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Exploring the Influence of Meditation Experience on Stress Responses and Empathy: The Mediating Role of Self-Expansion

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EXPLORING THE INFLUENCE OF MEDITATION EXPERIENCE ON STRESS RESPONSES AND EMPATHY: THE MEDIATING ROLE OF SELF EXPANSION

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Doctor of Philosophy

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I HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER MY SUPERVISION BY Jennifer N. Baumgartner ENTITLED Exploring the influence of meditation experience on stress responses and empathy: The mediating role of self expansion BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Doctor of Philosophy

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ABSTRACT

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The purpose of the present research was to examine the influence of meditation experience on biopsychosocial responses to stress, empathy, and sense of self. An expanded sense of self was examined as a pathway through which meditation experience influences appraisals, affect, and empathy. It was expected that meditation experience would predict greater challenge stressor appraisals in response to an acute psychosocial stressor and associated affective, behavioral, and psychophysiological stress outcomes. In addition, it was expected that greater meditation experience would predict higher trait empathy and empathic accuracy. Participants (N = 110) included experienced meditators from a variety of practices and people who were interested in meditation, but are otherwise non-meditators. Participants reported state affect, trait empathy, and selflessness at baseline, and then reported appraisals and affect regarding an impending stressor. Performance and cardiovascular physiology were recorded continuously during the stressor. Finally, participants watched a video of a target engaging with the same stressor. Participants were instructed to guess the target's affective state, which was used to discern empathic accuracy. Findings revealed that meditation predicted increased positive affect in response to the stressor and some aspects of performance. Meditation experience also

predicted less personal distress, a subcomponent of trait empathy. Lastly, path analyses showed that an expanded sense of self fully mediated the relation between meditation and increased positive affect in response to the stressor. This research provides some evidence that meditation facilitates positive stress outcomes and a subcomponent of empathy, and provides a novel mechanism through which meditation upregulates positive affect – by promoting a sense of self that is boundless and connected.

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DEDICATION

This dissertation is dedicated to the reader who I hope might feel just a little more connected to others and the world around them after reading this document. Although above all, this dissertation is dedicated to my parents who, without them, this would not have been possible, let alone conceivable. Through example, they have taught me the value of hard work and the true meaning of resilience, even during times that seemed impossible to overcome. Indeed, I owe them a debt of gratitude for their constant support and the space to allow me to explore the world to the depth of my abilities and ever-growing curiosity. I hope I have made you proud, as you both have made me.

I. INTRODUCTION

In the United States, chronic psychological stress is a main contributing factor to at least seven leading causes of death, including cancer, cardiovascular disease, accidental injuries, respiratory disorders, HIV/AIDS, cirrhosis of the liver, and suicide (Cohen, Janicki-Deverts, & Miller, 2007). It is estimated that as much as 75% of the United States' aggregate health care cost is for the treatment of these disorders and other stress-related complaints (Centers for Disease Control and Prevention, 2016). The experience of stress can also negatively impact psychological functioning. Stress is related to structural changes in the brain that mediate working memory (Arnsten, 2009), causes dysfunction in emotion regulatory processes (Tull, Barrett, McMillan, & Roemer, 2007), and is a major contributing factor toward feelings of unhappiness (Lyubomirsky, 2007). Understanding ways to help people manage their stress is of critical importance to improve health and overall quality of life.

Not only do people experience stress, they also observe other people experience stress. In contemporary society, people are inundated with stories and images of human suffering, such as watching a disaster unfold and its aftermath, or witnessing another person in pain (Miller, 2005). As with personal suffering, exposure to the suffering of others has consequences for health and quality of life. Exposure to suffering can increase negative emotions such as fear, guilt, and sadness (Paschali et al., 2013), anxiety regarding personal health (Karademas, 2009), and decrease well-being (Aguiar, Vala, Correia, & Pereira, 2008). However, research suggests that in some situations, exposure to human suffering

can evoke prosocial thoughts, emotions, and behaviors motivated toward alleviating suffering (Goetz, Keltner, & Simon-Thomas, 2010; Schroeder, Dovidio, Sibicky, Matthews, & Allen, 1998; Zaki, 2014). This research seeks to better understand ways to reduce the negative effects of suffering caused by stress while simultaneously promoting prosocial factors such as empathy. Specifically, this research examines the effects of a widely used and often researched stress management technique called meditation, on promoting a more expansive sense of self that not only reduces stress but also invites prosociality. This selflessness (Dambrun, 2016; Dambrun & Ricard, 2011), is hypothesized here to be a mechanism underlying the link between meditation and its relationship to stress reduction and empathy.

The Stress Process

The stress process begins with a conscious or unconscious evaluation, or appraisal, of a potentially stressful situation (Lazarus, 1999; Lazarus & Folkman, 1984; Schneider, 2004, 2008). This appraisal is the meaning a person attaches to the stressor, which drives subsequent affective, physiological, and behavioral responses (Tomaka, Blascovich, Kibler, & Ernst, 1997). Following an appraisal, the autonomic nervous system (ANS) mobilizes energy resources needed to engage with the stressful situation (Johnson, Kamilaris, Chrousos, & Gold, 1992; Larsen, Berntson, Poehlman, Ito, & Cacioppo, 2008; Stern, Ray, & Quigley, 2001). Generally, the fast-acting sympathetic nervous system (SNS) predominates while engaging with a stressor, providing a shunting of oxygenated blood to the body to support action. The stress process terminates when

the person no longer appraises the situation as one requiring coping. At this point, the parasympathetic nervous system (PNS) predominates, providing a return to baseline levels of physiological activity (Larsen et al., 2008; Stern et al., 2001). Moreover, the stress process is dynamic and mutable. Stress outcomes change as the situation changes and when novel information from the environment is attended to and appraised. A stimulus that was once appraised as a threat may be reinterpreted or reappraised in a positive or benign light.

Stress and Negative Health Outcomes

Although activation of the stress process is essential for survival, repeated, extreme, or prolonged activation can result in negative outcomes for health and well-being. People exposed to chronic sources of stress, such as being of a lower socioeconomic status (Baum, Garofalo, & Yali, 1999), being a caregiver of a chronically ill person (Pinquart & Söensen, 2003), or those who are exposed to adverse work environments (Taylor, Repetti, & Seeman, 1997) experience higher rates of depression, cardiovascular disease, and report lower levels of quality of life. Chronic stress can also leave people feeling helpless in their ability to manage future stressful episodes (Alloy & Abramson, 1982). Moreover, research from animal studies suggests that acute psychosocial stressors can result in negative health outcomes – potentiating atherosclerosis, which impairs vascular flexibility (Kaplan, Manuck, Williams, & Strawn, 1996). The inability to physiologically recover from acute stressors is also a robust

predictor of negative health consequences, including cardiovascular disease and all-cause mortality (Thayer & Lane, 2007).

Antecedents of Positive Stress Outcomes

Stressor appraisals. Research has examined various antecedents that contribute to positive stress outcomes. Variability in stress outcomes can be captured by how people initially appraise potentially stressful situations. The transactional theory of stress and coping suggests that primary and secondary appraisals combine to initiate the stress process (Lazarus & Folkman, 1984; Lazarus, 1999). Primary appraisals arise from beliefs, values, and goals, and are evaluations of the personal relevance and/or demands of a situation. Initially, the theory suggested that people held *challenge* appraisals when encounters were evaluated as having potential for gain or mastery, but *threat* appraisals when stressors held the potential for harm. *Secondary* appraisals were evaluations of the resources (e.g., material, coping) available to manage stressor demands. The theory suggests that it is the interplay of primary and secondary appraisals that determines downstream biopsychosocial stress outcomes (Lazarus, 1999).

