85$, $p = .001$, generalized $\eta 2 = .063$). The simple main effect of the group was significant in the ACCEPT ($p = .002$, $G\eta 2 = .212$) and REFRAME ($p = .024$, $G\eta 2 = .135$) conditions but

not in the REACT condition (p = .800, Gη2 = .007). For the ACCEPT condition, pairwise comparisons showed that the mean change in the negative affect rating was statistically significantly greater in WAITLIST (M = 1.52, SD = 0.56) than in MBSR-B (M = 0.88, SD = 0.59, p = .001, d = 1.12) and in MBSR (M = 0.95, SD = 0.60) than in WAITLIST (p = .005, d = 0.98). For the REFRAME condition, the pattern was different: the mean change in the negative affect rating was statistically significantly greater in WAITLIST (M = 1.23, SD = 0.60) than in MBSR-B (M = 0.72, SD = 0.66, p = .014, d = 0.81) and in MBSR (M = 1.32, SD = 0.78) than in MBSR-B (p = .006, d = 0.83) (Fig. 2).

Pre-ejection period

There was one extreme outlier that was deleted prior to the analysis. The data were relatively normally distributed, as assessed by QQ plots. There was homogeneity of variances (p > .05) and covariances (p > .001), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively; the assumption of sphericity was met for the two-way interaction (Mauchly's test of sphericity > .05). There was a statistically significant two-way interaction between group and condition (F(4, 116) = 2.75, p = .003, generalized η2 = .004). The simple main effect of group was significant only in the REFRAME condition (p = .006, Gη2 = .192) but not in the ACCEPT (p = .522, Gη2 = .045) or REACT (p = .832, Gη2 = .006) conditions. For the REFRAME condition, pairwise comparisons showed that the mean change in PEP was significantly different in MBSR-B (M = - 0.15, SD = 0.76) compared to WAITLIST (M = - 1.14, SD = 1.46, p = .01, d = 0.86) and in MBSR-B compared to MBSR (M = - 1.41, SD = 0.94, p = .003, d = 1.47) (Fig. 3).

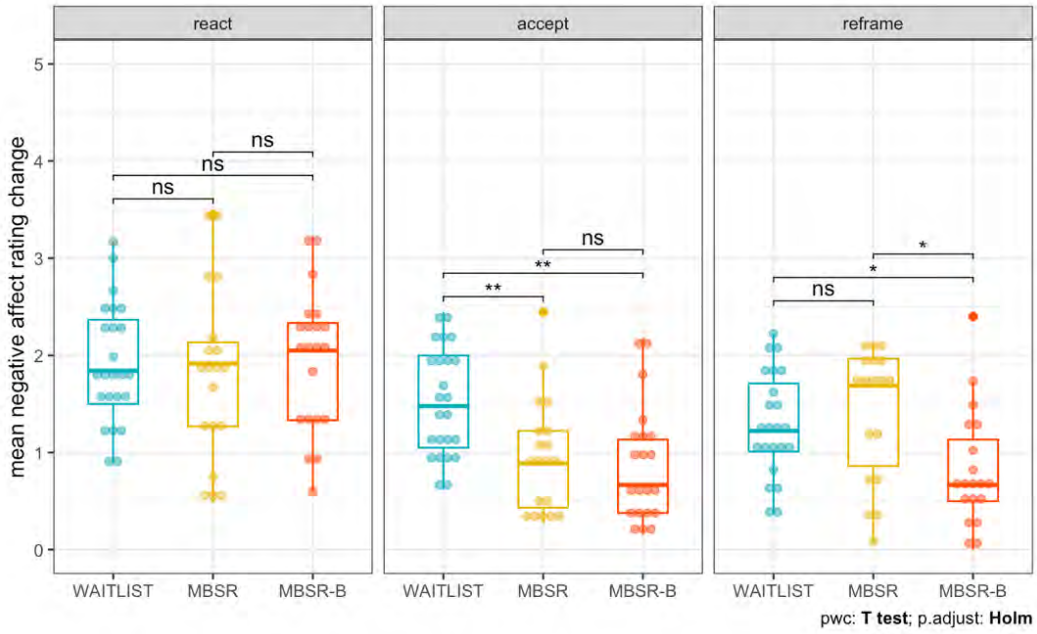


Figure 2. Negative affect rating change across conditions.

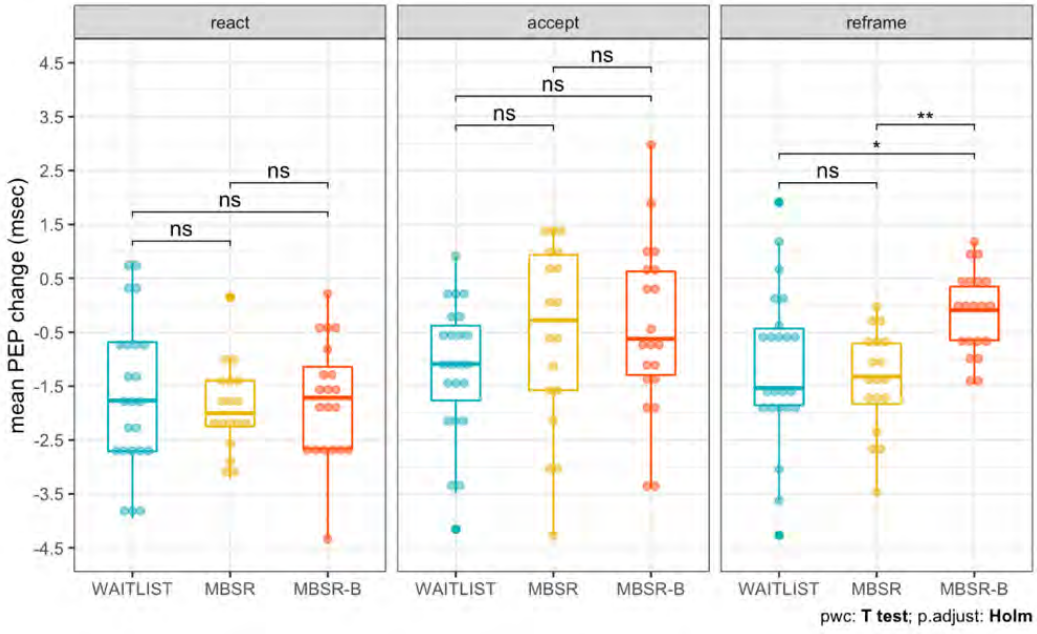


Figure 2. PEP change across conditions.

Table 1

Autobiographical Situations

	MBSR (*M, SD*)	MBSR-B (*M, SD*)	CNTR (*M, SD*)	F-value (*p*)	Partial eta2
Years since situation	3.60 (3.63)	4.93 (4.97)	3.46 (3.18)	0.90 (.413)	0.03
SC emotions at the event	6.94 (1.45)	7.27 (1.15)	7.42 (1.38)	0.70 (.501)	0.02
SC emotions now	4.13 (1.74)	4.25 (1.64)	4.27 (1.83)	0.04 (.964)	0.00
Emotional intensity NSB	7.02 (0.97)	6.82 (1.259	6.82 (1.06)	0.23 (.796)	0.01

Note. SC = self-conscious, NSB = negative self-beliefs, MBSR = Mindfulness Based Stress Reduction group, MBSR-B = Mindfulness Based Stress Reduction with an additional module group, WAITLIST = waitlist control group.

Heart Rate Variability

There were seven significant outliers, which were removed prior to analysis. The data were relatively normally distributed, as assessed by QQ plots. There was homogeneity of variances ($p > .05$) and covariances ($p > .001$), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively; the assumption of sphericity was met for the two-way interaction (Mauchly's test of sphericity > .05). There was no statistically significant two-way interaction between group and condition ($F(4, 84) = 0.363$, $p = .835$, generalized $\eta 2 = .008$). The main effect of group was not statistically significant ($F(2, 42) = 1.586$, $p = .217$, generalized $\eta 2 = .039$); the same results were found for the condition effect ($F(2, 84) = 1.451$, $p = .240$, generalized $\eta 2 = .016$).

Experiment II

Method

Participants

For the information on the recruitment and inclusion criteria, please refer to Chapter 4 (Methods section). Out of 62 participants who accomplished the TSST test, the response to the Emotion Regulation questionnaire was missing in one person

Materials

Intervention

An intervention description is presented earlier Chapter 4 (Methods section).

Trier Social Stress Test

For the Trier Social Stress procedure, refer to Chapter 4 (Methods section).

Measures

Self-report measures

Individual characteristics, practice log, MBSR-B program check, pre-experimental check. Refer to Chapter 4 (Methods section).

Emotion regulation. Emotion regulation was assessed with a constructed questionnaire, which was administered after the experiment. Participants were asked to (1) indicate to what degree they wanted to regulate their emotion during the task (1 = "not at all"; 7 = "a lot") and to what point their emotion regulation efforts were successful (1 = "not at all successful"; 7 = "very successful") and (2) to indicate if they used a particular emotion regulation strategy from a proposed list (e.g., acceptance or reappraisal) (1 = "completely disagree"; 7 = "completely agree") . Each emotion regulation strategy was assessed by two items. Internal consistency of the acceptance and reappraisal subscales was estimated using Cronbach's coefficient alpha and yielded acceptable values of 0.71 and 0.69, respectively.

Physiological measures

For physiological measures, refer to Chapter 4 (Methods section). For the association exploratory analyses, we used the following calculated variables: RMSSD % change to task, PEP % change to task, absolute change of negative affect, absolute change of positive affect.

Analyses

To test whether the groups were different in their degree of use of adaptive emotion regulative strategies (e.g., reappraisal, acceptance), we performed a one-way MANOVA, preceded by checking the necessary assumptions. A Pearson's product-moment correlation was run to assess the association between scores of ER and RMSSD % change, PEP % change, absolute change of negative affect and absolutechange of positive affect in the whole sample.

Results

Preliminary analyses

The results of preliminary analyses for the TSST can be found in Chapter 4 (Results section).

Main analyses

Emotion Regulation

To test the group difference in emotion regulation efforts and efficacy, we performed a univariate analysis of variance. No statistically significant difference among groups was detected ($F(4, 118) = .958$, $p = .433$, Wilks' $\Lambda = .063$).

To test whether the groups were different in their degree of use of adaptive emotion regulative strategies (e.g., reappraisal, acceptance), we performed a one-way MANOVA. The results demonstrated that there was a statistically significant difference among groups ($F(4, 118) = 2.590$, $p = .04$, Wilks' $\Lambda = .16$). Furthermore, we performed one-way ANOVAs with Holm–Bonferroni corrections for separate ER strategies. The group difference was found only in acceptance (Welch's $F(2, 38.06) = 5.07$, $p = .011$). Pairwise comparisons showed that the mean score of acceptance was statistically significantly higher in MBSR-B ($M = 5.38$, $SD = 1.24$) than in WAITLIST ($M = 4.38$, $SD = 1.58$, $p = .021$, $d = .71$) and in MBSR ($M = 5.53$, $SD = 0.67$) than in WAITLIST ($p = .017$, $d = 0.95$) (Fig. 3A). Descriptive statistics can be found in Table 2.

Association with physiological variables

There were statistically significant but small positive correlations between the score of acceptance and the PEP % change ($r(59) = 0.29$, $p = .021$) and between the score of acceptance and the absolute change in positive affect ($r(59) = 0.28$, $p = .03$) and a moderate negative correlation between the score of acceptance and the

absolute change of negative affect ($r(59) = - 0.39$, $p = .002$) (Fig. 3B-D). No association between the RMSSD % change and acceptance was detected ($r(59) = .02$, $p = .906$).

Table 2

Descriptive statistics emotion regulation strategies during TSST

Outcome	MBSR ($N = 17$) (M, SD)	MBSR-B ($N = 21$) (M, SD)	WAITLIST ($N = 24$) (M, SD)
accept	5.53 (1.25)	5.38 (1.24)	4.38 (1.58)
reappraise	5.09 (0.75)	5.02 (1.22)	4.75 (1.43)
desire to regulate	3.82 (1.74)	3.76 (1.87)	4.62 (1.74)
success of regulation	4.12 (1.58)	4.19 (1.50)	4.00 (1.47)

Note. MBSR = Mindfulness Based Stress Reduction group, MBSR-B = Mindfulness Based Stress Reduction with an additional module group, WAITLIST = waitlist control group.

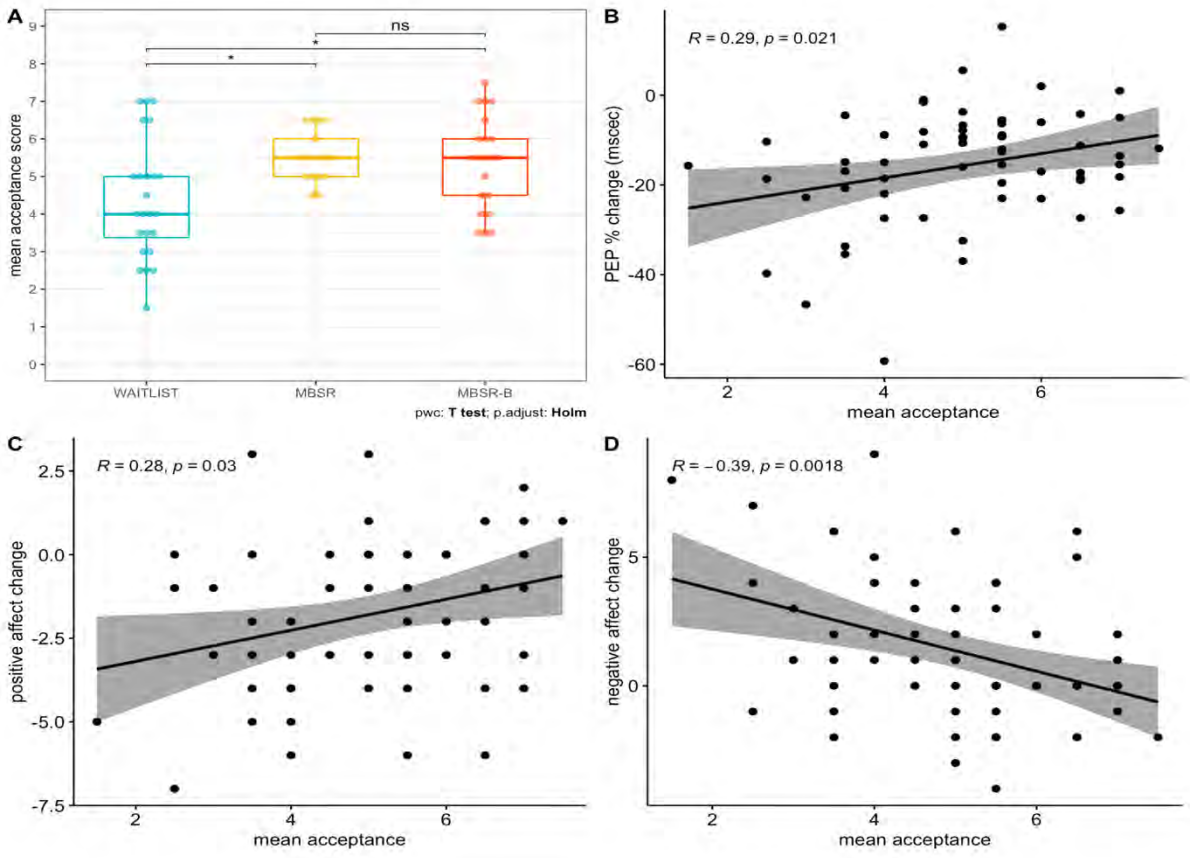


Figure 3. A. Group differences in the acceptance score; B-D. The association of acceptance with positive/negative affect and PEP change during the TSST in the complete sample.

Discussion

This study investigated the effects of two MBIs—a standard MBSR and a modified MBSR with an additional module based on other Buddhist practices—on the (1) effectiveness of acceptance and reappraisal in downregulating negative affect and the autonomic nervous system's (ANS) reactivity to negative self-beliefs (NSB) in the context of an ER task, and (2) spontaneous choice of acceptance and reappraisal in the context of induced social stress. Congruent with our hypothesis for Experiment I (i.e., the ER task), both MBSR and MBSR-B had a lower increase in negative affect in the acceptance condition compared to the control, and MBSR-B showed a lower increase in negative affect in the reappraisal condition compared to both MBSR and the control. On the physiological level, the effect of contemplative training was present only for PEP in the reappraisal condition, with MBSR-B showing a smaller decrease in ventricle contractility, thus suggesting lower sympathetic activation. Our hypotheses for Experiment II (i.e., the social stressor) were only partially confirmed: both experimental groups showed higher scores of acceptance compared to the control, and no effect was observed for reappraisal. Exploratory analyses demonstrated that higher acceptance was associated with lower negative affect, higher positive affect and fewer changes in sympathetic activation. These findings bring contextual nuance to the discussion about the association of contemplative training with the ER strategies of acceptance and reappraisal.