The biopsychosocial model of arousal regulation was developed from Lazarus' theory and examined the literal interplay of primary and secondary appraisals in response to situations that require active coping, or situations that are cognitively demanding and require effort (Blascovich & Tomaka, 1996; Obrist, 1981). This body of work conceptualizes challenge appraisals as manifesting when people appraise a potentially stressful situation as relevant to them (i.e., primary appraisals) and within their means to

cope (i.e., secondary appraisals: Schneider, 2004, 2008). This contrasts with threat appraisals where people appraise the situation as exceeding their ability to cope with the stressor demands. Within this theoretical framework, researchers examined the interaction of primary and secondary appraisals on stress outcomes (Tomaka, Blascovich, Kelsey, & Leitten, 1993). After learning about an impending mental arithmetic stressor, participants rated how threatening they thought the task would be (primary) and their ability to cope (secondary). Across experiments, the challenge group performed better in terms of generating more responses while making fewer errors than the threat group. Although both groups were physiologically mobilized, the challenge group had increased cardiac output (CO: amount of blood pumped over time) and decreased total peripheral resistance (TPR: peripheral receptivity of blood flow), demonstrating differential behavioral and psychophysiological response patterns for challenge and threat states.

The transactional theory of stress and coping also suggested that different appraisals evoke different emotional responses. Using a biopsychosocial approach, Schneider (2004) tested this postulate and found that participants who appraised an arithmetic stressor as a challenge experienced more positive and less negative affect than threatened participants, as well as replicated the challenge and threat hemodynamic patterns. A now robust body of research has demonstrated that challenge, relative to threat, drives a host of positive stress outcomes, including decreased subjective distress, increased positive affect, decreased negative affect, better task performance, better learning and transfer of learning to a novel task, and increased cardiac as oppose to

vascular reactivity (Baumgartner, Schneider, & Capiola, 2018; Gildea, Schneider, & Shebilske, 2007; Schneider, 2004, 2008; Schneider, Rivers, & Lyons, 2009; Tomaka et al., 1993; 1997).

This body of work suggests that challenge and threat appraisals result in a type of psychological and psychophysiological preparedness or orientation toward managing the demands of the stressful situation. Psychologically, people in a state of challenge believe they can overcome or even thrive in response to stress, resulting in increases in positive, approach-oriented emotions. Conversely, people in a state of threat tend toward withdrawal, resulting in increases in negative, avoidant-oriented emotions. Physiologically, challenge and threat appraisals differentially mobilize the autonomic nervous system (Tomaka et al., 1993, 1997) to facilitate an approach or avoidance orientation towards managing the demands of the stressful situation (Schneider, 2004; Schneider et al., 2009). Challenge and threat states both recruit SNS activation (Blascovich & Tomaka, 1996; Dienstbier, 1989). However, challenge states are characterized by greater amount of blood pumped out of the heart over time, coupled with decreased constriction of the heart muscles. In contrast, threat states are characterized by more moderate increases in cardiac output coupled with vasoconstriction (Kelsey, et al., 2000; Kelsey et al., 1998; Schneider, 2004, 2008; Schneider, Rench, Lyons, & Riffle, 2011; Tomaka et al., 1997). During a state of challenge, blood is shunted to the periphery to facilitate approach, whereas during a state of threat, is constrained more to the core relative to the muscles, denoting withdrawal or avoidance

(Schneider, 2004). This large and reliable body of research demonstrates that variability in affective, behavioral, and physiological stress outcomes depends largely on how people think about the situations in which they find themselves.

Emotion regulation. It is clear from stress and arousal regulation literature that affect is an important contributor to stress outcomes (see Lazarus, 1999; Schneider, 2004). Individual differences in the capacity to regulate emotions can influence stress outcomes. Emotion regulation is the process of altering the trajectory, experience, and expression of affective states, and depends largely on the ability to adjust appraisals and physiological arousal on a moment-to-moment basis (Gross, 1998, 2015). The process model of emotion regulation distinguishes between response-focused and antecedent-focused emotion regulation (Gross 1998). Emotions can be regulated before a situation arises, through antecedent-focused strategies, and during a situation via response-focused strategies (Gross, 1998, 2015). Antecedent-focused strategies modulate input into the emotion-generating system, whereas response-focused strategies modulate output of the system. More specifically, antecedent-focused strategies can alter the emotional trajectory by shifting attention or changing how one thinks about, or appraises, an emotion-generating event. Response-focused strategies alter an emotional response by changing the intensity or duration of the emotion (e.g., via re-appraisal). Disturbances in the ability to regulate emotions is linked to negative health and social outcomes, including anxiety and depression (Joormann & Gotlib, 2010), as well as an inability to respond appropriately to others (John & Gross, 2004).

The efficacy of emotion regulatory strategies has been investigated during potentially threatening or stressful situations. One study instructed participants to adopt a detached, third-person stance toward an amputation film or suppress their emotional responses entirely (Gross, 1998). Participants who were more detached experienced less sympathetic arousal in response to the disturbing film than participants instructed to suppress their emotional responses. Detachment, as an antecedent-focused emotion regulatory strategy, might also afford affective and physiological benefits when engaging with psychosocial stress. In another study, high trait reappraisers, or people who tend to re-evaluate their emotions as they unfold over time, reported less negative emotions, more positive emotions, and had greater challenge physiology (e.g., greater cardiac output and less total vascular resistance) when made angry during a laboratory stressor than their low trait reappraiser counterparts (Mauss, Cook Cheng, & Gross, 2007). Flexibility in emotion regulatory capacities appears to contribute to positive stress outcomes in terms of generating positive emotions and reducing psychophysiological arousal.

Other research suggests that response-focused strategies are useful in up- or down-regulating positive or negative affective states (Gross, 2015). Although positive affect is a component of the challenge response profile, it is commonly conceived that positive affect attenuates physiological arousal and promotes quicker recovery in response to provocation. Conversely, negative emotions are a component of the threat response profile, serving to heighten vigilance to sources of stress and consequently

arousing or even exacerbating psychophysiological arousal (Brosschot, Gerin, & Thayer, 2006; Fredrickson et al., 2000). In support of this, research suggests that initial negative emotions can be undone by the upregulation of positive emotions. In a study of bereaving older adults, the relationship between daily stress and negative affect was attenuated by an engagement of positive emotions (Ong, Bergeman, Bisconti, & Wallace, 2006). Taken together, these findings suggest that the capacity to regulate emotions on a moment-to-moment basis influences stress responding as it unfolds over time, with positive affect tending to facilitate benefits for the stress process and recovery.