The context of ER can be represented by a number of components, including in organisms carrying out regulation, the type of emotion eliciting stimuli, the selection and implementation of ER strategies and the types of outcomes assessed (Aldao, 2013). In this study, we assessed the effects of MBIs on acceptance and reappraisal both by instructing participants to use these strategies (Experiment I) and by

assessing which strategy participants implemented spontaneously (Experiment II). While in the instruction task the effects of MBIs on downregulating negative affect were present for both the acceptance and reappraisal conditions, spontaneous implementation choices showed that MBIs affected only acceptance. It can be hypothesized that MBIs broaden the range of regulatory strategies available for selection (Slutsky et al., 2017); while reappraisal is a commonly used ER strategy, acceptance is, to a larger extent, associated with mindfulness training or third-way therapies (Hayes & Feldman, 2004; Lindsay & Creswell, 2017b). Thus, contemplative training might have permitted to include acceptance to the regulatory repertoire by adding to an already existing reappraisal. Adding acceptance brings about benefits on the level of physiological stress regulation, and the exploratory analyses in this study suggest that acceptance is associated with a lesser increase in sympathetic activation and negative affect and a lesser decrease in positive affect. These results are congruent with a previous report showing that acceptance is associated with a reduced physiological response to stress in long-term meditation practitioners (Gamaiunova et al., 2019). In addition to broadening the repertoire of ER strategies, MBIs affected the effectiveness of both acceptance and reappraisal to downregulate negative affect in the context of instructed tasks. However, at the physiologic level (e.g., ANS sympathetic activation), this effect was present only for reappraisal. These results are more congruent with theoretical considerations on the differences between beginners and experts, whereby beginners are theorized to recur more often through active cognitive regulation, while long-term practitioners do not use prefrontal control and show enhanced bottom-up regulation (Chiesa et al., 2013; Hölzel et al., 2011).

The second contextual factor with the potential to affect the relationship between contemplative training and the ER strategies of acceptance and reappraisal is the MBI type. The specificity of a contemplative practice has been recognized as an

important factor in the evaluation of the outcomes of MBIs (Chapter 4, Engert et al., 2017; Morton et al., 2020). The results of this study also suggest that specificity matters, as only the MBSR-B group showed the effect of reducing physiological activation in response to NSBs under reappraisal conditions. While the effects of mindfulness training on the reappraisal can be explained through the development of the process of decentering—a metacognitive form of awareness, which allows practitioners to shift from the contents of consciousness to the process of consciousness itself, thus facilitating flexible selection of an appraisal (Garland et al., 2009b)—the additional training, implemented in the MBSR-B, can bring supplementary enhancement to the reappraisal process. MBSR-B training included, in addition to standard mindfulness training, short training in the Buddhist concepts of impermanence, suffering, and nonself. In the Buddhist framework, implicit teachings about the nature of reality complement experiential insights and bring out potential for additional clinical benefits (Shonin, Van Gordon, et al., 2014a, 2014b; Toneatto, 2002). While decentering is hypothesized to enhance reappraisal through a shift to the process of consciousness, explicit teachings can alter reappraisal through the creation of alternative schematic models or views based on Buddhist doctrinal tenets (Teasdale & Chaskalson, 2011a). The idea that specific cognitions derived from religious traditions have the potential to constitute a cognitive schema (Bjorck, 1995) and alter the appraisal process has found some empirical support (Newton & McIntosh, 2010). Although, to our knowledge, no studies have evaluated the effects of MBIs with elements of wisdom training on the reappraisal process, the results of a qualitative study in long-term meditation practitioners suggest that ideas from Buddhist doctrine, such as impermanence and not-self, were used to reinterpret the experience of being under social stress (Gamaiunova, Brandt, & Kliegel, 2021).

At the level of physiological response to stress and emotion-eliciting stimuli, we found an association between ER and decreased sympathetic activation. In

Experiment I, higher scores of acceptance were associated with a lower percent decrease in PEP in response to stress. In Experiment II, a lesser PEP decrease was observed in the reappraisal condition. PEP, an inotropic measure of myocardial contractility that controls the beta-adrenergic sympathetic influences on the heart, has been proposed as an index of effort, particularly in situations requiring active coping (Kelsey, 2012). However, PEP has also been linked to other-than-effort factors of stressful experience, such as social evaluation (Bosch et al., 2009) and behavioral and environmental uncertainty (Kelsey, 2012). In emotions research, an increase in sympathetic tone measured by PEP has been linked to the emotions of anger, disgust, embarrassment, and fear, while a decrease was associated with emotions of amusement and happiness (Kreibig, 2010). It can be hypothesized that acceptance requires less effort and/or reduces the negative effect of perceived uncertainty through the mechanism of nonjudgmental awareness. The effect of reappraisal on PEP in Experiment I being present only in the MBSR-B group suggests that the effectiveness of this ER strategy for downregulation of sympathetic activation in response to stressful emotional experiences can be enhanced by particular types of contemplative training, although the mechanisms of this effect are not clear.

Limitations and future directions

The study has a number of limitations. First, while it contrasts the spontaneous choice and instructed use of ER strategies, the emotion-eliciting stimuli in the task varied. While both experiments were based on ecologically valid stimuli related to social stress (Slavich, 2020), Experiment II used a stimulus requiring a more pronounced energy mobilization. Future studies can address this issue by comparing the choice and instructed use of ER strategies using the same experimental paradigm. Second, the assessment of the use of the ER strategies in Experiment II did not allow us to assess whether reappraisal and acceptance (or

other ER strategies) were used consistently and exclusively throughout the task. Taking into consideration a theoretical discussion on polyregulation, or the concurrent or sequential use of multiple approaches to regulate emotions within a single emotional episode (Ford et al., 2019), future studies should test whether contemplative training affects polyregulation efforts.

Future studies could explore the effects of contemplative training on other contextual dimensions of the ER process (Aldao, 2013). Of particular interest is an exploration of what constitutes a beneficial outcome of the ER process: while a hedonic goal consisting of decreasing negative affect and increasing or maintaining positive affect is assumed in most ER literature, contemplative training might affect this goal. Concerning the general effects of MBIs and contemplative training on acceptance and reappraisal, future studies could explore the common process underlying both ER strategies, as it has already been proposed that decentering can play a role in both types of regulatory efforts (Hayes-Skelton & Graham, 2013).

General discussion

This thesis focused on exploring the associations between psychological stress and contemplative practices derived from Buddhist traditions. Six studies followed the three main lines of investigation, as outlined in the Introduction: (1) the effect of contemplative practices on the psychophysiological response to stress (in terms of different physiological systems, affective response, and dynamics); (2) psychological mechanisms underlying the stress buffering effects of contemplative training (with focus on cognitive appraisals and emotion relegation); (3) stress-buffering effects of other-than-mindfulness elements of contemplative training. This section summarizes the main results of the studies, addresses their limitations, proposes future directions, and briefly discusses the possible clinical implications.

Overview of the main findings

Contemplative practices and stress: psychophysiological response

The first contribution of this work is that it provides further evidence that the association between contemplative training and psychological stress is apparent not only at the level of subjective evaluation, but also at the level of physiological changes. This tendency was detected both in long-term practitioners (Chapter 1) and as a result of contemplative interventions, such as MBSR (Chapter 4).

Study presented in Chapter 1 assessed the HPA axis and ANS stress reactivity to a social stressor in a population of long-term meditators, and the results suggested that long-term meditation practitioners ($N = 29$) have faster cortisol recovery than gender- and age-matched non-meditators ($N = 26$). No effect was observed on the changes in heart rate or HRV. Study presented in Chapter 4 assessed stress reactivity using the same stress-inducing experimental paradigm, but in a population of meditation-naive participants randomized to follow an eight-week mindfulness

program (N = 99). The assessment of stress-related physiological changes included markers of the HPA axis (cortisol), SAM system (alpha-amylase), and ANS (PEP as an index of sympathetic activity, and RMSSD as an index of parasympathetic control). The results suggest that mindfulness-based interventions reduced cortisol reactivity, attenuated sympathetic reactivity (PEP), and decreased vagal withdrawal (RMSSD).

While both studies demonstrated the association between contemplative training and the attenuation of the HPA axis reactivity, the results concerning the ANS system are not convergent. Previous studies (Engert et al., 2017) as well as our Study 1, suggested that the discrepancy between the effects of contemplative training on the HPA axis and ANS system could be explained by autonomic activity as a sign of general arousal irrespective of its valence, whereas HPA-axis activity is stress-specific and strongly determined by internal evaluations (which can be affected by contemplative training). While the idea that the ANS is not sensitive to social-evaluative threat was proposed in earlier theories, such as social preservation theory (Dickerson et al., 2009; Gruenewald et al., 2004), later empirical investigations (Bosch et al., 2009) demonstrated that autonomic reactions, such as changes in sympathetic activity and vagal tone, are actually very sensitive to social evaluation. To explain the discrepancy between the earlier and later studies, the authors (Bosch et al., 2009) suggested that methodological issues associated with stress measurement might play an important role: ANS is very sensitive to postural changes, which are rarely controlled in the context of tasks such as TSST. This explanation is also relevant to the current work: The study presented in Chapter 4 used an approach to ANS measurement which is methodologically superior in comparison to the approach used in the study presented in Chapter 1: Postural changes were controlled by adapting the protocol, which allowed us to carefully inspect signals for artifacts (while the study in Chapter 1 relied on the algorithm

provided by the manufacturer). Moreover, the possibility of differentiating SNS and PNS provided a more fine-grained assessment of autonomic changes.

Both studies contribute to growing body of research which suggests that there is an association of contemplative training and reduced physiological stress reactivity (Morton et al., 2020). Our results suggest that the effect of contemplative training on physiological markers of stress response is manifested in changes in the HPA axis and both branches of the ANS, affecting sympathetic activation and vagal control. While using heart rate variability as an important index in contemplative research has been previously emphasized (Christodoulou et al., 2020), our results in addition suggest that indices of sympathetic activation (such as PEP) are as much important.

As another contribution, this work enlarges the research framework beyond the reactivity hypothesis (Cacioppo et al., 1998), which emphasizes the role of recurrent stress reactivity in the development of disease. It provides rare empirical evidence that contemplative practice indeed reduces prolonged stress reactivity by attenuating psychophysiological responses in anticipation of and recovery from stress. This result supports recent theoretical models which suggest the negative role of the prolonged stress reactivity in the development of stress-related disorders (Brosschot et al., 2005).

Focusing on the temporal dynamics of the stress response, the results presented in Chapter 1 demonstrated that an association between contemplative training and stress was observed in the cortisol recovery index. In the study presented in Chapter 4, HPA axis reactivity was affected by contemplative training during the anticipation period. Concerning the ANS measurements presented in Chapter 4, contemplative effects on PEP were observed in both the anticipation and reactivity periods, and on RMSSD in the anticipation, task, and recovery. These findings strongly suggest that contemplative training has the potential to decrease prolonged reactivity to stress by

reducing anticipatory arousal and facilitating a faster recovery. This can provide a potential explanation for the discrepancies in the research results concerning contemplative practice effects on physiological changes (Morton et al., 2020): focus on reactivity in stress measurements can mask potential effects by failing to detect reduced prolonged activation. These results are ever more important given that the research that focused on contemplative training effects on anticipation of or recovery from stress is scarce (Britton et al., 2012; Fogarty et al., 2015; Hoge et al., 2018; Mayor & Gamaiunova). In addition, considering that prolonged stress reactivity largely depends on the cognitive representation of a stressor, even in the absence of the stressor itself (Brosschot et al., 2006), the results of this study point out the role of cognitive changes around the stressor in the effects of contemplative training on stress.

Concerning the assessment of affective changes in response to stress, this work demonstrates that contemplative training is associated not only with the reduction of negative affect in response to stress (Chapter 4), but also with the reduction of stress-induced self-conscious emotions, such as shame (Chapter 1), and a decreased reduction in positive affect (Chapters 1 and 4).

Taking a more detailed look at negative affect, in Chapter 1 there was no difference in negative affect between meditation practitioners and non-meditators when assessed using questionnaires. However, the groups differed in the state of shame, assessed immediately after the task. Qualitative assessment, accompanied by objective measures in Chapter 2 showed convergent results, demonstrating that the difference in negative affect between groups was driven primarily by negative emotions related to the self. The results of the intervention study (Chapter 4) also demonstrated the effect of contemplative training on reducing negative affect in anticipation and reaction to stress.

Interestingly, while the TSST is primarily designed to evoke negative emotions, the results of the qualitative assessment (Chapter 2) demonstrated that long-term practitioners experienced a wide range of positive emotions, such as curiosity, delight, and interest. The results of the intervention study (Chapter 4) confirmed these findings by demonstrating a smaller reduction in positive affect in response to stress after contemplative intervention. These results demonstrate that the assessment of the effects of contemplative training on affective changes in response to stress should not be limited to negative affect only, especially considering that negative affect is poorly correlated with certain biomarkers of stress, such as cortisol (Denson et al., 2009).

Self-conscious emotions, experienced primarily when actual or ideal self-representation is shattered (Tracy & Robins, 2004), are theorized to be more potent contributors to physiological responses to stress, driven primarily by the HPA axis (Kemeny et al., 2004). Contemplative practice, especially with the elements of wisdom training, may be associated with important changes in self-image, leading to the perception of the self as less solid (Epstein, 1988), thus reducing the magnitude of self-conscious cognition and affect.

There are several connections between the results on affective states obtained in this study and the previously published research: Several reports suggest that contemplative training reduces shame in agreement with our observations (Goldsmith et al., 2014; Sedighimornani et al., 2019; Woods & Proeve, 2014). The unexpected presence and lesser reduction of positive affect in response to stress induction demonstrated in Chapter 2 and Chapter 4 can potentially be explained by the effect of contemplative training on openness, which increases the ability to invite experiences, even if they are difficult (Creswell, 2017). Considering that positive emotions were found to be associated with faster recovery from stress (Fredrickson & Levenson, 1998; Robles et al., 2009), the effects of contemplative practice on

positive affect represent an important line of investigation. While several previous studies have reported an association between contemplative training and an increase in the positive affect (Fredrickson et al., 2017; Geschwind et al., 2011; Jislin-Goldberg et al., 2012), the results of this study provide evidence that this effect can also be observed in a challenging context, such as psychosocial stress.

Contemplative practices and stress: psychological mechanisms

Another area explored in this work are the psychological mechanisms associated with the stress-buffering effects of contemplative training, the first being cognitive appraisals. The results suggest that anticipatory cognitive appraisals of challenge and threat are affected only in short-term practitioners, but post-hoc qualitative assessment showed that long-term practitioners constructed their past stressful experiences in challenging rather than threatened terms. Furthermore, the results demonstrate that some forms of short-term contemplative training are associated with a cardiovascular profile corresponding to the challenge rather than threat.

Cognitive appraisals were first explored in the study presented in Chapter 1 in the framework of Transactional Model of Stress and Coping (Lazarus & Folkman, 1984), followed by qualitative assessments in Chapter 2, and by the study presented in Chapter 5, where in addition to the above-mentioned model, cognitive appraisals were assessed based on the biopsychosocial model of challenge and threat (Tomaka et al., 1997). The results presented in Chapter 1 demonstrated that long-term meditation practitioners and non-meditators did not differ in the level of anticipatory cognitive appraisal of either the challenge or threat. Convergently, the results of the qualitative assessment presented in Chapter 2 demonstrated that in the narratives related to the experience of stress, long-term meditation practitioners showed similar results to non-meditators' cognitive evaluations of a stressor,

emphasizing the ego threat feature of the stressful experience. However, long-term mediators also described their experiences as more challenging and thrustful. The results presented in Chapter 5 showed a pattern similar to the results of Chapter 1: the levels of anticipatory challenge and threat were not statistically significantly different between the experimental groups. However, exploratory analyses within each group showed that the level of challenge was significantly higher than threat in only one of the contemplative intervention groups (MBSR-B). Furthermore, the results presented in Chapter 5 demonstrated that one of the contemplative intervention groups (MBSR-B) demonstrated a more pronounced cardiovascular profile associated with challenge appraisal, that is, higher CO and lower TPR. The results of these studies suggest that in the framework of the transactional model of stress and coping, higher anticipatory challenge and threat appraisal could be observed only in interventional studies. These findings could be explained with the help of previous theoretical considerations, proposing that beginners require more cognitive processes in response to stimuli and show greater prefrontal activation, whereas long-term mediators do not use prefrontal control and are rather in the state of non-appraisal (Hölzel et al., 2011). The results of qualitative assessment, suggesting higher challenge than threat in the description of stressful experience in long-term meditators, do not contradict this idea, taking into consideration the timing of assessment (post-hoc vs. anticipatory phase). Furthermore, the results presented in Chapter 5 demonstrate that in the framework of the biopsychosocial model of challenge and threat, MBSR-B is associated with more adaptive cardiovascular response. These results are congruent with previous reports showing a similar pattern (Daubenmier et al., 2019; Manigault et al., 2021).