Stress Management

Meditation. The psychological nature of the stress and emotion regulation processes provides an avenue for modulating stress responses. Indeed, this is the foundation for most stress management techniques. Meditation has received much attention for it presumed effectiveness in helping people manage stress (Grossman, Niemann, Schmidt, & Walach, 2004; Sedlmeier et al., 2012). Meditation is broad category of mental training practices that involves intentional and sustained attention to ongoing sensory, cognitive, and emotional experience. Meditative practices are predominately drawn from the Buddhist tradition that emphasizes a soteriological or spiritual path for alleviating suffering and promoting well-being (Lutz, Jha, Dunne, & Saron, 2015). Some forms of meditation such as mindfulness meditation emphasize an impartialness and non-judgmental attitude toward phenomenological experiences (Desbordes et al., 2015; Kabat-Zinn, 1982, 1990). With mindfulness meditation, one is

vigilant of mind wandering and learns to bring the attention back to its focal point. Other forms of meditation such as loving kindness and compassion meditation aim to cultivate unconditional positive emotions such as love and warmth toward oneself and others (Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008; Hoffman, Grossman, & Hinton, 2011). In Vedic or transcendental meditation, the practitioner focuses on a repeated word or phrase (i.e., a "mantra") to induce a state of relaxation.

In the scientific and medical communities, research typically focuses on outcomes associated with mindfulness-based stress reduction (MBSR: Kabat-zinn, 1990, 1994) and its varieties. MBSR is a structuralized, group-based intervention consisting of mindfulness meditation, yoga, and dialogue with the goal of integrating mindfulness into everyday life. Although disparate in some regards, there is usually considerable overlap in the underlying ethics and focus between practices. In a contemporary context, the use of meditation in managing stress is widespread, including use in inter-city communities (Roth & Stanley, 2002), correctional facilities (Samuelson, Carmody, Kabat-Zinn, & Bratt, 2007), higher education (Baumgartner & Schneider, 2017), and the military (Stanley, Schaldach, Kiyonaga, & Jha, 2011). However, there appears to be a dose-response relationship between meditation and various psychological outcomes, such that the extent of cognitive, emotional, and physiological changes evoked by meditation is correlated with the amount of time one engages with meditation (Jha, Morrison, Parker, & Stanley, 2016; Lazar et al., 2005).

Meditation and Stress

Stressor appraisals. Meditation may exert its influence on the stress process through its influence on appraisals. College students who scored high on a trait mindfulness scale reported less threat appraisals, as indicated by a single-item measurement of perceived stress, and less use of avoidant coping strategies in anticipation of course examinations (Weinstein, Brown, & Ryan, 2009). In the same study, the relationship between mindfulness and well-being was fully mediated by perceptions of less threat, suggesting that mindfulness may gear individuals toward perceiving stressors as less threatening, which influences coping options and well-being. Another study randomized first-year college students to MBSR, a time and attention-matched control group, or a wait-list control group (Baumgartner & Schneider, 2017). Pre- and post-intervention, students reported the extent to which they appraised their academic-related stress on a continuum from challenge to threat, as in the tradition of the stress and arousal regulation literature. Participants also rated their persistence in achieving their academic-related goals, and semester grade-point average (GPA) was obtained. Relative to the other groups, the MBSR group appraised their academic-related stress as more challenging as oppose to threatening, were more persistent in achieving their academic-related goals, and had a higher semester GPA. These studies suggest that mindfulness and meditation training are associated with less threat and facilitate coping options that are approach-oriented.

Emotion regulation. Meditation training may instill the capacity to better modify and regulate emotional experiences. Some forms of meditation can be thought of as increasing the awareness and acceptance of emotions regardless of their valence

(Chambers, Gullone, & Allen, 2009; Desbordes et al., 2015), and as increasing the ability to alter the emotion generation and response systems. Such flexibility in regulatory capabilities allows meditators to experience their emotions without avoiding them (Weinstein et al., 2009), intensifying them (Carlson, Speca, Faris, Patel, 2007), or overly focusing on or ruminating about them (Jain et al., 2007). Meditation training has been shown to facilitate the upregulation of positive emotional stimuli, while decreasing reactivity to emotionally threatening stimuli. A brief mindfulness intervention compared to a time and attention-matched control group evoked more positive affect in response to an amusing film and less negative affect in response to an affectively mixed film (Erisman & Roemer, 2010). In another study, patients with social anxiety disorder underwent MBSR and then reported psychiatric symptoms, self-esteem, and engaged with a task that included negative self-referential statements (Goldin & Gross, 2010). Although no comparison group was used, MBSR was related to improvements in anxiety and depression symptoms, self-esteem, and decreased emotional reactivity to negative self-referential statements. Although these findings were predominately conducted with otherwise novice meditators who engaged with a meditation program, these findings suggest that meditation training increases positive emotional experiences and reduces reactivity to negative emotional experiences. More research is needed on the effects of more advanced levels of meditation practice on modulating the stress process.

Empathy

People may perceive themselves as independent, autonomous entities, but our affective (and other) states are intimately linked with other people. Everyone experiences personal distress, and there is great potential that people experience distress when witnessing others in distress (Engert, Plessow, Miller, Kirschbaum, & Singer, 2014). Understanding the affective states of others is called empathy. Empathy is a multidimensional construct that is characterized by a cognitive capacity to take on the perspective of another person, an affective response to another person that can entail sharing emotional states, and other regulatory mechanisms that facilitate self-other overlap (Decety & Jackson, 2004; Ickes, 1997). At a phenomenological level, empathy reflects the process of accurately identifying and understanding the internal states of others (Zaki, 2014; Zaki & Ochsner, 2012), and taking on that internal state as one's own (Hatfield, Cacioppo, & Rapson, 1994). Failing to understand the thoughts and feelings of others can be costly. Deficits in mental state recognition is a core feature of autism spectrum disorders (Baron-Cohen et al., 1995), and is a main contributor to impairments in social interactions (Hill & Frith, 2003). Importantly, the ability to accurately perceive and engage in prosocial behaviors to mitigate suffering depends largely on empathy (Batson, 1991a; Batson 1991b; Batson, 2011).

Empathetic accuracy. Empathy is multifaceted, and one of the key processes of empathy that transects definitions is the ability to accurately detect the emotional states of another person. This intersubjective phenomenon has been termed empathetic accuracy (Ickes, 1997; Ickes, Stinson, Bissonnette, & Garcia, 1990; Levenson & Ruef, 1992).

Empathetic accuracy depends on personal self-awareness to accurately discern the positive and negative experiences of another entity. Research suggests that situational factors can strengthen the ability to be empathetically accurate. Individuals who have a higher need for social inclusion and belongingness are better able to detect differences in emotional facial expressions and vocal tones (Pickett, Gardner, & Knowles, 2004). Other research video recorded married couples as they attempted to resolve a problem in their relationship (Simpson, Orina, & Ickes, 2003). Each partner watched the recording and rated the thoughts and feelings they had at different timepoints during the exchange. Empathetic accuracy was strengthened by the extent to which partners perceived the other's thoughts and feelings as nonthreatening. A different study also used mixed-sex dyads as participants and found that trait empathy predicted empathetic accuracy only for emotionally expressive targets, or individuals who were clearly expressing their felt emotions (Zaki, Bolger, & Ochsner, 2008). It appears that much of the variance in empathetic accuracy depends on the need for interpersonal closeness, feeling the interpersonal exchange as hospitable and less hostile, and the ability to discern subtle affective details in interpersonal exchanges.

Meditation and empathy. A fundamental goal of most meditative practices is to cultivate prosocial mental qualities, such as empathy (The Dalai Lama, 1995; Wallace, 2001b). There is research to support the claim. Compared to a wait-list control group, a modified 7-week MBSR intervention consisting of mindfulness, loving kindness, and forgiveness meditation increased reports of empathy in distressed premedical and medical

students (Shapiro, Schwartz, & Bonner, 1998). Another study found that compared to a health-discussion active control group, eight weeks of compassion meditation training improved performance on a theory of mind task that measured empathetic accuracy (Mascaro, Rilling, Negi, & Raison, 2013). Lastly, participants who listened to a brief 10-minute mindfulness recording, performed better on a test of empathic accuracy and had higher levels of compassion in handwritten notes to another person, compared with those who were instructed to immerse themselves in their thoughts and emotions (Tan, Lo, & Macrae, 2014). It appears that meditation training intensifies the degree to which people believe they are empathetic, and facilitates actual processes and behavior supported by empathy.

The Self

There is much research to suggest that meditation impacts personal stress responses, and its impact extends outward to influence interpersonal processes like empathy. However, the pathways through which meditation achieves both are lesser known, underscoring the need for a mechanistic evaluation of meditation practice. One way that meditation might alleviate stress is through its impact on attachment and identification with the self, which may also have implications for empathetic processes. For centuries, the self has been an important topic of interest to philosophers and psychologists alike (Allport, 1943; Baumeister, 1987; Greenwald, 1980; James, 1890/1950; Schlenker, 1980; Ziller, 1973). In Western psychological and philosophical traditions, people are thought to view the world via first-person subjectivity. That is, the

self is that which has thoughts and experience emotions. There is a sense of agency and ownership of thoughts, emotions, and even a spatial standpoint of one's body. As a result, an aggregate psychological entity encompasses what is known as "I," "me," "mine," and "myself," and no identity exists independent of these modalities. This perspective becomes the focal point to which the self is formed, affecting the ways in which people experience themselves, others, the environment, and is ultimately the foundation for the overall narrative of the individual.

There is a wealth of evidence showing that self-referential processes influence psychological functioning. Self-construal leads people to seek information that supports their self-esteem (Ditto & Lopez, 1993). Societies that promote self-constructions based on individualism have members who more often experience emotions such as pride and superiority compared to those in collectivistic societies (Kitayama, Markus, & Kurokawa, 2000). Self-construal has also been manipulated to ascertain directionality of its effect on behavior. Participants whose self-construal was manipulated to be "charitable" gave more to charity compared to participants in a control condition (Kraut, 1973). There are reasons to suggest that self-construal is influenced by meditation.

Emptiness. Buddhist philosophy about the self is largely divergent from Western science and philosophy. Much of Buddhist teachings are realized through contemplative introspection, which adopt a dynamic process orientation of all occurrences in the universe. These teachings emphasize that everything in the universe, including people, is in constant flux, change, transformation, and is therefore intimately connected. The

universe itself is described as impermanent, with material and non-material conditions arising and passing depending on other conditions that support their existence. The overarching focus is that entities do not exist independently. Instead, entities are considered "empty" of inherent essence or substance (Nhat Hanh, 1999). This emptiness can manifest in the phenomenological experience of the self. According to most Buddhist traditions, the self is illusory (Olendzki, 2011). The conventional language of the human cognitive and social systems creates the construct of the self out of convenience, although a self does not materially exist. Buddhist psychology views the person, the self, and all phenomena as an intersection of multiple relationships, interconnected and interdependent.

Selflessness. Buddhism posits that attachment generally, and to the self specifically, is the source of human suffering (Dalai Lama & Tutu, 2016). A central tenant is that unhealthy mental states manifest because of attachment – one becomes fixated on the attainment of objects and experiences that one believes will enhance well-being. In contrast, non-attachment to the self is thought to enable self-authenticity and psychological flourishing (Dalai Lama, & Cutler, 1998; Dambrun, 2016; Dambrun & Ricard, 2011; Sahdra, Ciarrochi, Parker, Marshall, & Heaven, 2015). This non-attachment to the self, or selflessness, is the awareness and acceptance that the self is an expansive entity, fundamentally interconnected with others and the environment (Dambrun & Ricard, 2011; Shiah, 2016). With true selflessness, the sense of boundaries between the self and other entities and phenomena are diminished and become

imperceptible (Berkovich-Ohana, Dor-Ziderman, Glicksohn, & Goldstein, 2013; Dambrun, 2016). There is a phenomenological reduction of self-referential mental processes and de-identification from these processes. Furthermore, it is thought that selflessness facilitates the experience of benevolent emotions, such as sympathy, joy, happiness, harmony, and compassion, because well-being is no longer driven by egocentricity (Dambrun & Richard, 2011). Thus, a sense of contentment and mental balance predominates. Ultimately, selflessness emerges when the self is phenomenologically experienced as an interconnected, transient event, rather than an independent focal point with reference to all aspects of psychological functioning.

Self-centeredness. At the opposing end of the selflessness continuum is self-centeredness, or the experience that one is fundamentally separate from others and entities of the world. Whereas with selflessness the self is diffuse, with self-centeredness the self is a solid, independent entity. Self-centered people consider their own condition as more important than that of others. As a result, self-centeredness involves attachment and hedonistic pursuits, such as the approach of gratifying states and avoidance of aversive states (Danbrun, 2016; Danbrun & Ricard, 2011). The distinction between selflessness and self-centeredness is thought to be malleable (Danbrun & Richard, 2011). People who are characteristically more self-centered can develop selfless tendencies over time. Although it may be unrealistic to promote a complete abolishment of self, as in true selflessness or emptiness, the present research examines the influence of meditation

experience on selflessness, as defined by a broad sense of connectedness, coupled with feelings of boundlessness.

Selflessness and Meditation

Meditation training is thought to shape selfless processes and a dominate tendency toward selflessness over time. There are two largely interdependent psychological processes facilitated by meditation that may account for the development of selflessness. The first is meta-awareness, which involves monitoring of experience and the redirection of attentional resources as needed (Chambers et al., 2009; Lutz et al., 2015). For example, during mindfulness meditation, one might realize that the mind has wandered, and then direct attention back to breath sensation. The other process is dereification, which reflects the degree to which perceptions, cognitions, and emotions are phenomenologically interpreted as mental events rather than accurate depictions of reality (Chambers et al., 2009; Lutz et al, 2015). Through meta-awareness and dereificiation, experienced meditators come to understand that mental events are constantly changing. Overtime, they adopt this schema into their sense of self (Brown & Ryan, 2003; Hölzel et al., 2011; Olendzki, 2006).