The second psychological mechanism evaluated in this study was emotion regulation. Chapter 1 demonstrated that the general use of reappraisal and acceptance is higher among long-term meditation practitioners than among non-

meditators. Furthermore, mediation analysis demonstrated that only habitual use of acceptance was partially responsible for the observed physiological stress reducing effects (cortisol recovery). The qualitative results presented in Chapter 2 provide further evidence that acceptance and reappraisal are routinely used by meditators in addition to decentering and attention to the body. The important finding of qualitative assessment is that the group of non-meditators did not recur to strategies other than reappraisal and had a high ratio of individuals who did not use any emotion regulation strategy. These results suggest that contemplative training broadens the repertoire of emotion regulation strategies. Study 6 targeted the effects of short contemplative training effects on acceptance and reappraisal in two different stressful contexts: TSST and ER tasks, based on personal stressful narratives and associated negative self-beliefs. The results demonstrated that (1) in terms of spontaneously chosen emotion regulation strategies during the TSST, intervention groups scored higher than the control group only in acceptance; further analyses demonstrated that acceptance was associated with changes in positive and negative affect and sympathetic activation; (2) in terms of application efficacy of reappraisal and acceptance during an instructed ER task, both intervention groups demonstrated reduced negative affect in the acceptance condition, but only one type of contemplative intervention (MBSR-B) had an effect on negative affect in the reappraisal condition. At the physiological level, only one meditation group (again MBSR-B), and only in the reappraisal condition, showed a reduction in sympathetic activation.

These results add to the literature on the association between contemplative training and emotion regulation strategies using top-down (such as reappraisal) and down-up (such as acceptance) paths (Farb et al., 2014; Modinos et al., 2010; Slutsky et al., 2017). According to this study's findings, contemplative training affects both reappraisal and acceptance. However, whereas spontaneous choice and habitual use

in situations of stress of both acceptance and reappraisal were affected by contemplative training, only acceptance was found to be associated with the attenuation of stress response at the physiological level: cortisol (Chapter 1) and PEP (Chapter 6). Furthermore, the effect of contemplative training on habitual use and spontaneous choice of ER differed from the effectiveness of the application of these strategies. While the effect of contemplative practice on downregulating negative affect evoked by NSB was present in both acceptance (both contemplative intervention groups) and reappraisal (one experimental group, MBSR-B), downregulation of sympathetic activation was present only in the reappraisal and only in one experimental group (MBSR-B). These results contribute to the literature, emphasizing the importance of the context of emotion regulation (Aldao, 2013) in terms of the particularity of stress and choice vs. effectiveness of emotion regulation strategies.

Contemplative practices and stress: effects of other-than-mindfulness elements

A topic addressed by this work in an exploratory manner was whether other-than-mindfulness elements inherent in Buddhist contemplative training have additional effects on stress reduction. Our first study of this question was presented in Chapter 3. It used a cross-sectional survey design to investigate the relationship between Buddhist insight and perceived stress in a population of long-term meditation practitioners ($N = 260$). Another study, which was presented in Chapter 4 ($N = 99$), adopted an interventional design to explore whether mindfulness-based intervention (MBSR) enhanced with additional modules based on other Buddhist practices will have larger stress-buffering effects.

The results presented in Chapter 3 demonstrated that Buddhist Insight, measured using a previously elaborated measure, the Insight Scale, has a negative

association with perceived stress. This relationship was partially mediated by irrational beliefs. Another finding of this study, based on the psychometric evaluation of the instrument, suggests that Buddhist insight is separate from mindfulness's predictive power; and after controlling for mindfulness in a regression model, insight remained a significant predictor of life satisfaction and anxiety. The results of the intervention indicated that participants in the mindfulness program enhanced with an additional module showed a slightly larger attenuation of physiological and affective responses to stress (Chapter 4), demonstrated challenge rather than threat appraisal, showed a cardiovascular profile associated with challenge (Chapter 5), and showed a higher capacity to use reappraisal to downregulate sympathetic activation evoked by stressful negative self-beliefs (Chapter 6).

Overall, the results of this thesis provide a preliminary indication that mindfulness is not the sole ingredient in contemplative training with the potential to reduce stress. These results represent one of the first attempts to empirically test the effects of second-generation mindfulness programs (Van Gordon & Shonin, 2020) on stress, following research interest in expanding the study of contemplative training to different varieties (Bayot et al., 2020; Chen & Jordan, 2020; Dahl & Davidson, 2019; Lomas, 2017). The results of both studies indicate that the add-on effects of other elements of Buddhist practice are at least partially based on cognitive elements. These findings are congruent with cognitive theories of religious coping, which state that elements of a traditional doctrine form a cognitive lens through which stressful events can be interpreted (McIntosh, 1995; Newton & McIntosh, 2010). In addition to cognitive or wisdom-based elements, the Buddhist framework offers training in compassion, loving kindness, and empathetic joy. Initial investigations show promising effects of these types of training on stress (Arch et al., 2014; Engert et al., 2017; Pace et al., 2009). While the intervention in Chapter 4 contained elements of

training related to compassion and loving-kindness, the pre-post measurement of these qualities did not differ in experimental groups, suggesting that standard mindfulness training has similar effects on the development of these qualities. The third element of the additional module in the study presented in Chapter 4, ethical training, could be hypothesized not only to foster better relationships but to be directly beneficial for the person practicing Buddhist ethics (Lomas, 2017). Considering that the ethical training in Buddhist traditions is designed to support meditative practices, it is possible to hypothesize that the observation of certain ethical precepts can reduce perseverative cognition which is directly related to prolonged stress activation (Brosschot et al., 2005).

Limitations

This work has several limitations that are outlined separately for each study in the corresponding chapters. The most important among them are briefly discussed here.

The small sample sizes for certain analyses resulted from missing ANS data (Chapter 1), the higher-than-expected attrition rate, and the overall small sample size (Chapter 4). A larger sample size in the observational study would render its conclusions regarding the ANS system more compelling. In the interventional study it would allow for direct comparison of experimental groups increasing the current understanding of the stress-buffering effect of various contemplative approaches.

The differences in the methodology of ANS assessment in the studies presented in Chapters 1 and 4 do not allow for direct comparison of long-term meditation practitioners with participants of contemplative training interventions. The study presented in Chapter 4 employed a state-of-the-art assessment of cardiovascular function, allowing for separation of PNS and SNS, and for detecting artifacts directly in the EKG signal. Had the direct comparison of stress-related changes in the PNS

and SNS been available in Chapter 1, our understanding of the effect of contemplative practice length on cardiovascular function during stress could have been increased.

The non-homogeneity of contemplative training was a limitation in several studies. The studies presented in Chapters 1, 2, and 3 included long-term meditation practitioners from different contemplative traditions, and the experimental group with an additional module (MBSR-B) in the study presented in Chapter 4 contained various elements of different types of contemplative training (such as compassion, loving-kindness, wisdom, and ethics). Taking into consideration the growing evidence of specific effects of various contemplative approaches, it is less clear which elements contribute the most to the stress-buffering.

Finally, the assessment of other-than-mindfulness factors in contemplative training demonstrated that the measures used required further elaboration. While Chapter 3 presented the results of the validation of the Buddhist Insight Scale, this measure did not capture related pre-post changes in participants in Chapter 4. The Buddhist questionnaire, a measure related to the Insight Scale, which was created to assess pre-and post-change wisdom, ethics, and the four immeasurables (Chapter 4), was only partially successful; there was no statistically significant difference in the wisdom score between mindfulness with Buddhist elements and the control of standard mindfulness training. While the results can be explained by a partial intervention failure, it is possible that the measure of such complex constructs as wisdom or insight requires more fine-grained wording.

Future directions

This section outlines future research directions on contemplative practices and stress by focusing on conceptual, methodological, and clinical considerations.

Conceptual considerations

As shown in the introduction of this dissertation, research on contemplative practice and stress is still in its infancy, with many unanswered questions and areas unexplored. The progress in this area of research depends on conceptual precision and shared theoretical frameworks, preferably built on strong foundations of research in the field of stress. This thesis demonstrates that the relationship between contemplative training and stress can often be explained with a nuanced application of existing theories in the field of stress, such as the biopsychosocial model of challenge and threat (Tomaka et al., 1993), hypothesis of prolonged stress activation (Brosschot et al., 2005), or social preservation theory (Dickerson et al., 2009). While a substantial number of theoretical frameworks have focused on delineating how contemplative training (in most cases, mindfulness) impacts health (Creswell & Lindsay, 2014; Hölzel et al., 2011), a shared conceptual research framework on contemplative practice and stress is still lacking. Such a framework would pay more attention to (1) the type of socio-environmental adversity, as not all psychological stressors are the same (Slavich, 2020); (2) physiological and affective systems implicated, which will allow to reduce equaling the notion of "stress" to one particular index; (3) psychological mechanisms, both new and those that have already been established in the field of stress research; (4) dynamics and context of stress; and (5) particularity of contemplative training in terms of techniques, duration, and way of administration. Considering that the relationship between stress and health is complex (O'Connor et al., 2021), more fine-grained results would allow for conclusions about the stress-reduction role in contemplative practice effects on health.

The notion of contemplative practices is very broad (Komjathy, 2018), and it is crucial to come to a shared definition. Although several attempts have been made (Davidson & Dahl, 2017; Komjathy, 2018; Roth, 2006), a more global approach is

required where different parameters of contemplative practices (length, tradition, context of practice, etc.) come into play, e.g., while studying the association between contemplative training and stress. Another important contextual aspect concerns cultural differences in the implementation of contemplative training. Several empirical reports suggest that cultural particularities play a role in the interpretation of mindfulness and propose adaptations of existing programs (Cotter & Jones, 2020; Hoffman, 2019). Distinction between individualistic and collectivist cultures, cultural psychologies of personhood, cultural preferences for regulatory strategies, content of analogies are just a few factors which can influence the implementation of a standardized mindfulness protocol.

The exploration of mechanisms linking contemplative training and stress reduction remains a priority. Future studies focused on emotion regulation—recognized as one of the most crucial mechanisms of contemplative training—should not only study distinct ER strategies, but also psychological factors surrounding the process of emotion regulation. For example, ER or cognitive appraisal can be both heavily influenced by metacognition. Metacognitive skills (decentering, reperceiving, metacognitive insight, etc.) describe an ability to see the experience of one's thoughts, emotions, and sensations as events in the mind, rather than reality (Fresco et al., 2007; Shapiro et al., 2006; Teasdale et al.,1995) and are highly linked to mindfulness (Jankowski & Holas, 2014). A shift into a metacognitive perspective, which consists in stepping outside the thought content, allows to modify the automatic appraisal or facilitate a reappraisal of a stressor (Garland, 2007). Future studies should address the direct role of metacognition in stress response and its association with core mechanisms of contemplative training.

A subtle area of investigation in the research domain on ER and contemplative training are distinct CP effects on acceptance and reappraisal. According to previous empirical observations, acceptance and reappraisal are partially overlapping

constructs: acceptance contains an element of reappraisal, but what is being reappraised is not the emotion eliciting stimulus, but the emotional reaction (Wolgast et al., 2013). This conceptual overlap should be taken in consideration while discussing results of empirical studies contrasting the effects of these two regulation strategies.

Methodological considerations

Analysis of results of this study suggest that methodological design could be at least partially responsible for non-homogeneous results in contemplative practice and stress (Morton et al., 2020). In order to avoid potentially confounding factors, similar guidelines should be followed, particularly for biological measurements (Labuschagne et al., 2019). A strict control of postural changes during experiments, solid pre-experimental assessments, careful choice of indices for physiological variables could significantly improve the comparability of studies and eliminate fluctuations brought about by methodological differences.

As this thesis concentrates primarily on social-evaluative stress and shame producing stimuli, future studies should address other stress-inducing environmental challenges, such as social exclusion, isolation, conflict, and workplace stress. This will allow for the determination of the type of stress that is most impacted by contemplative training. On the side of contemplative practices, it remains to be determined which type of contemplative approach is best suited for stress-reduction purposes. From the methodological standpoint, it is important to rigorously assess the effects of different approaches, both separately and in combination. Separate assessment of effects of different contemplative approaches provides us with insights into the way in which various types of mental training affect stress response (Engert et al., 2017). However, taking in consideration that traditionally contemplative practices were used also in combination, mutually

reinforcing the training effect (Grabovac et al., 2011), the effectiveness of these combined approaches for stress reduction is yet to be determined. Testing different contemplative approaches, it is recommended to evaluate the minimum required time for a particular approach to have an effect. While the development of contemplative skills aimed at the development of focus or open awareness are rather straight forward, wisdom- or ethics-developing approaches are more complex and might require longer time to master. Future studies should test whether wisdom- and ethics-developing practices can be efficient in short-term interventions.

In terms of the context of a practice, it is strongly recommended that research designs are not limited to randomized clinical trials only. Observational studies in natural settings and experiments in the populations of long-term practitioners represent an important area of research, as expert meditators represent a suitable human model to address questions of brain plasticity. Several studies focused on the changes in the brain structure or connectivity brought about by a long-term practice (Engen et al., 2018; Luders et al., 2013): in terms of research on structural physiological changes, interventional studies with short-term contemplative programs have obvious limitations. Furthermore, research reports suggest that the level of expertise in meditation practitioners can play an important role: expert meditators with a higher number of practice hours demonstrated a different pattern of neural activation during focused meditation in comparison to experts with lower practice hours (Brefczynski-Lewis et al., 2007; Lutz et al., 2008). Systematic comparisons of long- and short-term practitioners in stress-related brain activation or structural changes of regions responsible for stress response are still very rare.

Finally, considering that the field is still young, mixed methodology and qualitative approaches can serve an important function by helping to generate new hypotheses and triangulate empirical results from objective measures (Barbour, 1999; Johnson & Onwuegbuzie, 2004). In addition to the pragmatic aims of

triangulation and hypothesis generation, first-person approaches enrich objective findings by exposing different facets of subjective experiences (Lumma & Weger, 2021).

Clinical considerations

This study did not directly focus on clinical implications of contemplative approaches. However, taking in consideration the role of stress-related physiological changes in the aetiology of several psychiatric and somatic disorders (Sala et al., 2004; Schneiderman et al., 2005), integration of contemplative training in clinical programs and evaluation of their effectiveness represent an important research area.

Standard MBIs, such as MBSR, MBCT and other programs based primarily on mindfulness have been evaluated for their effectiveness in several disorders (Creswell, 2017). The effectiveness of SG-MBIs, which include other elements of Buddhist contemplative training, received significantly less attention. The most studied SG-MBIs included compassion or loving-kindness training (Kirby et al., 2017), and preliminary evidence suggests that these types of interventions lead to positive psychological and clinical effects even after short training (Hofmann, 2011). Future studies should focus on the clinical effectiveness of this type of interventions for different psychiatric and somatic conditions, test the effectiveness of different lengths of programs, and determine the adverse effects.

The empirical support for the effectiveness of other types of SG-MBIs, in particular of those focused on the development of wisdom and ethics, is still lacking. Programs containing elements of wisdom or ethics training have only started to appear: for example, meditation awareness training (MAT), which is grounded in the Buddhist principles of wisdom, meditation, and ethical awareness (Van Gordon et al., 2014), or ethics-oriented mindfulness training (Bayot et al., 2020). Future studies should test the clinical utility of such programs, taking into consideration

numerous integration issues, such as correct presentation of taught concepts, training of the intervention providers, and testing for adverse effects (Shonin, Van Gordon, et al., 2014b). Direct comparison of such SG-MBIs with standard mindfulness programs would determine the equivalency, superiority, or inferiority of these programs for specific health conditions. A particular research attention should be paid to the program length, as wisdom-developing contemplative approaches might require longer interventions.

Research on SG-MBIs opened a discussion about a possibility of re-introducing "spiritual", "transcendent", and "value building" elements into contemplative training (Dahl & Davidson, 2019). Such interventions can draw inspiration from a larger pool of contemplative approaches belonging to different religious and spiritual traditions. Clinical interventions based on practices from religious contexts can be framed as explicitly non-secular to better suit to patients belonging to a religious or spiritual tradition in question (Knabb et al., 2018). Considering the accumulated literature on the association of religious and spiritual practices with stress (Koenig & Cohen, 2002), this direction represents an important path in augmenting the clinical benefits of contemplative approaches. As for decontextualized or recontextualized practice in clinical settings, additional information on the origin of the practice and the ethical or religious system in which it is embedded can be helpful, as a failure to acknowledge the complexity of context reduces the beneficial effects of such practices (Ozawa-de Silva, 2016).

References

Ahani, A., Wahbeh, H., Nezamfar, H., Miller, M., Erdogmus, D., & Oken, B. (2014). Quantitative change of EEG and respiration signals during mindfulness meditation. *Journal of Neuroengineering and Rehabilitation*, *11*(1), 1-11.