States of consciousness achieved through meditation have been shown to impact self-referential processing and expand the sense of self. For example, neuroimaging studies have demonstrated that brain structures supporting a detached sense of self are structurally and functionally impacted by meditation (Farb et al., 2007). Meditation has also been linked to an attenuation of beta-band activity in the right inferior parietal lobe

(Dor-Ziderman, Berkovich-Ohana, Glicksohn, & Goldstein, 2013), which is a region of the brain involved in the conscious experience of the narrative self, or a self as an 'I' (Ionta et al., 2011). In a qualitative analysis of diaries, researchers found that meditation training facilitated an "observing self," or a self characterized by less identification with the contents of experience (Kerr, Josyula, & Littenberg, 2011). Other research shows that meditation develops a flexible sense of self boundaries. Compared to a resting control group, participants who engaged with a brief body-scan meditation reported a decreased saliency of body boundaries (Danbrun, 2016). In a neurophenomenological study, experienced mindfulness meditators were instructed to voluntarily bring about states of 'timelessness,' or being outside of time, and 'spacelessness,' or being outside space, while brain activity was recorded (Berkovich-Ohana et al., 2013). Meditators reported less body awareness during the induction, which correlated with alterations in brain regions associated with bodily experience, such as the posterior cingulate, right temporoparietal junction, and cerebellum (Damasio, 1999). Finally, a qualitative investigation found that a long-term practitioner of mindfulness meditation ("S") with over 20,000 hours of practice could shift on demand between three distinct stages of consciousness (Ataria, Dor-Ziderman, Berkovich-Ohana, 2015). In the default stage, S shifted from sensing the self as independent from the rest of the world to sensing the self in relation to the world. S reported feeling located in 'a body,' but not within his own body. In the second stage, S described dissolving body boundaries, such that his body boundaries were more diffuse and spacious. In the final stage, S reported an expansion of

self, followed by a complete dissolution of self. Meditation, and particularly high levels of meditation experience, appears to expand the sense of self in fundamental ways.

Selflessness and Stress Processing

Research suggests that the way people relate to the self translates into how people relate to potential stressors. Classic social psychological theories of the self, including self-affirmation theory (Steele, 1988) and cognitive adaptation theory (Taylor, 1983), posit that affirmation or enhancement of the self can buffer against threatening events. Greater self-esteem instability predicts threat in response to stressors, as indicated by lower cardiac output and higher total peripheral resistance (a threat response pattern), whereas greater self-esteem stability predicts challenge, indicated by higher cardiac output and lower total peripheral resistance (Seery, Blascovich, Weisbuch, & Vick, 2004). Thus, it appears that self-referential processing operates before the appraisal process unfolds, driving downstream stress responses. Despite showing that self-referential processing affects stress outcomes, research has not examined whether broader, less self-centered processing promotes positive stress outcomes.

Selflessness and appraisals. Selflessness has been theoretically related with an approach orientation toward all aspects of sensory and affective experience. The boundaries between the self and environmental input that account for these experiences become illusory (Dambrun & Ricard, 2011). Conversely, self-centeredness has been equated with hedonistic pursuits – approaching stimuli that are gratifying for the self and avoiding those that could bring discomfort. It is plausible then that a more expansive self-

structure affords an approach orientation toward potentially stressful situations, whereas more self-centeredness self fosters avoidance. As with selflessness, a challenge state is associated with an approach orientation, whereas threat is associated with avoidance (Schneider, 2004; Schneider et al., 2009). It is therefore theoretically plausible that selflessness may be a pathway toward appraising stimuli within the environment as less threatening and consequently more challenging.

From a social psychological perspective, research has shown that an expanded sense of self weakens ego-investment or egotistic appraisals and increases personal distance from stressors. Processing stress in the normal sense implies ego investment. The individual is engaged with the stressful episode as it relates to the self. Conversely, personal distance is negatively correlated with emotional intensity (Van Boven, Kane, McGraw, & Dale, 2010), as the emotion is no longer attached to a reference point. In turn, an expanded self may foster greater mental flexibility in appraising potentially stressful situations, leading to less threat and avoidance. Past research has shown that adopting a self-distanced perspective reduces the intensity of negative affective states such as anger and sadness more than a self-immersed perspective (Katzir & Eyal, 2013), which is more self-centered. In the clinical domain, a study asked people with posttraumatic stress disorder (PTSD) to recall the traumatic event that led to their condition from either a field or an observer vantage point (McIsaac & Eich, 2004). From a field vantage point, participants recalled the event from their own eyes, whereas from an observer vantage point, participants recalled the event from the perspective of a

detached spectator. Adopting a detached perspective, or one that was separated from the self, attenuated emotional intensity and anxiety more than adopting a field perspective. It is possible that the diminishment of momentary self-concept reduces egotistic appraisal and particularly those that signal threat.

Selflessness and emotion regulation. Activating real or imagined feelings of connectedness, a fundamental aspect of selflessness, may be beneficial for the generation of positive affective states. Participants who imagined an attachment figure such as a supportive person relative to a neutral figure reported increased positive affect and displayed reduced physiological reactivity in response to a passive coping task (Bryant & Chan, 2015). A meta-analysis showed that individual differences in cognitive, affective, and experiential connectedness with nature is related to increased positive affect, vitality, and life satisfaction (Capaldi, Dopko, & Zelenski, 2014). Of concern to the present investigation, associations were strongest for the inclusion of nature in the self and reported happiness. It is possible that a self-structure that invites connectedness toward others and the environment facilitates comfort and ease while engaging with stress.

Selflessness, Empathy, and Empathic Accuracy

Selflessness, as with empathy, is inherently intersubjective (Thompson, 2009). Selfless people perceive the self and other as inseparable entities. Experiencing empathy for others implies a degree of self-other overlap and weakened self-focused psychological processing. Evidence from both social psychological research on the dynamic self and research on close relationships support the hypothesis that self expansion facilitates

empathy. In a series of studies using a social exclusion manipulation, non-excluded participants reliably underestimated the severity of social pain (e.g., feelings of ostracism, shame, and guilt) in others compared with excluded participants, who were more accurate in their estimates (Nordgren, Banas, & MacDonald, 2011). This suggests that a shared experience of an affective state facilitates an understanding of that state in others. Another study found that non-attachment, defined as a flexible way of relating to experience without clinging on to or suppressing any aspect of that experience, predicts peer-evaluations of prosocial behavior (Sahdra et al., 2015). As with selflessness, nonattachment to the self may increase similar prosocial outcomes.

Other research suggests that greater perceived or actual boundaries between the self and other impedes empathetic responding. Research suggests that self-reported empathy has a stronger effect on helping intentions when the helper and the target belong to the same cultural group than to different cultural groups (Stürmer, Snyder, & Kropp, 2006). Another study examined soccer fans who witnessed a fan of their favorite team or of a rival team experience pain, and then were given the opportunity to engage in helping behavior (Hein, Silani, Preuschoff, Batson, & Singer, 2010). Participants were more likely to help an ingroup member (i.e., favorite team) than an outgroup member (i.e., rival team), which resulted in higher reports of empathetic concern and greater activation of the anterior insula, a brain area associated with empathy. This effect was mediated by the degree of perceived similarity among ingroup members. Moreover, research has shown that an interdependent self, or a self-construal defined by interconnectedness with others,

influences empathetic behavior. Participants primed with an interdependent self sat closer to a stranger in a waiting area than participants primed with a dependent self, or a self that is bounded and independent from others (Holland, Roeder, van Baaren, Brandt, & Hannover, 2004). These findings suggest that self-other closeness may be one mechanism that underlies empathetic responding. Selflessness, a construct defined partially by a broad sense of connectedness, might be an important component of empathetic processes.

Purpose and hypotheses

Integrating across diverse literatures, the purpose of the present research was twofold: 1) to examine the influence of meditation experience on stress responses, empathy, and selflessness, and 2) to examine selflessness as a pathway through which meditation influences stress responses and empathy. Figure 1 illustrates hypothesized pathways. It was hypothesized that greater meditation experience would relate to positive stress outcomes (Hypothesis 1a-e: greater challenge stressor appraisals, more positive affect, less negative affect, better performance, and challenge psychophysiology: greater cardiac output coupled with reduced total peripheral resistance), greater empathy (Hypothesis 2a-b: trait empathy and empathetic accuracy), and greater selflessness (Hypothesis 3). From these relationships, various mediation models were hypothesized. The first model proposed that the link between meditation experience and challenge stressor appraisals would be mediated by greater selflessness (Hypothesis 4). The second model proposed that the link between meditation experience and greater positive affect in

response to stress would be mediated by greater selflessness (Hypothesis 5).[1] The next set of hypothesized mediation models concerned trait empathy and empathic accuracy. It was hypothesized that the link between meditation experience and trait empathy would be mediated by greater selflessness (Hypothesis 6). Lastly, the relationship between meditation experience and empathic accuracy would be mediated by greater selflessness (Hypothesis 7).

[1] A hypothesis specifying an indirect effect of meditation on performance and psychophysiology via selflessness was not proposed due to a relative lack of theoretical and empirical evidence for such a link. Instead, the focus was on appraisals and positive affect.

II. METHOD

Power Analysis

A power analysis was computed to determine the minimum required sample size using the following parameters: Cohen's F = .25 for a medium effect, α = .05, and power = .80. With this guidance and that of similarly designed studies (e.g., Baer, Lykins, & Peters, 2012; Baer, Samuel, & Lykins, 2011), 109 participants were determined to be needed to have sufficient power for detecting the hypothesized effects.

Participants

Overall sample. Participants (N = 110, age: M = 31.64, SD = 14.04, 50% female) were 55 adults who self-identified as having a current meditation practice and 55 adults who have never meditated, but reported an interest in meditation. People interested in meditation but were otherwise nonmeditators were recruited to control for demand-characteristics in expectancies of meditation benefits. Of those that reported their ethnicity, the majority (n = 68, 61.8%) were Caucasian, followed by Asian or Pacific Islander (n = 25, 22.7%), African American (n = 11, 10%), American Indian or Alaskan Native (n = 2, 1.8%), Hispanic (n = 2, 1.8%), and other (n = 2, 1.8%). Education was widespread. 29.1% (n = 32) received some college education or have earned a Bachelor's degree, followed by a Master's degree (n = 19, 17.3%), Associate's degree (n = 11, 10%), high school diploma or the equivalent (n = 5, 4.5%), or a medical or doctorate degree (n = 4, 3.6%). A large majority (n = 94, 86.2%) had an annual income between $20,000-$75,000. Demographic

characteristics of the meditating and non-meditating samples are shown in Table 1. Group differences in demographic characteristics were discerned using dependent samples *t*-tests for continuous variables and chi-square analyses for categorical variables. Only age differed among meditators (M = 35.04, SD = 15.95), and non-meditators (M = 28.31, SD = 11.04), $t(107) = 2.57$, $p = .012$, as was therefore used as a covariate. Recruitment took place at local Sanghas and yoga groups, as well as online advertisements, online listservs, and posted flyers around the community and university setting. The study was advertised with the title "Information Processing Study" to blind potential participants to the purpose of the study.

Meditating sample. Concerning the meditating sample, most (69%) reported meditating 3-7 times a week (M = 4.00, SD = 2.29). A large majority (73%) report meditation sessions lasting 10-30 minutes (M = 23.85, SD = 20.42). Mean duration of meditation practice in years was 7.58 (SD = 9.55). Mean lifetime hours of meditation practice was 962.20 (SD = 1658.82). A moderate percentage (N = 11, 20%) report having been on a meditation retreat in the past 2 years, lasting on average 916.36 total minutes (SD = 1730.48) or 15.27 hours spent in meditation. Thus, the current sample was representative of, and in some cases, exceeded the level of meditation experience reported in other similarly conducted studies (Baer et al., 2012; Rosenkranz et al., 2016).

The types of meditation practiced were diverse with a large majority of participants (78.2%) report practicing mindfulness meditation, followed by loving kindness meditation (32.7%), compassion meditation (18.2%), transcendental meditation (18.2%), and other

(10.9%). Lastly, 18% (n = 10) report being of the Zen Buddhist tradition or were not sure (n = 25, 45.5%), and referenced self-improvement (n = 11, 20%) as the main motivation of their meditation practice, followed by wellness (n = 6, 10.9%), enlightenment (n = 5, 9.1%), and self or spiritual transcendence (n = 4, 7.3%).

Setting

Participants were run individually in an electrically shielded and soundproof experimental room equipped with a computer monitor, physiology equipment, an armchair, an unobtrusive video camera, a video monitor, audio speakers, and an intercom system for communication and monitoring. Adjacent to the experimental room was a control room where experimenters monitored participants and controlled experimental procedures.

Measures

Recruitment. A recruitment survey was distributed to all potential participants who expressed interest in the study (see Appendix A). The survey inquired meditation interest and experience, as well as demographic information. Participants who identified as a current meditator reported daily minutes of meditation practice, frequency per week, number of years, and lifetime hours of practice (Baer et al., 2012). The survey also inquired meditation retreat experience in terms of last attended, meditation retreat and total retreat time. Other meditation-related questions included meditation tradition and meditation motivation (Khalsa et al., 2008; Zanesco et al., 2013). Demographic information included age, sex, ethnicity, education, and income. Participants over the age of 18 were eligible, as

were participants with normal to corrected to normal vision, without current or a family history of cardiovascular disease, and women who were not pregnant.

Meditation experience. Meditation experience variables (minutes daily, times a week, years, and lifetime hours) were highly intercorrelated (see Table 2). Therefore, a standardized meditation experience variable was created from *z*-scores of each variable, and then the average of those z-scores. The following equation was computed from standardized averages to represent meditation experience:

$$\text{Meditation experience} = (z\text{Daily} + z\text{Week} + z\text{Years} + z\text{LifetimeHours})$$

where higher scores denoted greater experience.

State affect. The Positive and Negative Affect Scale (PANAS: Watson, Clark, & Tellegen, 1988) obtained reports of state affect. Twenty items were rated on a 5-point scale ranging from 1 = *slightly or not at all* to 5 = *extremely* regarding current feelings. The ten positive items were attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong, and active. The ten negative items were distressed, upset, hostile, irritable, scared, afraid, ashamed, guilty, nervous, and jittery. Affect scores were calculated by averaging items into a composite score for positive and negative affect. Internal consistency for the PANAS and all other self-report instruments are displayed in Table 4.

Empathy. The Interpersonal Reactivity Index (IRI: Davis, 1983) is a multidimensional measurement of empathy. Various subscales capture the

multidimensional nature of empathy. The personal distress (PD) subscale measured feelings of personal unease and discomfort in reaction to tense interpersonal situations. The empathic concern (EC) subscale measured the tendency to experience feelings of sympathy, compassion, and concern for others. The perspective taking (PT) subscale measured the tendency to adopt the psychological viewpoint of others. The fantasy subscale is not relevant to the present investigation, and was therefore not used. Twenty-eight items were rated on a 5-point scale ranging from 1 = *does not describe me well* to 5 = *describes me very well*. A PD item is, "When I see someone who badly needs help in an emergency, I go to pieces." An EC item is, "I often have tender, concerned feelings for people less fortunate than me." A PT item is, "I try to look at everybody's side of a disagreement before I make a decision." Scores were calculated by averaging all items into a composite score. Subscale scores were calculated by averaging PD, EC, and PT items into a composite score.