Aldao, A. (2013). The future of emotion regulation research: Capturing context. *Perspectives on Psychological Science*, *8*(2), 155-172.

Anderson, C. S. (2004). Anitya (impermanence). In R. E. Buswell Jr (Ed.), *Encyclopedia of Buddhism.* (Vol. II, pp. 23-24). MacMillan Reference Books.

Arbuckle, J. L. (2014). Amos (version 23.0)[computer program]. *Chicago: IBM SpSS*.

Arch, J. J., Brown, K. W., Dean, D. J., Landy, L. N., Brown, K., & Laudenslager, M. L. (2014). Self-compassion training modulates alpha-amylase, heart rate variability, and subjective responses to social evaluative threat in women. *Psychoneuroendocrinology*, *42*, 49-58.

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: Emotion regulation following a focused breathing induction. *Behaviour Research and Therapy*, *44*(12), 1849-1858.

Arlt Mutch, V. K., Evans, S., & Wyka, K. (2021). The role of acceptance in mood improvement during Mindfulness-Based Stress Reduction. *Journal of Clinical Psychology*, *77*(1), 7-19.

Aronson, H. (2004). *Buddhist practice on Western ground: Reconciling Eastern ideals and Western psychology*. Shambhala Publications.

Asnaani, A., Sawyer, A. T., Aderka, I. M., & Hofmann, S. G. (2013). Effect of suppression, reappraisal, and acceptance of emotional pictures on acoustic eye-blink startle magnitude. *Journal of Experimental Psychopathology*, *4*(2), 182-193.

Astin, J. A. (1997). Stress reduction through mindfulness meditation. *Psychotherapy and Psychosomatics*, *66*(2), 97-106.

Ataria, Y., Dor-Ziderman, Y., & Berkovich-Ohana, A. (2015). How does it feel to lack a sense of boundaries? A case study of a long-term mindfulness meditator. *Consciousness and Cognition*, *37*, 133-147.

Austin, J. H. (2009). *Selfless insight*. MIT Press.

Bae, D., Matthews, J. J., Chen, J. J., & Mah, L. (2021). Increased exhalation to inhalation ratio during breathing enhances high-frequency heart rate variability in healthy adults. *Psychophysiology*, e13905.

Baer, R. (2015). Ethics, values, virtues, and character strengths in mindfulness-based interventions: A psychological science perspective. *Mindfulness*, *6*(4), 956-969.

Barbour, R. S. (1999). The case for combining qualitative and quantitative approaches in health services research. *Journal of Health Services Research & Policy*, *4*(1), 39-43.

Bargh, J. A., & Williams, L. E. (2007). The nonconscious regulation of emotion. In J. J. Gross (Ed.), *Handbook of emotion regulation* (Vol. 1, pp. 429-445). Guilford Press.

Batchelor, S. (2012). A secular Buddhism. *Journal of Global Buddhism*, *13*, 87-107.

Batchelor, S. (2015). *After Buddhism: Rethinking the Dharma for a secular age*. Yale University Press.

Bauer, P. R., Poletti, S., Lutz, A., & Sabourdy, C. (2019). Coping with seizures through mindfulness meditation: A qualitative study of a mindfulness-based intervention in epilepsy. *Mindfulness*, *10*(10), 2010-2025.

Bayot, M., Vermeulen, N., Kever, A., & Mikolajczak, M. (2020). Mindfulness and empathy: Differential effects of explicit and implicit buddhist teachings. *Mindfulness*, *11*(1), 5-17.

Bech, P., Olsen, L. R., Kjoller, M., & Rasmussen, N. K. (2003). Measuring well-being rather than the absence of distress symptoms: A comparison of the SF-36

Mental Health subscale and the WHO-Five well-being scale. *International Journal of Methods in Psychiatric Research*, *12*(2), 85-91.

Benson, H., Beary, J. F., & Carol, M. P. (1974). The relaxation response. *Psychiatry*, *37*(1), 37-46.

Benson, H., & Klipper, M. Z. (1975). *The relaxation response*. Morrow New York.

Bernstein, A., Hadash, Y., Lichtash, Y., Tanay, G., Shepherd, K., & Fresco, D. M. (2015). Decentering and related constructs: A critical review and metacognitive processes model. *Perspectives on Psychological Science*, *10*(5), 599-617.

Bernstein, D. P., & Lemmens, H. (2005). Stroke volume equation for impedance cardiography. *Medical and Biological Engineering and Computing*, *43*(4), 443-450.

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1991). Autonomic determinism: the modes of autonomic control, the doctrine of autonomic space, and the laws of autonomic constraint. *Psychological Review*, *98*(4), 459-487.

Berntson, G. G., Quigley, K. S., Norman, G. J., & Lozano, D. L. (2017). Cardiovascular psychophysiology. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology, 4th ed.* (pp. 183-216). Cambridge University Press.

Beshai, S., Bueno, C., Yu, M., Feeney, J. R., & Pitariu, A. (2020). Examining the effectiveness of an online program to cultivate mindfulness and self-compassion skills (Mind-OP): Randomized controlled trial on Amazon's Mechanical Turk. *Behaviour Research and Therapy*, *134*, 103724.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., Segal, Z. V., Abbey, S., Speca, M., Velting, D., & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, *11*(3), 230-241.

Bjorck, J. P. (1995). A self-centered perspective on McIntosh's religious schema. *The International Journal for the Psychology of Religion*, *5*(1), 23-29.

Blackhart, G. C., Eckel, L. A., & Tice, D. M. (2007). Salivary cortisol in response to acute social rejection and acceptance by peers. *Biological Psychology*, *75*(3), 267-276.

Blascovich, J. (2008). Challenge, threat, and health. In J. Y. Shah & W. L Gardner (Eds.), *Handbook of motivation science.* (pp. 481-493). Guilford Press.

Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. *Advances in Experimental Social Psychology*, *28*, 1-51.

Bodhi, B. (2011). What does mindfulness really mean? A canonical perspective. *Contemporary Buddhism*, *12*(01), 19-39.

Bollen, K. A., & Stine, R. A. (1992). Bootstrapping goodness-of-fit measures in structural equation models. *Sociological Methods & Research*, *21*(2), 205-229.

Bosch, J. A., De Geus, E. J., Carroll, D., Goedhart, A. D., Anane, L. A., van Zanten, J. J. V., Helmerhorst, E. J., & Edwards, K. M. (2009). A general enhancement of autonomic and cortisol responses during social evaluative threat. *Psychosomatic Medicine*, *71*(8), 877-885.

Boyatzis, R. (1988). *Transforming Qualitative Information: Thematic Analysis and Code Development*. Sage.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., & Davidson, R. J. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proceedings of the National Academy of Sciences*, *104*(27), 11483-11488.

Brewer, J. A., Sinha, R., Chen, J. A., Michalsen, R. N., Babuscio, T. A., Nich, C., Grier, A., Bergquist, K. L., Reis, D. L., Potenza, M. N., Carroll, K. M., & Rounsaville,

B. J. (2009). Mindfulness Training and Stress Reactivity in Substance Abuse: Results from a Randomized, Controlled Stage I Pilot Study. *Substance Abuse*, *30*(4), 306-317.

Britton, W. B., Shahar, B., Szepsenwol, O., & Jacobs, W. J. (2012). Mindfulness-based cognitive therapy improves emotional reactivity to social stress: Results from a randomized controlled trial. *Behavior Therapy*, *43*(2), 365-380.

Brosschot, J. F., Gerin, W., & Thayer, J. F. (2006). The perseverative cognition hypothesis: A review of worry, prolonged stress-related physiological activation, and health. *Journal of Psychosomatic Research*, *60*(2), 113-124.

Brosschot, J. F., Pieper, S., & Thayer, J. F. (2005). Expanding stress theory: Prolonged activation and perseverative cognition. *Psychoneuroendocrinology*, *30*(10), 1043-1049.

Brosschot, J. F., & Thayer, J. F. (2003). Heart rate response is longer after negative emotions than after positive emotions. *International Journal of Psychophysiology*, *50*(3), 181-187.

Brosschot, J. F., Verkuil, B., & Thayer, J. F. (2017). Exposed to events that never happen: Generalized unsafety, the default stress response, and prolonged autonomic activity. *Neuroscience & Biobehavioral Reviews*, *74*, 287-296.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*(4), 822-848.

Brown, K. W., Ryan, R. M., Creswell, J. D., & Niemiec, C. P. (2008). Beyond me: Mindful responses to social threat. In H. A. Wayment & J. J. Bauer (Eds.), *Transcending self-interest: Psychological explorations of the quiet ego* (pp. 75-84). American Psychological Association.

Browne, M., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136-162). Sage.

Bruya, B., & Ardelt, M. (2018). Wisdom can be taught: A proof-of-concept study for fostering wisdom in the classroom. *Learning and Instruction*, *58*, 106-114.

Buchanan, T. W., al'Absi, M., & Lovallo, W. R. (1999). Cortisol fluctuates with increases and decreases in negative affect. *Psychoneuroendocrinology*, *24*(2), 227-241.

Butler, E. A., Wilhelm, F. H., & Gross, J. J. (2006). Respiratory sinus arrhythmia, emotion, and emotion regulation during social interaction. *Psychophysiology*, *43*(6), 612-622.

Buuren, S. v., & Groothuis-Oudshoorn, K. (2010). mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software*, *45*, 1-68.

Cacioppo, J. T., Berntson, G. G., Malarkey, W. B., Kiecolt-Glaser, J. K., Sheridan, J. F., Poehlmann, K. M., Burleson, M. H., Ernst, J. M., Hawkley, L. C., & Glaser, R. (1998). Autonomic, Neuroendocrine, and Immune Responses to Psychological Stress: The Reactivity Hypothesisa. *Annals of the New York Academy of Sciences*, *840*(1), 664-673.

Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (1997). Beyond bipolar conceptualizations and measures: The case of attitudes and evaluative space. *Personality and Social Psychology Review*, *1*(1), 3-25.

Camm, A., Malik, M., Bigger, J., Breithardt, G., Cerutti, S., Cohen, R., Coumel, P., Fallen, E., Kennedy, H., & Kleiger, R. (1996). Heart rate variability: Standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *Circulation*, *93*(5), 1043-1065.

Campbell, J., & Ehlert, U. (2012). Acute psychosocial stress: Does the emotional stress response correspond with physiological responses? *Psychoneuroendocrinology*, *37*(8), 1111-1134.

Carlson, J. M., Dikecligil, G. N., Greenberg, T., & Mujica-Parodi, L. R. (2012). Trait reappraisal is associated with resilience to acute psychological stress. *Journal of Research in Personality*, *46*(5), 609-613.

Carlson, L. E., Ursuliak, Z., Goodey, E., Angen, M., & Speca, M. (2001). The effects of a mindfulness meditation-based stress reduction program on mood and symptoms of stress in cancer outpatients: 6-month follow-up. *Supportive Care in Cancer*, *9*(2), 112-123.

Carmody, J., & Baer, R. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of Behavioral Medicine*, *31*(1), 23-33.

Cassidy, E. L., Atherton, R. J., Robertson, N., Walsh, D. A., & Gillett, R. (2012). Mindfulness, functioning and catastrophizing after multidisciplinary pain management for chronic low back pain. *Pain*, *153*(3), 644-650.

Chambers, R., Gullone, E., & Allen, N. B. (2009). Mindful emotion regulation: An integrative review. *Clinical Psychology Review*, *29*(6), 560-572.

Chen, S., & Jordan, C. H. (2020). Incorporating ethics into brief mindfulness practice: Effects on well-being and prosocial behavior. *Mindfulness*, *11*(1), 18-29.

Chida, Y., & Steptoe, A. (2010). Greater cardiovascular responses to laboratory mental stress are associated with poor subsequent cardiovascular risk status: A meta-analysis of prospective evidence. *Hypertension*, *55*(4), 1026-1032.

Chiesa, A., & Serretti, A. (2009). Mindfulness-based stress reduction for stress management in healthy people: A review and meta-analysis. *The Journal of Alternative and Complementary Medicine*, *15*(5), 593-600.

Chiesa, A., Serretti, A., & Jakobsen, J. C. (2013). Mindfulness: Top–down or bottom–up emotion regulation strategy? *Clinical Psychology Review*, *33*(1), 82-96.

Chishima, Y., Mizuno, M., Sugawara, D., & Miyagawa, Y. (2018). The influence of self-compassion on cognitive appraisals and coping with stressful events. *Mindfulness*, *9*(6), 1907-1915.

Christodoulou, G., Salami, N., & Black, D. S. (2020). The utility of heart rate variability in mindfulness research. *Mindfulness*, *11*(3), 554-570.

Christopher, M. S. (2003). Albert Ellis and the Buddha: Rational soul mates? A comparison of Rational Emotive Behaviour Therapy (REBT) and Zen Buddhism. *Mental Health, Religion & Culture*, *6*(3), 283-293.

Clark, D. A., & Beck, A. T. (2011). *Cognitive therapy of anxiety disorders: Science and practice*. Guilford Press.

Cohen, S., Hamrick, N., Rodriguez, M. S., Feldman, P. J., Rabin, B. S., & Manuck, S. B. (2002). Reactivity and vulnerability to stress-associated risk for upper respiratory illness. *Psychosomatic Medicine*, *64*(2), 302-310.

Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *JAMA*, *298*(14), 1685-1687.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A Global measure of perceived stress. *Journal of Health and Social Behavior*, *24*(4), 385-396.

Cole, D. A. (1987). Utility of confirmatory factor analysis in test validation research. *Journal of Consulting and Clinical Psychology*, *55*(4), 584-594.

Coleman, J. W. (2002). *The new Buddhism: The Western transformation of an ancient tradition*. Oxford University Press.

Cotter, E. W., & Jones, N. (2020). A review of Latino/Latinx participants in mindfulness-based intervention research. *Mindfulness*, *11*(3), 529-553.

Crabtree, B. F., & Miller, W. F. (1992). A template approach to text analysis: Developing and using codebooks. In B. F. Crabtree & W. L. Miller (Eds.), *Doing qualitative research.* (pp. 93-109). Sage Publications, Inc.

Creswell, J. D. (2017). Mindfulness interventions. *Annual Review of Psychology*, *68*, 491-516.

Creswell, J. D., & Lindsay, E. K. (2014). How does mindfulness training affect health? A mindfulness stress buffering account. *Current Directions in Psychological Science*, *23*(6), 401-407.

Creswell, J. D., Pacilio, L. E., Lindsay, E. K., & Brown, K. W. (2014). Brief mindfulness meditation training alters psychological and neuroendocrine responses to social evaluative stress. *Psychoneuroendocrinology*, *44*, 1-12.

Cullinan, W. E., Herman, J. P., Helmreich, D. L., & Watson Jr, S. J. (1995). A neuroanatomy of stress. In M. J. Friedman, D. S. Charney, A. Y. Deutch (Eds.), *Neurobiological and clinical consequences of stress: From normal adaptation to post-traumatic stress disorder.* (pp. 3-26). Lippincott Williams & Wilkins Publishers.

Dahl, C. J., & Davidson, R. J. (2019). Mindfulness and the contemplative life: Pathways to connection, insight, and purpose. *Current Opinion in Psychology*, *28*, 60-64.

Dahl, C. J., Lutz, A., & Davidson, R. J. (2015). Reconstructing and deconstructing the self: Cognitive mechanisms in meditation practice. *Trends in Cognitive Sciences*, *19*(9), 515-523.

Dambrun, M., & Ricard, M. (2011). Self-centeredness and selflessness: A theory of self-based psychological functioning and its consequences for happiness. *Review of General Psychology*, *15*(2), 138-157.

Dan-Glauser, E. S., & Gross, J. J. (2015). The temporal dynamics of emotional acceptance: Experience, expression, and physiology. *Biological Psychology*, *108*, 1-12.

Dandoy, A. C., & Goldstein, A. G. (1990). The use of cognitive appraisal to reduce stress reactions: A replication. *Journal of Social Behavior and Personality*, *5*(4), 275-285.

Daubenmier, J., Epel, E. S., Moran, P. J., Thompson, J., Mason, A. E., Acree, M., Goldman, V., Kristeller, J., Hecht, F. M., & Mendes, W. B. (2019). A randomized controlled trial of a mindfulness-based weight loss intervention on cardiovascular reactivity to social-evaluative threat among adults with obesity. *Mindfulness*, *10*(12), 2583-2595.

David, D., Schnur, J., & Belloiu, A. (2002). Another search for the "hot" cognitions: Appraisal, irrational beliefs, attributions, and their relation to emotion. *Journal of Rational-Emotive and Cognitive-Behavior Therapy*, *20*(2), 93-131.

Davidson, R. J., & Dahl, C. J. (2017). Varieties of contemplative practice. *JAMA Psychiatry*, *74*(2), 121-123.

de Boer, M. J., Steinhagen, H. E., Versteegen, G. J., Struys, M. M., & Sanderman, R. (2014). Mindfulness, acceptance and catastrophizing in chronic pain. *PLoS ONE*, *9*(1), e87445.