Selflessness. Selflessness was assessed on a continuum using a modified version of the Inclusion of Other in the Self Scale (IOS) to represent a broad sense of interconnectedness, and the Visual Analog of Body Boundaries (VAS) to represent sense of boundaries from others. Instructions were tailored for timepoint of use.

Inclusion of Other in the Self Scale **(IOS).** The IOS is a widely-adopted and single-item, pictorial measure of the degree to which the self is included in a close relationship (Aron, Aron, & Smollan, 1992). The IOS measures perceived closeness in

terms of sharing the characteristics of another entity. Seven Venn Diagrams with degrees of overlapping circles representing the self and a referent are presented (see Appendix B). Nine self-other referents were used to capture the expansive nature of selflessness: "strangers," "friends," "family", "community", "humanity", "other beings", "the environment", "the world," and "the universe." Participants were instructed to consider each referent and select the circles that best represent how close they feel toward that referent at baseline and retrospectively post-stressor and empathetic accuracy task. Items are scored from 1 (no overlap) to 7 (almost complete overlap). For each timepoint, items were averaged into a single composite score.

Visual Analog of Body Boundaries (VAS). The VAS depicts seven human bodies with an outline to represent sense of body boundaries. These body boundaries vary from almost imperceptible (light and disconnected line) to extremely salient (bolded and connected line: see Appendix C). As with the IOS, participants rated their sense of body boundaries at baseline, and retrospectively after engaging with the stressor and empathetic accuracy task. Scores ranged from 0.0 to 15.5, with higher scores indicating higher salience in perceived body boundaries, and lower scores reflecting less salience in perceived body boundaries, and thus greater selflessness.

Selflessness variable. For ease of interpretation and use in regression analyses, a standardized selflessness variable was created from averaged IOS and VAS scales at each timepoint. We proceeded with standardization procedures based on high correlations

among IOS and VAS scales across timepoints (see Table 3). IOS and VAS scales were assembled into *z*-scores and then averaged. The following equation was computed from standardized averages to represent selflessness:

$$\text{Selflessness} = z\text{IOS} + (z\text{VAS} * -1)$$

where *z*VAS was multiplied by -1 to create higher scores that represent less body boundaries.

Stressor appraisals. The Stressor Appraisals Scale (SAS: Schneider, 2008) obtained reports of anticipatory stressor appraisals. Participants rated how threatening they believed the stressor would be and how able they can cope with the stressor demands. Ten items were rated on a 5-point scale ranging from 1 = *not at all* to 5 = *extremely* regarding appraisals of the upcoming task. A primary appraisal item is, "How stressful do you expect the task to be?" A secondary appraisal item is, "How well do you think you can manage the demands imposed on you by your classes?" Appraisals were determined by averaging primary and secondary appraisals scores into composite scores, and then computing a ratio of primary to secondary composites. Lower scores denoted challenge appraisals, while higher scores denoted threat appraisals.

Collectivism. The selflessness/self-centeredness continuum differs from the conceptually related continuum of collectivism/individualism (Markus & Kitayama, 1991). Collectivists convene of the self as parts or aspects of a group. Consequently, their relationships with others are of highest value (Singelis, Triandis, Bhawuk, & Gelfand,

1995). Although conceptually related, the selflessness/self-centeredness continuum differs from collectivism in that selflessness encompasses a broader, more expansive self structure that encapsulate all the elements of others and the environment as reference points. Considering their conceptual overlap, the collectivism subscale of the Individualism/Collectivism Scale (ICS: Singelis et al., 1995) controlled for the potential influence of collectivism on selflessness, independent of meditation.

The collectivism subscale of the ICS is divided into a horizontal collectivism (HC) and vertical collectivism (VC), each consisting of 8-items. HC includes perceiving the self a part of the collective, yet seeing all members of the collective as the same, whereas VC includes perceiving the self as a part of a collective, yet accepting inequality within the collective. The HC subscale was used in the present investigation and will be discussed solely for this purpose. Participants rated their agreement with each HC item using a 9-point scale ranging from 1 = *never or definitively no* and 9 = *always or definitely yes*. A sample item is, "It is important to maintain harmony within my group." Scores were calculated by summing items into a composite score.

Experimental Tasks

Psychosocial stressor. The stressor was a two-minute vocal mental arithmetic task. After a five-minute physiological baseline, participants were instructed to subtract aloud by increments of 7 from a 4-digit number for two minutes. Speed and accuracy were emphasized. The following instructions were provided over microphone:

> For the next part of the experiment I would like you to perform a vocal mental arithmetic task consisting of rapid serial subtractions by steps of seven. Your task is to count backwards out loud by sevens starting from a four-digit number. For example, starting with the number 1000 and counting backward out loud by seven would go something like this, "1000, 993, 986, 979, 972, 965, and so on. I would like you to perform this task as quickly and as accurately as you can for several minutes. Do you have any questions?

Responses were ostensibly video recorded to evoke socio-evaluative threat (Kelsey et al., 2000). After two-minutes, participants were instructed to stop and wait for future instructions, constituting a two-minute recovery period. This active coping task engages cardiovascular physiology in much the same way that a physical task would (Obrist, 1981), and has been validated for use as a psychophysiological stressor (Kelsey, 1991; Kelsey et al., 1998, 2000) and for engaging challenge and threat states (see Blascovich & Tomaka, 1996). Physiological stress responses were recorded continuously. Task performance was assessed by counting the total number of responses provided and the number of errors. Percentage correct was calculated from these values.

Autonomic measurement. Autonomic signals were recorded and digitized using AcqKnowledge 4.3 data acquisition system (Biopac Systems, Goleta, CA) at a sampling rate of 1,000 Hz. An impedance cardiograph (ZKG: Model HIC-2000, Instrumentation for Medicine) and continuous blood pressure monitor (Model 7000, Colin blood pressure monitor) collected autonomic signals. The impedance cardiograph utilizes an alternating current, passed through two outer electrodes, while two inner recording electrodes measure the surface potential (proportional to impedance) across the thoracic cylinder. The impedance permits the recording of changes in the velocity of blood flow into the thorax,

and particularly those associated with the ejection of blood flow into the aorta (Stern et al., 2001). Tetrapolar aluminum-mylar tape band electrodes were used (Sherwood et al., 1990). A blood pressure cuff was placed over the brachial artery of the non-dominant arm to obtain heart rate, systolic (SBP) and diastolic blood (DBP) pressure. The cuff applies a non-occlusive pressure (20 mm Hg), allowing the continuous assessment of SBP and DBP, and mean arterial pressure on each cardiac cycle. Data were collected according to published standards (Sherwood et al., 1990), which have been adopted widely.