De Silva, P. (1984). Buddhism and behaviour modification. *Behaviour Research and Therapy*, *22*(6), 661-678.

DeMichelis, C., Ferrari, M., Rozin, T., & Stern, B. (2015). Teaching for wisdom in an intergenerational high-school-English class. *Educational Gerontology*, *41*(8), 551-566.

Denson, T., Spanovic, M., & Miller, N. (2009). Cognitive appraisals and emotions predict cortisol and immune responses: A meta-analysis of acute laboratory social stressors and emotion inductions. *Psychological Bulletin*, *135*(6), 823-853.

Desbordes, G., Gard, T., Hoge, E. A., Hölzel, B. K., Kerr, C., Lazar, S. W., Olendzki, A., & Vago, D. R. (2015). Moving beyond mindfulness: Defining equanimity as an outcome measure in meditation and contemplative research. *Mindfulness*, *6*(2), 356-372.

Desrosiers, A., Vine, V., Klemanski, D. H., & Nolen-Hoeksema, S. (2013). Mindfulness and emotion regulation in depression and anxiety: Common and distinct mechanisms of action. *Depression and Anxiety*, *30*(7), 654-661.

Dews, S., Kaplan, J., & Winner, E. (1995). Why not say it directly? The social functions of irony. *Discourse Processes*, *19*(3), 347-367.

Deyo, M., Wilson, K. A., Ong, J., & Koopman, C. (2009). Mindfulness and rumination: Does mindfulness training lead to reductions in the ruminative thinking associated with depression? *EXPLORE: The Journal of Science and Healing*, *5*(5), 265-271.

Dickerson, S. S., Gruenewald, T. L., & Kemeny, M. E. (2009). Psychobiological responses to social self threat: Functional or detrimental? *Self and Identity*, *8*(2-3), 270-285.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *130*(3), 355-391.

Dickerson, S. S., Kemeny, M. E., Aziz, N., Kim, K. H., & Fahey, J. L. (2004). Immunological effects of induced shame and guilt. *Psychosomatic Medicine*, *66*(1), 124-131.

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The Satisfaction With Life scale. *Journal of Personality Assessment*, *49*(1), 71-75.

Dull, V. T., & Skokan, L. A. (1995). A cognitive model of religion's influence on health. *Journal of Social Issues*, *51*(2), 49-64.

Efron, B., & Tibshirani, R. J. (1994). *An introduction to the bootstrap*. Chapman & Hall/CRC press.

Egloff, B., Schmukle, S. C., Burns, L. R., & Schwerdtfeger, A. (2006). Spontaneous emotion regulation during evaluated speaking tasks: Associations with

negative affect, anxiety expression, memory, and physiological responding. *Emotion*, *6*(3), 356–366.

Ehring, T., Tuschen-Caffier, B., Schnülle, J., Fischer, S., & Gross, J. J. (2010). Emotion regulation and vulnerability to depression: Spontaneous versus instructed use of emotion suppression and reappraisal. *Emotion*, *10*(4), 563-572.

Ellis, A. (1962). *Reason and emotion in psychotherapy*. Lyle Stuart.

Ellis, A., David, D., & Lynn, S. J. (2009). Rational and irrational beliefs: A historical and conceptual perspective. In D. Daniel, S. J. Lynn, & A. Ellis (Eds.), *Rational and Irrational Beliefs* (pp. 3-22). Oxford University Press.

Ellis, A., & Dryden, W. (2007). *The practice of rational emotive behavior therapy*. Springer.

Ellis, A., & Harper, R. A. (1975). *A new guide to rational living*. Prentice-Hall.

Emavardhana, T., & Tori, C. D. (1997). Changes in self-concept, ego defense mechanisms, and religiosity following seven-day vipassana meditation retreats. *Journal for the Scientific Study of Religion*, *36*(2), 194-206.

Engen, H. G., Bernhardt, B. C., Skottnik, L., Ricard, M., & Singer, T. (2018). Structural changes in socio-affective networks: Multi-modal MRI findings in long-term meditation practitioners. *Neuropsychologia*, *116*, 26-33.

Engert, V., Efanov, S. I., Duchesne, A., Vogel, S., Corbo, V., & Pruessner, J. C. (2013). Differentiating anticipatory from reactive cortisol responses to psychosocial stress. *Psychoneuroendocrinology*, *38*(8), 1328-1337.

Engert, V., Kok, B. E., Papassotiriou, I., Chrousos, G. P., & Singer, T. (2017). Specific reduction in cortisol stress reactivity after social but not attention-based mental training. *Science Advances*, *3*(10), e1700495.

Epel, E., Daubenmier, J., Moskowitz, J. T., Folkman, S., & Blackburn, E. (2009). Can meditation slow rate of cellular aging? Cognitive stress, mindfulness, and telomeres. *Annals of the New York academy of sciences*, *1172*(1), 34-53.

Epel, E. S., McEwen, B. S., & Ickovics, J. R. (1998). Embodying psychological thriving: Physical thriving in response to stress. *Journal of Social Issues*, *54*(2), 301-322.

Epstein, M. (1988). The deconstruction of the self: Ego and 'egolessness' in Buddhist insight meditation. *The Journal of Transpersonal Psychology*, *20*(1), 61-69.

Everly, G. S., & Lating, J. M. (2013). The anatomy and physiology of the human stress response. In J. G. S. Everly & J. M. Lating (Eds.), *A Clinical Guide to the Treatment of the Human Stress Response* (pp. 17-51). Springer New York.

Everly, G. S., & Lating, J. M. (2013). Stress-related disease: A Review. In G. S. Everly & J. M. Lating (Eds.), *A Clinical Guide to the Treatment of the Human Stress Response* (pp. 85-127). Springer.

Everly, G. S., & Lating, J. M. (2019). The anatomy and physiology of the human stress response. In In G. S. Everly & J. M. Lating (Eds.), *A Clinical Guide to the Treatment of the Human Stress Response* (pp. 19-56). Springer.

Farb, N. A., Anderson, A. K., Irving, J. A., & Segal, Z. V. (2014). Mindfulness interventions and emotion regulation. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 548–567). Guilford Press.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175-191.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods*, *5*(1), 80-92.

Field, A. (2009). *Discovering statistics using SPSS*. Sage publications.

Fiske, S. T., & Linville, P. W. (1980). What does the schema concept buy us? *Personality and Social Psychology Bulletin*, *6*(4), 543-557.

Fogarty, F. A., Lu, L. M., Sollers, J. J., Krivoschekov, S. G., Booth, R. J., & Consedine, N. S. (2015). Why it pays to be mindful: Trait mindfulness predicts

physiological recovery from emotional stress and greater differentiation among negative emotions. *Mindfulness*, *6*(2), 175-185.

Folkman, S. (2008). The case for positive emotions in the stress process. *Anxiety, Stress, and Coping*, *21*(1), 3-14.

Folkman, S., & Lazarus, R. S. (1984). *Stress, appraisal, and coping*. Springer Publishing Company.

Folkman, S., Lazarus, R. S., Dunkel-Schetter, C., DeLongis, A., & Gruen, R. J. (1986). Dynamics of a stressful encounter: Cognitive appraisal, coping, and encounter outcomes. *Journal of Personality and Social Psychology*, *50*(5), 992-1003.

Folkman, S., & Moskowitz, J. T. (2000). Positive affect and the other side of coping. *American Psychologist*, *55*(6), 647-654.

Ford, B. Q., Gross, J. J., & Gruber, J. (2019). Broadening our field of view: The role of emotion polyregulation. *Emotion Review*, *11*(3), 197-208.

Forman, E. M., & Herbert, J. D. (2009). New directions in cognitive behavior therapy: Acceptance-based therapies. In In W. T. O'Donohue & J. E. Fisher (Eds.), *General principles and empirically supported techniques of cognitive behavior therapy*. (pp. 77-101). John Wiley & Sons, Inc.

Fredrickson, B., & Levenson, R. W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition & Emotion*, *12*(2), 191-220.

Fredrickson, B. L. (2002). How does religion benefit health and well-being? Are positive emotions active ingredients? *Psychological Inquiry*, *13*(3), 209-213.

Fredrickson, B. L., Boulton, A. J., Firestine, A. M., Van Cappellen, P., Algoe, S. B., Brantley, M. M., Kim, S. L., Brantley, J., & Salzberg, S. (2017). Positive emotion correlates of meditation practice: A comparison of mindfulness meditation and loving-kindness meditation. *Mindfulness*, *8*(6), 1623-1633.

Fredrickson, B. L., Mancuso, R. A., Branigan, C., & Tugade, M. M. (2000). The undoing effect of positive emotions. *Motivation and Emotion*, *24*(4), 237-258.

Fresco, D. M., Moore, M. T., van Dulmen, M. H. M., Segal, Z. V., Ma, S. H., Teasdale, J. D., & Williams, J. M. G. (2007). Initial psychometric properties of the experiences questionnaire: Validation of a self-report measure of decentering. *Behavior Therapy*, *38*(3), 234-246.

Fromm, E. (1959). Psychoanalysis and Zen Buddhism. *Psychologia*, *2*(2), 79-99.

Fylan, F. (2005). Semi-structured interviewing. In J. Miles & P. Gilbert (Eds.), *A handbook of research methods for clinical and health psychology* (pp. 65–78). Oxford University Press.

Gaab, J., Blättler, N., Menzi, T., Pabst, B., Stoyer, S., & Ehlert, U. (2003). Randomized controlled evaluation of the effects of cognitive–behavioral stress management on cortisol responses to acute stress in healthy subjects. *Psychoneuroendocrinology*, *28*(6), 767-779.

Gaab, J., Rohleder, N., Nater, U. M., & Ehlert, U. (2005). Psychological determinants of the cortisol stress response: The role of anticipatory cognitive appraisal. *Psychoneuroendocrinology*, *30*(6), 599-610.

Gamaiunova, L., Brandt, P.-Y., Bondolfi, G., & Kliegel, M. (2019). Exploration of psychological mechanisms of the reduced stress response in long-term meditation practitioners. *Psychoneuroendocrinology*, *104*, 143-151.

Gamaiunova, L., Brandt, P.-Y., & Kliegel, M. (2016). Meditative insight: Validation of a French version of Ireland's Insight Scale (2012) and exploration of relationships between meditative insight and perceived stress. *Mental Health, Religion & Culture*, *19*(8), 883-896.

Gamaiunova, L., Brandt, P.-Y., & Kliegel, M. (2021). Contemplative training and psychological stress: An analysis of first-person accounts. *Mindfulness*, *12*(8), 2034-2049.

Garland, E. L. (2007). The meaning of mindfulness: A second-order cybernetics of stress, metacognition, and coping. *Complementary Health Practice Review*, *12*(1), 15-30.

Garland, E., Gaylord, S., & Fredrickson, B. (2011). Positive reappraisal mediates the stress-reductive effects of mindfulness: An upward spiral process. *Mindfulness*, *2*(1), 59-67.

Garland, E., Gaylord, S., & Park, J. (2009). The role of mindfulness in positive reappraisal. *Explore*, *5*(1), 37-44.

Garland, E. L., Hanley, A., Farb, N. A., & Froeliger, B. (2015). State mindfulness during meditation predicts enhanced cognitive reappraisal. *Mindfulness*, *6*(2), 234-242.

Garnefski, N., & Kraaij, V. (2007). The Cognitive Emotion Regulation Questionnaire. *European Journal of Psychological Assessment*, *23*(3), 141-149.

Garnefski, N., Kraaij, V., & Spinhoven, P. (2001). Negative life events, cognitive emotion regulation and emotional problems. *Personality and Individual Differences*, *30*(8), 1311-1327.

Gaudreau, P., Sanchez, X., & Blondin, J.-P. (2006). Positive and negative affective states in a performance-related setting: Testing the factorial structure of the panas across two samples of French-Canadian participants. *European Journal of Psychological Assessment*, *22*(4), 240-249.

Geschwind, N., Peeters, F., Drukker, M., van Os, J., & Wichers, M. (2011). Mindfulness training increases momentary positive emotions and reward experience in adults vulnerable to depression: A randomized controlled trial. *Journal of Consulting and Clinical Psychology*, *79*(5), 618-628.

Gex-Fabry, M., Jermann, F., Kosel, M., Rossier, M. F., Van der Linden, M., Bertschy, G., Bondolfi, G., & Aubry, J.-M. (2012). Salivary cortisol profiles in patients

remitted from recurrent depression: One-year follow-up of a mindfulness-based cognitive therapy trial. *Journal of Psychiatric Research*, *46*(1), 80-86.

Gilbert, P. (2009). Introducing compassion-focused therapy. *Advances in Psychiatric Treatment*, *15*(3), 199-208.

Gilbert, P., & Procter, S. (2006). Compassionate mind training for people with high shame and self-criticism: Overview and pilot study of a group therapy approach. *Clinical Psychology & Psychotherapy: An International Journal of Theory & Practice*, *13*(6), 353-379.

Gloster, A. T., Klotsche, J., Aggeler, T., Geisser, N., Juillerat, G., Schmidlin, N., Müller-Siemens, S., & Gaab, J. (2019). Psychoneuroendocrine evaluation of an acceptance and commitment based stress management training. *Psychotherapy Research*, *29*(4), 503-513.

Goldin, P. R. & Gross, J. J. (2010). Effect of mindfulness meditation training on the neural bases of emotion regulation in social anxiety disorder. *Emotion*, *10*(1), 83-84.

Goldin, P. R., Moodie, C. A., & Gross, J. J. (2019). Acceptance versus reappraisal: Behavioral, autonomic, and neural effects. *Cognitive, Affective, & Behavioral Neuroscience*. 19(4), 927-944.

Goldin, P. R., Thurston, M., Allende, S., Moodie, C., Dixon, M. L., Heimberg, R. G., & Gross, J. J. (2021). Evaluation of cognitive behavioral therapy vs mindfulness meditation in brain changes during reappraisal and acceptance among patients with social anxiety disorder: A randomized clinical trial. *JAMA Psychiatry*, *78*(10), 1134-1142.

Goldsmith, R. E., Gerhart, J. I., Chesney, S. A., Burns, J. W., Kleinman, B., & Hood, M. M. (2014). Mindfulness-based stress reduction for posttraumatic stress symptoms: Building acceptance and decreasing shame. *Journal of Evidence-based Complementary & Alternative Medicine*, *19*(4), 227-234.

Goldstein, J. (2013). *Mindfulness: A practical guide to awakening*. Sounds True.

Goleman, D. J., & Schwartz, G. E. (1976). Meditation as an intervention in stress reactivity. *Journal of Consulting and Clinical Psychology*, *44*(3), 456-466.

Gómez, L. O. (2004). Meditation. In R. E. Buswell Jr (Ed.), *Encyclopedia of Buddhism* (Vol. II, pp. 520-530). MacMillan Reference Books.

Gordon, D. J. (2009). *A critical history of mindfulness-based psychology* [BA Thesis, Wesleyan University]. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.170.1995&rep=rep1&type=pdf

Gordon, M. (2010). Learning to laugh at ourselves: Humor, self-transcendence, and the cultivation of moral virtues. *Educational Theory*, *60*(6), 735-749.

Grabovac, A. D., Lau, M. A., & Willett, B. R. (2011). Mechanisms of mindfulness: A Buddhist psychological model. *Mindfulness*, *2*(3), 154-166.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, *11*(3), 255-274.

Gross, J. J. (1998a). Antecedent-and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality and Social Psychology*, *74*(1), 224-237.

Gross, J. J. (1998b). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, *2*(3), 271-299.

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348-362.

Gross, J. J., & Levenson, R. W. (1997). Hiding feelings: The acute effects of inhibiting negative and positive emotion. *Journal of Abnormal Psychology*, *106*(1), 95-103.

Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction and health benefits: A meta-analysis. *Journal of Psychosomatic Research*, *57*(1), 35-43.

Grossman, P., & Van Dam, N. T. (2011). Mindfulness, by any other name…: Trials and tribulations of Sati in Western psychology and science. *Contemporary Buddhism*, *12*(1), 219-239.

Gruenewald, T. L., Kemeny, M. E., Aziz, N., & Fahey, J. L. (2004). Acute threat to the social self: Shame, social self-esteem, and cortisol activity. *Psychosomatic Medicine*, *66*(6), 915-924.

Gunaratana, B., & Gunaratana, H. (2011). *Mindfulness in plain English*. Wisdom Publications.

Hadash, Y., Segev, N., Tanay, G., Goldstein, P., & Bernstein, A. (2016). The decoupling model of equanimity: Theory, measurement, and test in a mindfulness intervention. *Mindfulness*, *7*(5), 1214-1226.

Harris, C. R. (2001). Cardiovascular responses of embarrassment and effects of emotional suppression in a social setting. *Journal of Personality and Social Psychology*, *81*(5), 886-897.

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling [White paper]. Retrieved from http://www.afhayes.com/ public/process2012.pdf.

Hayes, A. M., & Feldman, G. (2004). Clarifying the construct of mindfulness in the context of emotion regulation and the process of change in therapy. *Clinical Psychology: Science and Practice*, *11*(3), 255-262.

Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (2011). *Acceptance and commitment therapy: The process and practice of mindful change*. Guilford Press.

Hayes-Skelton, S., & Graham, J. (2013). Decentering as a common link among mindfulness, cognitive reappraisal, and social anxiety. *Behavioural and Cognitive Psychotherapy*, *41*(3), 317-328.

Heatherton, T. F., & Polivy, J. (1991). Development and validation of a scale for measuring state self-esteem. *Journal of Personality and Social Psychology*, *60*(6), 895-910.

Hellhammer, D. H., Wüst, S., & Kudielka, B. M. (2009). Salivary cortisol as a biomarker in stress research. *Psychoneuroendocrinology*, *34*(2), 163-171.

Herman, J. P., & Cullinan, W. E. (1997). Neurocircuitry of stress: Central control of the hypothalamo–pituitary–adrenocortical axis. *Trends in Neurosciences*, *20*(2), 78-84.

Het, S., Rohleder, N., Schoofs, D., Kirschbaum, C., & Wolf, O. T. (2009). Neuroendocrine and psychometric evaluation of a placebo version of the 'Trier Social Stress Test'. *Psychoneuroendocrinology*, *34*(7), 1075-1086.

Hill, L., Siebenbrock, A., Sollers, J., & Thayer, J. F. (2009). Are all measures created equal? Heart rate variability and respiration. *Biomedical Sciences Instrumentation*, *45*, 71-76.

Hofmann, J., Heintz, S., Pang, D., & Ruch, W. (2020). Differential relationships of light and darker forms of humor with mindfulness. *Applied Research in Quality of Life*, *15*(2), 369-393.

Hofmann, S. G., & Asmundson, G. J. (2008). Acceptance and mindfulness-based therapy: New wave or old hat? *Clinical Psychology Review*, *28*(1), 1-16.

Hofmann, S. G., Grossman, P., & Hinton, D. E. (2011). Loving-kindness and compassion meditation: Potential for psychological interventions. *Clinical Psychology Review*, *31*(7), 1126-1132.

Hofmann, S. G., Heering, S., Sawyer, A. T., & Asnaani, A. (2009). How to handle anxiety: The effects of reappraisal, acceptance, and suppression strategies on anxious arousal. *Behaviour Research and Therapy*, *47*(5), 389-394.

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *Journal of Consulting and Clinical Psychology*, *78*(2), 169-183.

Hoffman, D. M. (2019). Mindfulness and the cultural psychology of personhood: Challenges of self, other, and moral orientation in Haiti. *Culture & Psychology*, *25*(3), 302-323.

Hoge, E. A., Bui, E., Palitz, S. A., Schwarz, N. R., Owens, M. E., Johnston, J. M., Pollack, M. H., & Simon, N. M. (2018). The effect of mindfulness meditation training on biological acute stress responses in generalized anxiety disorder. *Psychiatry Research*, *262*, 328-332.

Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics*, *6*, 65-70.

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, *6*(6), 537-559.

Houtveen, J. H., Groot, P. F., & De Geus, E. J. (2005). Effects of variation in posture and respiration on RSA and pre-ejection period. *Psychophysiology*, *42*(6), 713-719.

Hu, L. t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1-55.

Hutcherson, C. A., Seppala, E. M., & Gross, J. J. (2008). Loving-kindness meditation increases social connectedness. *Emotion*, *8*(5), 720-724.

Ireland, M. J. (2012). Meditative insight: Conceptual and measurement development. *Mental Health, Religion & Culture*, *16*(1), 79-99.

Jackson, R. R. (2004). Prajña (Wisdom). In R. E. Buswell Jr (Ed.), *Encyclopedia of Buddhism*. MacMillan Reference Books.

Jain, S., Shapiro, S. L., Swanick, S., Roesch, S. C., Mills, P. J., Bell, I., & Schwartz, G. E. (2007). A randomized controlled trial of mindfulness meditation versus relaxation training: Effects on distress, positive states of mind, rumination, and distraction. *Annals of Behavioral Medicine*, *33*(1), 11-21.

Jamieson, J. P., Mendes, W. B., & Nock, M. K. (2013). Improving acute stress responses: The power of reappraisal. *Current Directions in Psychological Science*, *22*(1), 51-56.

Jamieson, J. P., Nock, M. K., & Mendes, W. B. (2012). Mind over matter: Reappraising arousal improves cardiovascular and cognitive responses to stress. *Journal of Experimental Psychology: General*, *141*(3), 417-422.

Jankowski, T., & Holas, P. (2014). Metacognitive model of mindfulness. *Consciousness and Cognition*, *28*, 64-80.

Jansen, A. S., Van Nguyen, X., Karpitskiy, V., Mettenleiter, T. C., & Loewy, A. D. (1995). Central command neurons of the sympathetic nervous system: Basis of the fight-or-flight response. *Science*, *270*(5236), 644-646.

Jentsch, V. L., & Wolf, O. T. (2020). The impact of emotion regulation on cardiovascular, neuroendocrine and psychological stress responses. *Biological Psychology*, 107893.

Jermann, F., Van der Linden, M., d'Acremont, M., & Zermatten, A. (2006). Cognitive Emotion Regulation Questionnaire (CERQ): Confirmatory factor analysis and psychometric properties of the French translation. *European Journal of Psychological Assessment*, *22*(2), 126-131.

Jislin-Goldberg, T., Tanay, G., & Bernstein, A. (2012). Mindfulness and positive affect: Cross-sectional, prospective intervention, and real-time relations. *The Journal of Positive Psychology*, *7*(5), 349-361.

Johnson, B., & Turner, L. A. (2003). Data collection strategies in mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (pp. 297-319). Sage Publications.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14-26.

Juster, R.-P., Perna, A., Marin, M.-F., Sindi, S., & Lupien, S. J. (2012). Timing is everything: Anticipatory stress dynamics among cortisol and blood pressure reactivity and recovery in healthy adults. *Stress*, *15*(6), 569-577.

Kabat-Zinn, J. (1990). *Full catastrophe living: The program of the stress reduction clinic at the University of Massachusetts Medical Center*. Delta.

Kabat-Zinn, J. (2003). Mindfulness-based stress reduction (MBSR). *Constructivism in the Human Sciences*, *8*(2), 73-83.

Kabat-Zinn, J. (2013). *Full catastrophe living, revised edition: How to cope with stress, pain and illness using mindfulness meditation*. Hachette UK.

Kelsey, R. M. (2012). Beta-adrenergic cardiovascular reactivity and adaptation to stress: The cardiac pre-ejection period as an index of effort. In R. A. W. G. H. E. Gendolla (Ed.), *How motivation affects cardiovascular response: Mechanisms and applications.* (pp. 43-60). American Psychological Association.

Kemeny, M. E., Gruenewald, T. L., & Dickerson, S. S. (2004). Shame as the emotional response to threat to the social self: Implications for behavior, physiology, and health. *Psychological Inquiry*, *15*(2), 153-160.

Kirby, J. N., Tellegen, C. L., & Steindl, S. R. (2017). A meta-analysis of compassion-based interventions: Current state of knowledge and future directions. *Behavior Therapy*, *48*(6), 778-792.

Kirschbaum, C., Kudielka, B. M., Gaab, J., Schommer, N. C., & Hellhammer, D. H. (1999). Impact of gender, menstrual cycle phase, and oral contraceptives on the activity of the hypothalamus-pituitary-adrenal axis. *Psychosomatic Medicine*, *61*(2), 154-162.

Kirschbaum, C., Pirke, K.-m., & Hellhammer, D. H. (1995). Preliminary evidence for reduced cortisol responsivity to psychological stress in women using oral contraceptive medication. *Psychoneuroendocrinology*, *20*(5), 509-514.

Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The 'Trier Social Stress Test' – A tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*(1-2), 76-81.

Kishita, N., & Shimada, H. (2011). Effects of acceptance-based coping on task performance and subjective stress. *Journal of Behavior Therapy and Experimental Psychiatry*, *42*(1), 6-12.

Knabb, J. J., & Vazquez, V. E. (2018). A randomized controlled trial of a 2-week internet-based contemplative prayer program for Christians with daily stress. *Spirituality in Clinical Practice*, *5*(1), 37.

Koenig, H. G., & Cohen, H. J. (2002). *The link between religion and health: Psychoneuroimmunology and the faith factor*. Oxford University Press.

Koerten, H. R., Watford, T. S., Dubow, E. F., & O'Brien, W. H. (2020). Cardiovascular effects of brief mindfulness meditation among perfectionists experiencing failure. *Psychophysiology*, *57*(4), e13517.

Kohl, A., Rief, W., & Glombiewski, J. A. (2012). How effective are acceptance strategies? A meta-analytic review of experimental results. *Journal of Behavior Therapy and Experimental Psychiatry*, *43*(4), 988-1001.

Komjathy, L. (2018). *Introducing contemplative studies*. Wiley Blackwell.

Kraus, S., & Sears, S. (2008). Measuring the immeasurables: Development and initial validation of the Self-Other Four Immeasurables (SOFI) scale based on

Buddhist teachings on loving kindness, compassion, joy, and equanimity. *Social Indicators Research*, *92*(1), 169.

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological Psychology*, *84*(3), 394-421.

Kristeller, J., & Rapgay, L. (2013). Buddhism: A blend of religion, spirituality, and psychology. In K. I. Pargament, J. J. Exline, & J. W. Jones (Eds.), *APA handbook of psychology, religion, and spirituality (Vol 1): Context, theory, and research* (pp. 635-652). American Psychological Association.

Krkovic, K., Clamor, A., & Lincoln, T. M. (2018). Emotion regulation as a predictor of the endocrine, autonomic, affective, and symptomatic stress response and recovery. *Psychoneuroendocrinology*, *94*, 112-120.

Kudielka, B. M., Buske-Kirschbaum, A., Hellhammer, D. H., & Kirschbaum, C. (2004). Differential heart rate reactivity and recovery after psychosocial stress (TSST) in healthy children, younger adults, and elderly adults: The impact of age and gender. *International Journal of Behavioral Medicine*, *11*(2), 116-121.

Kudielka, B. M., & Kirschbaum, C. (2005). Sex differences in HPA axis responses to stress: A review. *Biological Psychology*, *69*(1), 113-132.

Kudielka, B. M., Schommer, N. C., Hellhammer, D. H., & Kirschbaum, C. (2004). Acute HPA axis responses, heart rate, and mood changes to psychosocial stress (TSST) in humans at different times of day. *Psychoneuroendocrinology*, *29*(8), 983-992.

Kushner, K. P. (2017). Zen and behavioral health: A review of the evidence. In A. Masuda & W. T. O'Donohue (Eds.), *Handbook of Zen, Mindfulness, and Behavioral Health* (pp. 153-168). Springer International Publishing.

Labuschagne, I., Grace, C., Rendell, P., Terrett, G., & Heinrichs, M. (2019). An introductory guide to conducting the Trier Social Stress Test. *Neuroscience & Biobehavioral Reviews*, *107*, 686-695.

Lam, S., Dickerson, S. S., Zoccola, P. M., & Zaldivar, F. (2009). Emotion regulation and cortisol reactivity to a social-evaluative speech task. *Psychoneuroendocrinology*, *34*(9), 1355-1362.

Lazarus, R. S., & Folkman, S. (1984). *Stress, Appraisal, and Coping*. Springer.

Lazarus, R. S., & Folkman, S. (1987). Transactional theory and research on emotions and coping. *European Journal of Personality*, *1*(3), 141-169.

Leary, M. R. (2003). The self and emotion: The role of self-reflection in the generation and regulation of affective experience. In R. J. Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), *Series in affective science. Handbook of affective sciences* (pp. 773-786). Oxford University Press.

Leary, M. R. (2007). How the self became involved in affective experience: Three sources of self-reflective emotions. In J. L. Tracy, R. W. Robins, & J. P. Tangney (Eds.), *The self-conscious emotions: Theory and research* (pp. 38-52). Guilford Press.

Lefcourt, H. M., Davidson, K., Shepherd, R., Phillips, M., Prkachin, K., & Mills, D. (1995). Perspective-taking humor: Accounting for stress moderation. *Journal of Social and Clinical Psychology*, *14*(4), 373-391.

Lieberman, M. D., Eisenberger, N. I., Crockett, M. J., Tom, S. M., Pfeifer, J. H., & Way, B. M. (2007). Putting feelings into words. *Psychological Science*, *18*(5), 421-428.

Lindahl, J. R., & Britton, W. B. (2019). 'I have this feeling of not really being here': Buddhist meditation and changes in sense of self. *Journal of Consciousness Studies*, *26*(7-8), 157-183.

Linden, W., Earle, T., Gerin, W., & Christenfeld, N. (1997). Physiological stress reactivity and recovery: Conceptual siblings separated at birth? *Journal of Psychosomatic Research*, *42*(2), 117-135.

Lindsay, E. K., & Creswell, J. D. (2017). Mechanisms of mindfulness training: Monitor and Acceptance Theory (MAT). *Clinical Psychology Review*, *51*, 48-59.

Lindsay, E. K., Young, S., Smyth, J. M., Brown, K. W., & Creswell, J. D. (2018). Acceptance lowers stress reactivity: Dismantling mindfulness training in a randomized controlled trial. *Psychoneuroendocrinology*, *87*, 63-73.

Liu, J. J., Ein, N., Gervasio, J., & Vickers, K. (2019). The efficacy of stress reappraisal interventions on stress responsivity: A meta-analysis and systematic review of existing evidence. *PLoS ONE*, *14*(2), e0212854.

Liverant, G. I., Brown, T. A., Barlow, D. H., & Roemer, L. (2008). Emotion regulation in unipolar depression: The effects of acceptance and suppression of subjective emotional experience on the intensity and duration of sadness and negative affect. *Behaviour Research and Therapy*, *46*(11), 1201-1209.

Llabre, M. M., Spitzer, S. B., Saab, P. G., Ironson, G. H., & Schneiderman, N. (1991). The reliability and specificity of delta versus residualized change as measures of cardiovascular reactivity to behavioral challenges. *Psychophysiology*, *28*(6), 701-711.

Lo, P.-C., & Wu, S.-D. (2007). Effect of Zen meditation practice on perceived stress in college students: A survey study. *Biomedical Engineering: Applications, Basis and Communications*, *19*(06), 409-413.

Lomas, T. (2017). Recontextualizing mindfulness: Theravada Buddhist perspectives on the ethical and spiritual dimensions of awareness. *Psychology of Religion and Spirituality*, *9*(2), 209-219.

Lovallo, W. R. (2010). Cardiovascular responses to stress and disease outcomes: A test of the reactivity hypothesis. *Hypertension*, *55*(4), 842-843.

Lovallo, W. R., & Gerin, W. (2003). Psychophysiological reactivity: Mechanisms and pathways to cardiovascular disease. *Psychosomatic Medicine*, *65*(1), 36-45.

Low, C. A., Stanton, A. L., & Bower, J. E. (2008). Effects of acceptance-oriented versus evaluative emotional processing on heart rate recovery and habituation. *Emotion*, *8*(3), 419-424.

Luders, E., Thompson, P. M., Kurth, F., Hong, J. Y., Phillips, O. R., Wang, Y., Gutman, B. A., Chou, Y. Y., Narr, K. L., & Toga, A. W. (2013). Global and regional alterations of hippocampal anatomy in long-term meditation practitioners. *Human Brain Mapping*, *34*(12), 3369-3375.

Lumma, A.-L., & Weger, U. (2021). Looking from within: Comparing first-person approaches to studying experience. *Current Psychology*, 1-17.

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, *12*(4), 163-169.

Lutz, J., Herwig, U., Opialla, S., Hittmeyer, A., Jäncke, L., Rufer, M., Grosse Holtforth, M., & Brühl, A. B. (2013). Mindfulness and emotion regulation—an fMRI study. *Social Cognitive and Affective Neuroscience*, *9*(6), 776-785.

Lyubomirsky, S., & Lepper, H. (1999). A measure of subjective happiness: Preliminary reliability and construct validation. *Social Indicators Research*, *46*(2), 137-155.

MacQueen, K. M., McLellan, E., Kay, K., & Milstein, B. (1998). Codebook development for team-based qualitative analysis. *CAM Journal*, *10*(2), 31-36.

Maier, K. J., Waldstein, S. R., & Synowski, S. J. (2003). Relation of cognitive appraisal to cardiovascular reactivity, affect, and task engagement. *Annals of Behavioral Medicine*, *26*(1), 32-41.

Malouff, J. M., & Schutte, N. S. (1986). Development and validation of a measure of irrational belief. *Journal of Consulting and Clinical Psychology*, *54*(6), 860-862.

Manigault, A. W., Peters, B. J., & Zoccola, P. M. (2021). When enhanced awareness threatens: Interactive effects of domain-specific awareness and acceptance

manipulations on cardiovascular indices of challenge and threat. *Psychophysiology*, *58*(1), e13697.

Marschall, D., Sanftner, J., & Tangney, J. P. (1994). *The State Shame and Guilt Scale*. George Mason University.

Martens, A., Greenberg, J., & Allen, J. J. (2008). Self-esteem and autonomic physiology: Parallels between self-esteem and cardiac vagal tone as buffers of threat. *Personality and Social Psychology Review*, *12*(4), 370-389.

Martin, R. A., Kuiper, N. A., Olinger, L. J., & Dance, K. A. (1993). Humor, coping with stress, self-concept, and psychological well-being. *Humor: International Journal of Humor Research*, *6*(1), 89-104.

Matthews, K. A., Woodall, K. L., & Allen, M. T. (1993). Cardiovascular reactivity to stress predicts future blood pressure status. *Hypertension*, *22*(4), 479-485.

Mauss, I. B., Cook, C. L., Cheng, J. Y., & Gross, J. J. (2007). Individual differences in cognitive reappraisal: Experiential and physiological responses to an anger provocation. *International Journal of Psychophysiology*, *66*(2), 116-124.

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion*, *5*(2), 175-190.

Mayor, E., & Gamaiunova, L. (2014). Using wearable technology for psychophysiological experiments: Gender roles and cognitive appraisal impact cardiac response to socio-evaluative stress. *Proceedings of the 4th EAI International Conference on Wireless Mobile Communication and Healthcare*, 15-18.

Mayor, E., & Gamaiunova, L. (2015). Mobile device-based mindfulness intervention promotes emotional regulation during anticipatory stress. *Proceedings of the 5th EAI International Conference on Wireless Mobile Communication and Healthcare,* 258-262.

McCabe, P. M., & Schneiderman, N. (1985). Psychophysiologic reactions to stress. In In N. Schneiderman and J. T. Tap (Eds.), *Behavioral medicine: The biopsychosocial approach.* (pp. 99-131). Lawrence Erlbaum Associates, Inc.

McCarty, R. (2016). Chapter 4 - The Fight-or-Flight Response: A Cornerstone of Stress Research. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (pp. 33-37). Academic Press.

McDonald, R. P., & Ho, M.-H. R. (2002). Principles and practice in reporting structural equation analyses. *Psychological Methods*, *7*(1), 64-82.

McEwen, B. S. (1998a). Protective and damaging effects of stress mediators. *New England Journal of Medicine*, *338*(3), 171-179.

McEwen, B. S. (1998b). Stress, adaptation, and disease: Allostasis and allostatic load. *Annals of the New York Academy of Sciences*, *840*(1), 33-44.

McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica*, *22*(3), 276-282.

McIntosh, D. N. (1995). Religion-as-schema, with implications for the relation between religion and coping. *The International Journal for the Psychology of Religion*, *5*(1), 1-16.

McMahan, D. L. (2008). *The making of Buddhist modernism*. Oxford University Press.

Mezzacappa, E. S., Kelsey, R. M., Katkin, E. S., & Sloan, R. P. (2001). Vagal rebound and recovery from psychological stress. *Psychosomatic Medicine*, *63*(4), 650-657.

Mikulas, W. L. (1978). Four Noble Truths of Buddhism related to behavior therapy. *The Psychological Record*, *28*(1), 59-67.

Mikulas, W. L. (2007). Buddhism & Western psychology: Fundamentals of integration. *Journal of Consciousness Studies*, *14*(4), 4-49.

Moacanin, R. (2003). *The essence of Jung's psychology and Tibetan Buddhism: Western and Eastern paths to the heart*. Simon and Schuster.

Modinos, G., Ormel, J., & Aleman, A. (2010). Individual differences in dispositional mindfulness and brain activity involved in reappraisal of emotion. *Social Cognitive and Affective Neuroscience*, *5*(4), 369-377.

Monteiro, L. (2015, November). *Ethics and secular mindfulness programs: Sila as victim of the fallacy of values-neutral therapy* [Paper presentation]. *American Academy of Religion, Atlanta, USA.*

Moran, C. C., & Massam, M. M. (1999). Differential influences of coping humor and humor bias on mood. *Behavioral Medicine*, *25*(1), 36-42.

Morone, N. E., Lynch, C. S., Greco, C. M., Tindle, H. A., & Weiner, D. K. (2008). "I felt like a new person." The effects of mindfulness meditation on older adults with chronic pain: Qualitative narrative analysis of diary entries. *The Journal of Pain*, *9*(9), 841-848.

Morton, M. L., Helminen, E. C., & Felver, J. C. (2020). A systematic review of mindfulness interventions on psychophysiological responses to acute stress. *Mindfulness*, *1*(9), 2039-2054.

Nater, U. M., Rohleder, N., Gaab, J., Berger, S., Jud, A., Kirschbaum, C., & Ehlert, U. (2005). Human salivary alpha-amylase reactivity in a psychosocial stress paradigm. *International Journal of Psychophysiology*, *55*(3), 333-342.

Neff, K. D., & Vonk, R. (2009). Self-compassion versus global self-esteem: Two different ways of relating to oneself. *Journal of Personality*, *77*(1), 23-50.

Newton, A. T., & McIntosh, D. N. (2010). Specific religious beliefs in a cognitive appraisal model of stress and coping. *International Journal for the Psychology of Religion*, *20*(1), 39-58.

Nijjar, P. S., Puppala, V. K., Dickinson, O., Duval, S., Duprez, D., Kreitzer, M. J., & Benditt, D. G. (2014). Modulation of the autonomic nervous system assessed through heart rate variability by a mindfulness based stress reduction program. *International Journal of Cardiology*, *177*(2), 557-559.

Nilsson, H., & Kazemi, A. (2016). From Buddhist sati to Western mindfulness practice: A contextual analysis. *Journal of Religion & Spirituality in Social Work: Social Thought*, *35*(1-2), 7-23.

Nunan, D., Jakovljevic, D. G., Donovan, G., Hodges, L. D., Sandercock, G. R. H., & Brodie, D. A. (2008). Levels of agreement for RR intervals and short-term heart rate variability obtained from the Polar S810 and an alternative system. *European Journal of Applied Physiology*, *103*(5), 529-537.

Nyklíček, I., Mommersteeg, P., Van Beugen, S., Ramakers, C., & Van Boxtel, G. J. (2013). Mindfulness-based stress reduction and physiological activity during acute stress: A randomized controlled trial. *Health Psychology*, *32*(10), 1110-1113.

O'Connor, D. B., Thayer, J. F., & Vedhara, K. (2021). Stress and health: A review of psychobiological processes. *Annual Review of Psychology*, *72*, 663-688.

Obrist, P. A. (2012). *Cardiovascular psychophysiology: A perspective*. Springer Science & Business Media.

Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, *9*(5), 242-249.

Olendzki, A. (2006). The transformative impact of non-self. In D. K. Nauriyal, M. S. Drummond, & Y. B. Lal (Eds.), *Buddhist thought and applied psychological research: Transcending the boundaries* (pp. 250-261). Taylor & Francis Routledge.

Olendzki, A. (2010). *Unliminting mind: The radically experiential psychology of Buddhism*. Wisdom Publications.

Ozawa-de Silva, B. (2016). Contemplative science and secular ethics. *Religions*, *7*(8), 98.

Pace, T. W., Negi, L. T., Adame, D. D., Cole, S. P., Sivilli, T. I., Brown, T. D., Issa, M. J., & Raison, C. L. (2009). Effect of compassion meditation on neuroendocrine,

innate immune and behavioral responses to psychosocial stress. *Psychoneuroendocrinology*, *34*(1), 87-98.

Pepping, C. A., O'Donovan, A., & Davis, P. J. (2013). The positive effects of mindfulness on self-esteem. *The Journal of Positive Psychology*, *8*(5), 376-386.

Peterson, L. G., & Pbert, L. (1992). Effectiveness of a meditation-based stress reduction program in the treatment of anxiety disorders. *American Journal of Psychiatry*, *149*(7), 936-943.

Petitmengin, C., van Beek, M., Bitbol, M., Nissou, J.-M., & Roepstorff, A. (2019). Studying the experience of meditation through micro-phenomenology. *Current Opinion in Psychology*, *28*, 54-59.

Phillips, R. E., Cheng, C. M., Pargament, K. I., Oemig, C., Colvin, S. D., Abarr, A. N., Dunn, M. W., & Reed, A. S. (2009). Spiritual coping in American Buddhists: An exploratory study. *The International Journal for the Psychology of Religion*, *19*(4), 231-243.

Phillips, R. E., Michelle Cheng, C., Oemig, C., Hietbrink, L., & Vonnegut, E. (2012). Validation of a Buddhist coping measure among primarily non-Asian Buddhists in the United States. *Journal for the Scientific Study of Religion*, *51*(1), 156-172.

Pranke, P. A. (2004). Vipassana (Sanskrit Vipasyana). In R. E. Buswell Jr (Ed.), *Encyclopedia of Buddhism.* MacMillan Reference Books.

Preacher, K. J., & Kelley, K. (2011). Effect size measures for mediation models: Quantitative strategies for communicating indirect effects. *Psychological Methods*, *16*(2), 93-115.

Pruessner, J. C., Baldwin, M. W., Dedovic, K., Renwick, R., Mahani, N. K., Lord, C., Meaney, M., & Lupien, S. (2005). Self-esteem, locus of control, hippocampal volume, and cortisol regulation in young and old adulthood. *Neuroimage*, *28*(4), 815-826.

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*, *28*(7), 916-931.

Przyrembel, M., & Singer, T. (2018). Experiencing meditation–Evidence for differential effects of three contemplative mental practices in micro-phenomenological interviews. *Consciousness and Cognition*, *62*, 82-101.

Pulopulos, M. M., Baeken, C., & De Raedt, R. (2020). Cortisol response to stress: The role of expectancy and anticipatory stress regulation. *Hormones and Behavior*, *117*, 104587.

Pulopulos, M. M., Vanderhasselt, M.-A., & De Raedt, R. (2018). Association between changes in heart rate variability during the anticipation of a stressful situation and the stress-induced cortisol response. *Psychoneuroendocrinology*, *94*, 63-71.

Rasmussen, M. K., & Pidgeon, A. M. (2011). The direct and indirect benefits of dispositional mindfulness on self-esteem and social anxiety. *Anxiety, Stress, & Coping*, *24*(2), 227-233.

Roberts, A. L., Malspeis, S., Kubzansky, L. D., Feldman, C. H., Chang, S. C., Koenen, K. C., & Costenbader, K. H. (2017). Association of trauma and posttraumatic stress disorder with incident systemic lupus erythematosus in a longitudinal cohort of women. *Arthritis & Rheumatology*, *69*(11), 2162-2169.

Robins, C. J. (2002). Zen principles and mindfulness practice in dialectical behavior therapy. *Cognitive and Behavioral Practice*, *9*(1), 50-57.

Robles, T. F., Brooks, K. P., & Pressman, S. D. (2009). Trait positive affect buffers the effects of acute stress on skin barrier recovery. *Health Psychology*, *28*(3), 373-378.

Rosenkranz, M. A., Lutz, A., Perlman, D. M., Bachhuber, D. R. W., Schuyler, B. S., MacCoon, D. G., & Davidson, R. J. (2016). Reduced stress and inflammatory

responsiveness in experienced meditators compared to a matched healthy control group. *Psychoneuroendocrinology*, *68*, 117-125.

Rosenzweig, S., Greeson, J. M., Reibel, D. K., Green, J. S., Jasser, S. A., & Beasley, D. (2010). Mindfulness-based stress reduction for chronic pain conditions: Variation in treatment outcomes and role of home meditation practice. *Journal of Psychosomatic Research*, *68*(1), 29-36.

Roth, H. (2006). Contemplative studies: Prospects for a new field. *Teachers College Record*, *108*(9), 1787-1815.

Ryan, R. M., & Brown, K. W. (2003). Why we don't need self-esteem: On fundamental needs, contingent love, and mindfulness. *Psychological Inquiry*, *14*(1), 71-76.

Sacamano, J., & Altman, J. K. (2016). Beyond mindfulness: Buddha nature and the four postures in psychotherapy. *Journal of Religion and Health*, *55*(5), 1585-1595.

Sala, M., Perez, J., Soloff, P., Di Nemi, S. U., Caverzasi, E., Soares, J. C., & Brambilla, P. (2004). Stress and hippocampal abnormalities in psychiatric disorders. *European Neuropsychopharmacology*, *14*(5), 393-405.

Sapolsky, R. M. (2007). Stress, stress-related disease, and emotional regulation. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 606-615). The Guilford Press.

Schafer, J. L., & Olsen, M. K. (1998). Multiple imputation for multivariate missing-data problems: A data analyst's perspective. *Multivariate Behavioral Research*, *33*(4), 545-571.

Shapiro, S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology*, *65*(6), 613–626.

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information*, *44*(4), 695-729.

Scherer, K. R., Schorr, A., & Johnstone, T. (2001). Appraisal processes in emotion: Theory, methods, research. Oxford University Press.

Schneiderman, N., Ironson, G., & Siegel, S. D. (2005). Stress and health: Psychological, behavioral, and biological determinants. *Annual Review of Clinical Psychology*, *1*(1), 607-628.

Schnell, T., Fuchs, D., & Hefti, R. (2020). Worldview under stress: Preliminary findings on cardiovascular and cortisol stress responses predicted by secularity, religiosity, spirituality, and existential search. *Journal of Religion and Health*, *59*(6), 2969-2989.

Schommer, N. C., Hellhammer, D. H., & Kirschbaum, C. (2003). Dissociation between reactivity of the hypothalamus-pituitary-adrenal axis and the sympathetic-adrenal-medullary system to repeated psychosocial stress. *Psychosomatic Medicine*, *65*(3), 450-460.

Sedighimornani, N., Rimes, K. A., & Verplanken, B. (2019). Exploring the relationships between mindfulness, self-compassion, and shame. *Sage Open*, *9*(3), 2158244019866294.

Seeman, T. E., Singer, B. H., Rowe, J. W., Horwitz, R. I., & McEwen, B. S. (1997). Price of adaptation—allostatic load and its health consequences: MacArthur studies of successful aging. *Archives of Internal Medicine*, *157*(19), 2259-2268.

Seery, M. D. (2011). Challenge or threat? Cardiovascular indexes of resilience and vulnerability to potential stress in humans. *Neuroscience & Biobehavioral Reviews*, *35*(7), 1603-1610.

Segal, Z. V., Williams, M., & Teasdale, J. (2018). *Mindfulness-based cognitive therapy for depression*. Guilford Publications.

Shapiro, S., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology*, *62*(3), 373-386.

Shapiro, S., Oman, D., Thoresen, C. E., Plante, T. G., & Flinders, T. (2008). Cultivating mindfulness: Effects on well-being. *Journal of Clinical Psychology*, *64*(7), 840-862.

Sharma, A., & Dewangan, R. L. (2017). Can wisdom be fostered: Time to test the model of wisdom. *Cogent Psychology*, *4*(1), 1-17.

Shearer, A., Hunt, M., Chowdhury, M., & Nicol, L. (2016). Effects of a brief mindfulness meditation intervention on student stress and heart rate variability. *International Journal of Stress Management*, *23*(2), 232-254.

Sherwood, A., Allen, M. T., Fahrenberg, J., Kelsey, R. M., Lovallo, W. R., & Van Doornen, L. J. (1990). Methodological guidelines for impedance cardiography. *Psychophysiology*, *27*(1), 1-23.

Shonin, E., Van Gordon, W., Dunn, T. J., Singh, N. N., & Griffiths, M. D. (2014). Meditation awareness training (MAT) for work-related wellbeing and job performance: A randomised controlled trial. *International Journal of Mental Health and Addiction*, *12*(6), 806-823.

Shonin, E., Van Gordon, W., & Griffiths, M. D. (2014a). Changing paradigms: Buddhist insight in Western psychological treatments. *Psy-PAG Quarterly*, *92*, 35-39.

Shonin, E., Van Gordon, W., & Griffiths, M. D. (2014b). The emerging role of Buddhism in clinical psychology: Toward effective integration. *Psychology of Religion and Spirituality*, *6*(2), 123-137.

Siegel, R. D., Germer, C. K., & Olendzki, A. (2009). Mindfulness: What is it? Where did it come from? In Didonna, F. (Ed.), *Clinical handbook of mindfulness* (pp. 17-35). Springer.

Silva, P. d. (2006). The tsunami and its aftermath in Sri Lanka: Explorations of a Buddhist perspective. *International Review of Psychiatry*, *18*(3), 281-287.

Slavich, G. M. (2020). Social safety theory: A biologically based evolutionary perspective on life stress, health, and behavior. *Annual Review of Clinical Psychology*, *16*, 265-295.

Slutsky, J., Rahl, H., Lindsay, E. K., & Creswell, J. D. (2017). Mindfulness, emotion regulation, and social threat. In Papies, E. K., Karremans J. (Eds.), *Mindfulness in social psychology* (pp. 79-93). Routledge.

Smith, B., Dalen, J., Wiggins, K., Tooley, E., Christopher, P., & Bernard, J. (2008). The brief resilience scale: Assessing the ability to bounce back. *International Journal of Behavioral Medicine*, *15*(3), 194-200.

Smith, T. W. (1982). Irrational beliefs in the cause and treatment of emotional distress: A critical review of the rational-emotive model. *Clinical Psychology Review*, *2*(4), 505-522.

Sousa, V. D., & Rojjanasrirat, W. (2011). Translation, adaptation and validation of instruments or scales for use in cross-cultural health care research: A clear and user-friendly guideline. *Journal of Evaluation in Clinical Practice*, *17*(2), 268-274.

Sparby, T. (2018). It's like growing roots inside something deeply familiar: An explorative qualitative study of anthroposophic mantra practice and the subsidiary exercises. *Religions*, *9*(8), 245.

Spiegelman, J. M., & Miyuki, M. (1985). *Buddhism and Jungian psychology*. Falcon Press.

Starks, H., & Brown Trinidad, S. (2007). Choose your method: A comparison of phenomenology, discourse analysis, and grounded theory. *Qualitative Health Research*, *17*(10), 1372-1380.

Ștefan, C. A., Căpraru, C., & Szilágyi, M. (2018). Investigating effects and mechanisms of a mindfulness-based stress reduction intervention in a sample of college students at risk for social anxiety. *Mindfulness*, *9*(5), 1509-1521.

Steptoe, A., & Vögele, C. (1986). Are stress responses influenced by cognitive appraisal? An experimental comparison of coping strategies. *British Journal of Psychology*, *77*(2), 243-255.

Strahan, R., & Gerbasi, K. C. (1972). Short, homogeneous versions of the Marlow-Crowne Social Desirability Scale. *Journal of Clinical Psychology*, *28*(2), 191-193.

Suler, J. R. (1993). *Contemporary psychoanalysis and Eastern thought* (Vol. 21). SUNY Press.

Sullivan, G., Apergis, J., Bush, D., Johnson, L. R., Hou, M., & Ledoux, J. (2004). Lesions in the bed nucleus of the stria terminalis disrupt corticosterone and freezing responses elicited by a contextual but not by a specific cue-conditioned fear stimulus. *Neuroscience*, *128*(1), 7-14.

Suresh, K. (2011). An overview of randomization techniques: An unbiased assessment of outcome in clinical research. *Journal of Human Reproductive Sciences*, *4*(1), 8-11.

Suzuki, D. T. (1991). *An introduction to zen buddhism*. Grove Press.

Szekeres, R. A., & Wertheim, E. H. (2015). Evaluation of Vipassana meditation course effects on subjective stress, well-being, self-kindness and mindfulness in a community sample: Post-course and 6-month outcomes. *Stress and Health*, *31*(5), 373-381.

Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, *16*(4), 213-225.

Taren, A. A., Creswell, J. D., & Gianaros, P. J. (2013). Dispositional mindfulness co-varies with smaller amygdala and caudate volumes in community adults. *PLoS ONE*, *8*(5), e64574.

Tarvainen, M. P., Niskanen, J.-P., Lipponen, J. A., Ranta-Aho, P. O., & Karjalainen, P. A. (2014). Kubios HRV–heart rate variability analysis software. *Computer Methods and Programs in Biomedicine*, *113*(1), 210-220.

Taylor, S. E., & Crocker, J. (1981). Schematic bases of social information processing. In E. T. Higgins, C. P. Herman, & M. P. Zanna (Eds.), *Social cognition: The Ontario symposium* (Vol. 1, pp. 89-134). Lawrence Erlbaum Associates, Inc.

Teasdale, J. D., & Chaskalson, M. (2011a). How does mindfulness transform suffering? I: The nature and origins of dukkha. *Contemporary Buddhism*, *12*(1), 89-102.

Teasdale, J. D., & Chaskalson, M. (2011b). How does mindfulness transform suffering? II: The transformation of dukkha. *Contemporary Buddhism*, *12*(1), 103-124.

Teasdale, J. D., Segal, Z., & Williams, M. (1995). How does cognitive therapy prevent depressive relapse and why should attentional control (mindfulness) training help? *Behaviour Research and Therapy*, *33*(1), 25–39.

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers III, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews*, *36*(2), 747-756.

Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders*, *61*(3), 201-216.

Thoits, P. A. (2010). Stress and health: Major findings and policy implications. *Journal of Health and Social Behavior*, *51*(1_suppl), S41-S53.

Thompson, R. A. (1994). Emotion regulation: A theme in search of definition. *Monographs of the Society for Research in Child Development*, *59*(2-3), 25-52.

Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological, and behavioral effects of threat and challenge appraisal. *Journal of Personality and Social Psychology*, *65*(2), 248-260.

Tomaka, J., Blascovich, J., Kibler, J., & Ernst, J. M. (1997). Cognitive and physiological antecedents of threat and challenge appraisal. *Journal of Personality and Social Psychology*, *73*(1), 63-72.

Toneatto, T. (2002). A metacognitive therapy for anxiety disorders: Buddhist psychology applied. *Cognitive and Behavioral Practice*, *1*(9), 72-78.

Tracy, J. L., & Robins, R. W. (2004). Putting the self into self-conscious emotions: A theoretical model. *Psychological Inquiry*, *15*(2), 103-125.

Tripathi, K. (2004). Respiration and heart rate variability: A review with special reference to its application in aerospace medicine. *Indian Journal of Aerospace Medicine*, *48*(1), 64-75.

Ulrich-Lai, Y. M., & Herman, J. P. (2009). Neural regulation of endocrine and autonomic stress responses. *Nature Reviews. Neuroscience*, *10*(6), 397-409.

Uno, H., Tarara, R., Else, J. G., Suleman, M. A., & Sapolsky, R. M. (1989). Hippocampal damage associated with prolonged and fatal stress in primates. *Journal of Neuroscience*, *9*(5), 1705-1711.

Uphill, M. A., Rossato, C. J. L., Swain, J., & O'Driscoll, J. (2019). Challenge and threat: A critical review of the literature and an alternative conceptualization [Review]. *Frontiers in Psychology*, *10*(1255).

Ursin, H., & Eriksen, H. R. (2004). The cognitive activation theory of stress. *Psychoneuroendocrinology*, *29*(5), 567-592.

Vago, D., & David, S. (2012). Self-awareness, self-regulation, and self-transcendence (S-ART): A framework for understanding the neurobiological mechanisms of mindfulness [Review]. *Frontiers in Human Neuroscience*, *6*, 1-30.

Van Gordon, W., & Shonin, E. (2020). Second-generation mindfulness-based interventions: Toward more authentic mindfulness practice and teaching. *Mindfulness*, *11*(1), 1-4.

Van Gordon, W., Shonin, E., & Griffiths, M. D. (2017). Buddhist emptiness theory: Implications for psychology. *Psychology of Religion and Spirituality*, *9*(4), 309-318.

Van Gordon, W., Shonin, E., Sumich, A., Sundin, E. C., & Griffiths, M. D. (2014). Meditation awareness training (MAT) for psychological well-being in a sub-clinical sample of university students: A controlled pilot study. *Mindfulness*, *5*(4), 381-391.

Varela, F. J., & Shear, J. (1999). First-person methodologies: What, why, how. *Journal of Consciousness Studies*, *6*(2-3), 1-14.

Vors, O., Marqueste, T., & Mascret, N. (2018). The Trier Social Stress Test and the Trier Social Stress Test for groups: Qualitative investigations. *PLoS ONE*, *13*(4), e0195722.

Wachholtz, A., & Austin, E. (2013). Contemporary spiritual meditation: Practices and outcomes. In K. I. Pargament, J. J. Exline, & J. W. Jones (Eds.), *APA handbook of psychology, religion, and spirituality (Vol 1): Context, theory, and research* (pp. 311-327). American Psychological Association.

Wallace, B. A. (2009). *Contemplative science: Where Buddhism and neuroscience converge*. Columbia University Press.

Wallace, B. A. (2010). *The Four Immeasurables: Practices to Open the Heart*. Snow Lion Publications.

Wallace, B. A., & Shapiro, S. L. (2006). Mental balance and well-being: Building bridges between Buddhism and Western psychology. *American Psychologist*, *61*(7), 690-701.

Wang, M., & Saudino, K. J. (2011). Emotion regulation and stress. *Journal of Adult Development*, *18*(2), 95-103.

Watson, D., Clark, L. A., & Carey, G. (1988). Positive and negative affectivity and their relation to anxiety and depressive disorders. *Journal of Abnormal Psychology*, *97*(3), 346-353.

Way, B. M., Creswell, J. D., Eisenberger, N. I., & Lieberman, M. D. (2010). Dispositional mindfulness and depressive symptomatology: Correlations with limbic and self-referential neural activity during rest. *Emotion*, *10*(1), 12-24.

Weinstein, N., Brown, K. W., & Ryan, R. M. (2009). A multi-method examination of the effects of mindfulness on stress attribution, coping, and emotional well-being. *Journal of Research in Personality*, *43*(3), 374-385.

Weisbuch-Remington, M., Mendes, W. B., Seery, M. D., & Blascovich, J. (2005). The nonconscious influence of religious symbols in motivated performance situations. *Personality and Social Psychology Bulletin*, *31*(9), 1203-1216.

White, W. B., & Anwar, Y. A. (2001). Evaluation of the overall efficacy of the Omron office digital blood pressure HEM-907 monitor in adults. *Blood Pressure Monitoring*, *6*(2), 107-110.

Wielgosz, J., Schuyler, B. S., Lutz, A., & Davidson, R. J. (2016). Long-term mindfulness training is associated with reliable differences in resting respiration rate. *Scientific Reports*, *6*(1), 1-6.

Wirtz, P. H., Känel, R. v., Emini, L., Suter, T., Fontana, A., & Ehlert, U. (2007). Variations in anticipatory cognitive stress appraisal and differential proinflammatory cytokine expression in response to acute stress. *Brain, Behavior, and Immunity*, *21*(6), 851-859.

Wojnarowska, A., Kobylinska, D., & Lewczuk, K. (2020). Acceptance as an emotion regulation strategy in experimental psychological research: What we know

and how we can improve that knowledge [Opinion]. *Frontiers in Psychology*, *11*(242).

Wolgast, M., Lundh, L.-G., & Viborg, G. (2011). Cognitive reappraisal and acceptance: An experimental comparison of two emotion regulation strategies. *Behaviour Research and Therapy*, *49*(12), 858-866.

Wolgast, M., Lundh, L.-G., & Viborg, G. (2013). Cognitive restructuring and acceptance: An empirically grounded conceptual analysis. *Cognitive Therapy and Research*, *37*(2), 340-351.

Woods, H., & Proeve, M. (2014). Relationships of mindfulness, self-compassion, and meditation experience with shame-proneness. *Journal of Cognitive Psychotherapy*, *28*(1), 20-33.

Woody, A., Hooker, E. D., Zoccola, P. M., & Dickerson, S. S. (2018). Social-evaluative threat, cognitive load, and the cortisol and cardiovascular stress response. *Psychoneuroendocrinology*, *97*, 149-155.

Yuan, K.-H., Marshall, L. L., & Bentler, P. M. (2002). A unified approach to exploratory factor analysis with missing data, nonnormal data, and in the presence of outliers. *Psychometrika*, *67*(1), 95-121.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, *67*(6), 361-370.

Zoccola, P. M., Dickerson, S. S., & Zaldivar, F. P. (2008). Rumination and cortisol responses to laboratory stressors. *Psychosomatic Medicine*, *70*(6), 661-667.

Appendix A. Chapter 4 supplementary materials

Table A1

Overview of the additional module contents for the MBSR-B program

Week	Theme	10 minutes of introduction during class	10 minutes of audio instructions on how to apply it "informally" in daily life (day after class)	Practicing the informal practices when possible during the week	Daily 10-minutes guided meditation centered upon the topic
1	impermanence	x	x	being aware of the impermanence of emotions (self and others)	-
2	Ethics	x	x	abstaining from one minor unethical action for the week (like gossiping), practicing one generous action	contemplation on gratefulness and generosity
3	Lovingkindness	x	x	using informal lovinkindness intentions during difficult conversations	lovingkindness meditation
4	Compassion	x	x	using informal compassionate intentions when meeting someone who faces difficulties	compassion meditation
5	Not-self	x	x	being aware of moments of "selfing" during the week vs moments of mindful activities	open awareness meditation with focus on "desidentification"
6	Craving	x	x	being mindful when craving is present, planning one pleasant activity that is not part of those that are associated with addiction (food, screens, etc.)	"urge surfing" meditation
7	No theme	-	-	any of the previously introduced practices	any of the previously practiced meditations

Table A2

Items of the Buddhist module questionnaire (English)

Please read carefully the following statements and indicate **to what point they are true for you**. Use the following scale.

1 (not at all true) ---------10 (very true)

1. All things, whether material or mental, are continuously changing.
2. Nothing remains permanent.
3. Life consists of suffering and dissatisfaction.
4. Suffering arises from our desire to have and control things.
5. There is no unchanging, permanent self or essence in living beings.
6. What we perceive as self is a formation of our thoughts, feelings, emotions, sensations, memory, reason and intelligence.

Please read carefully the following statements and indicate **how often you have this type of experience**. Use the following scale.

1 (never) ---------10 (very often)

7. I experience appreciative joy at the success and good fortune of others.
8. I experience pleasure when other people are well.
9. I experience compassion towards other beings.
10. I experience compassion towards myself.
11. I feel undisturbed by outer events, my thoughts and emotions.
12. I manage to maintain balance of my mind in the face of adversity.
13. I feel love and benevolence for all beings.
14. I wish all being happiness.

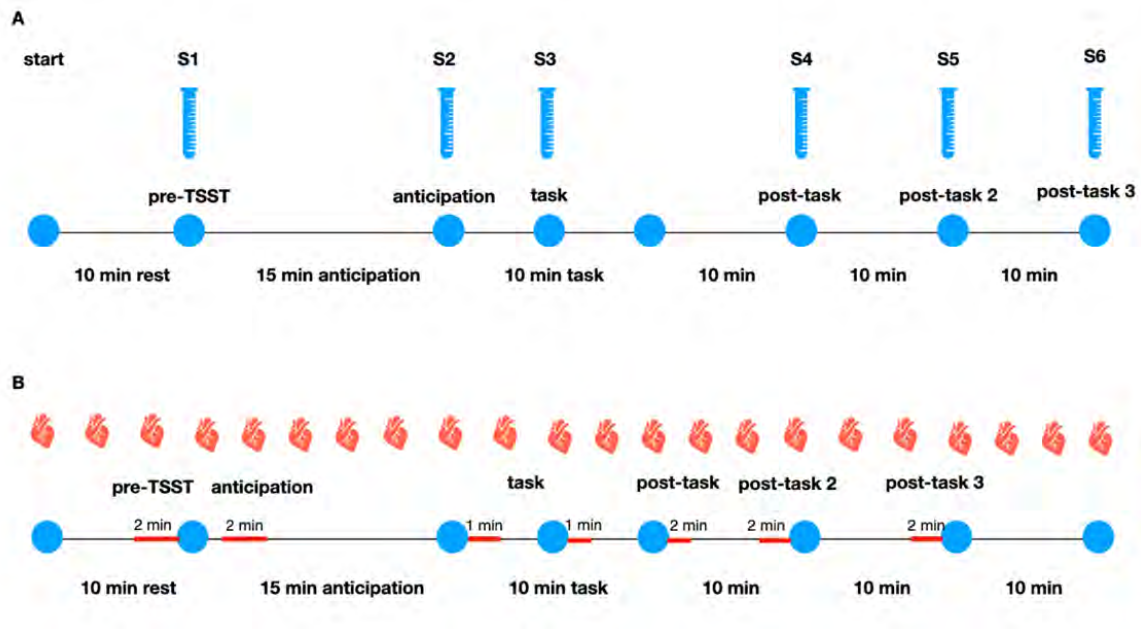
Please read carefully the following statements and indicate **how often you practice the following**. Use the following scale.

1 (never) ---------10 (very often)

15. I act generously towards others.
16. I offer my resources, time, or knowledge to others without expecting anything in return.
17. I say lies or exaggerate things.
18. I engage in idle talk or gossip.
19. I intentionally harm others.
20. I steal things or get what I need in a fraudulent way.

Figure A1

Details of sampling during the TSST experiment



Note. (A) S1-S6 = saliva samples. (B) Cardiovascular measures were taken continuously; red line represents chunks of the data used for the analyses.

Appendix B. Chapter 5 supplementary materials

Figure B1

Details of sampling during the TSST experiment