Autonomic data reduction. Physiological raw data was processed using Mindware (Mindware Technologies, Gahanna, OH) custom interactive software and inspected visually for artifacts, such as sneezes or other acute movements. Data for each participant was inspected to ensure the peaks of the R-waves are correctly marked for ensemble averaging. Those that appeared incorrectly marked were corrected within the software, and R-peaks were inserted when necessary. The cleaned signals were computed into parameters for subsequent analyses

Autonomic parameters. The baseline impedance between the recording electrodes (Z0) and the rate of change in impedance on a given beat (dZ/dt) derived measures of cardiac performance (Sherwood et al., 1990). By combining these signals with electrocardiogram (EKG) signals, stroke volume (SV: the volume of the blood pumped out of the left ventricle on each heart beat), cardiac output (CO: the amount of blood pumped out of the heart over time), and pre-ejection period (PEP: a systolic time interval representing the contractility of the heart) are estimated. CO is calculated by multiplying

heart rate (HR: the number of times the heart beats over time) by SV. CO is combined with mean arterial blood pressure to estimate total peripheral resistance (TPR: resistance of the peripheral vasculature). CO and TPR are derived to distinguish challenge and threat motivational states (Blascovich & Tomaka, 1996; Schneider, 2004, 2008). SBP, DBP, and HR are monitored with a continuous blood pressure monitor, and inputted into the interactive software. The arithmetic mean of each epoch was used to discern autonomic parameters. The two minutes of task performance was reflected in six, 20-sec. time periods. Each 20-sec. time period was ensemble averaged, then two time periods were averaged to create scores for each task minute for each autonomic parameter. Reactivity scores were obtained by subtracting the last minute of baseline activity from the first task minute of activity.

Challenge physiology variable. A continuous challenge physiology variable was created for use in a regression framework. To account for the interdependence of the hemodynamic measures, *z*-scores were computed for CO and TPR reactivity values, then the inverse of zTPR was calculated so that higher scores represented challenge physiological responses. *z*CO and inverse of *z*TPR were summed (Baumgartner et al., 2018; Blascovich. Seery, Mugridge, Norris, & Weisbuch, 2004). The following equation was used:

$$\text{Challenge physiology} = z\text{CO} + (z\text{TPR} * -1)$$

where higher scores denoted challenge physiology.

Empathetic accuracy task. The empathetic accuracy task naturalistically assessed empathetic reactance toward a target engaging with the same psychosocial stressor as participants (Engert et al., 2014; Ickes et al., 1990). The first participant served as the target and was video recorded while engaging with the 2-minute task period of the stressor. The target retrospectively rated affect experienced during the stressor using items from the PANAS. Subsequent participants severed as observers, and passively watched the video recording. Observers were instructed to report the emotions they believed the target felt using the PANAS. Procedurally, the empathic accuracy task always occurred post-stressor for observers.

Empathic accuracy. Empathetic accuracy was reflected by the degree of correspondence between target and observer affect ratings. A bivariate correlation was computed for target and observer ratings to represent accuracy (Zaki, Weber, Bolger, & Ochsner, 2008), where higher scores indicated greater overlap in responses.

***Manipulation check*.** A single-item assessed the extent to which the observer was familiar with the target prior to the study using a 5-point scale ranging from 1 = *not at all familiar* to 5 = *very familiar*. The item "Were you familiar with the person in the video before the study?" assessed familiarity. All participants indicated no previous familiarity or neutral familiarity. Therefore, all empathic accuracy data were utilized in subsequent analyses.

Phenomenological writing task. Although not associated with a priori hypotheses, a phenomenological writing task served as an exploratory assessment of the lived experience of the self while engaging with the stressor and empathic accuracy task. Participants were instructed to write three sentences about the thoughts and feelings they experienced during each task. The following instructions were provided:

> For the next few moments, reflect on any thoughts or feelings you experienced while you were [doing the counting backwards task] OR [watching the video]. You should reflect on your sense of presence, any bodily sensations you had, and/or your relationship with your immediate surroundings while you were [doing the task] OR [watching the video]. Write 3 statements about your experiences.

These thoughts were coded using procedures developed in past research (Cacioppo, von Hippel, & Ernst, 1997). Written responses were coded by trained and blinded researchers for the number of statements reflecting expanded self-referential thinking (Ataria et al., 2015; Dor-Ziderman et al., 2013; Hadash, Plonsker, Vago, & Bernstein, 2016). Expanded self-referential thinking refers to descriptions of experiential content that is situated in the third-person, focusing on the situation and not the self, and is more 'other' as oppose to self-oriented. For example, a feeling of anger could be described as, "I was angry," or "A sense of anger." The latter does not express ownership of the emotional experience, and thus lacks a centralized self relating to the experience (Hadash et al., 2016). Inter-coder reliability for the post-stressor writing task was excellent (Shrout & Fleiss, 1979), as indicated by the intra-class correlation coefficients, ICC(2,1)Statements = .99; ICC(2,1)Self-expansion = .99. Likewise, inter-coder reliability for the post-empathetic

accuracy task was also excellent, ICC(2,1)Statements = .99; ICC(2,1)Self-expansion = .94. Examples of written responses given by meditators and non-meditators are provided in Appendix D.

Procedure

Interested participants were pre-screened for eligibility by completing the recruitment survey. Eligible participants were scheduled for the laboratory session, and instructed not to eat, drink, smoke, or exercise at least two hours prior to arrival. Participants provided written informed consent. After consent, participants reported affect, generalized selflessness (IOS and VAS), empathy, and collectivism. Participants were then prepared to engage with the stressor. A female experimenter affixed physiological sensors around the participant's neck and torso, and a blood pressure cuff was placed around the participant's non-dominant arm. Physiological signal adequacy was ensured before the task commenced. The same experimenter provided stressor instructions, after which, participants reported appraisals and affect. An experimenter recorded responses during the stressor. After the stressor, participants reported selflessness. The empathetic accuracy followed, including video watching and affect ratings. After the video was over, participants completed the manipulation check and reported selflessness. Pre-debriefing included inquiring whether participants could guess the intent of the study.[2] Finally,

[2] No participants accurately guessed the intent of the study.

participants were debriefed and compensated for their time. Figure 2 provides a visual flow of the procedure.

III. RESULTS

Preliminary Analyses

Data were inspected visually and summary statistics were computed to ensure survey data were entered correctly. Physiological outliers were determined by discerning excessive autonomic values beyond three standard deviations from the mean (Schneider, 2004). In the case of outliers, that value was changed to represent three standard deviations beyond the mean for subsequent analyses.[3] Galton analysis of skewness and standardized Pearson measurement of kurtosis indicated that no independent or dependent variables violated assumptions of normality (George & Mallery, 2010). Consequently, no corrective procedures were employed.

General Relationships Among Study Variables

Table 5 displays descriptive statistics and bivariate correlates for study variables. Age, also higher in the meditating sample, and sex were correlated with several study key variables, and were therefore used as covariates in subsequent analyses (Raab, Day, & Sales, 2000). Beginning with stress responses, meditation experience was related to higher secondary appraisals (i.e., evaluation of coping resources) and more positive affect, but was unrelated to primary appraisals and negative affect. Concerning performance during the stressor, meditation experience was related to more correct

[3] Outliers were compared to non-outliers to discern significant mean differences. There were no detected outliers in baseline heart rate (HR), cardiac output (CO), and total peripheral resistance (TPR). There was no significant difference in task HR, $t(105) = 1.00$, $p = .32$, as well as task CO and TPR, as there were no detected outliers for these parameters.

answers and less errors, but was unrelated to number of responses. There were no significant correlations for meditation experience and cardiac or vascular reactivity. Concerning empathy-related variables, meditation experience was unrelated to overall trait empathy and empathic accuracy, but was significantly and negatively related to personal distress, a subcomponent of trait empathy. Finally, meditation experience showed a strong and positive relationship with selflessness.

Primary Analyses

Stress responses. Hypotheses concerning the relationship between meditation experience and stress outcomes were examined with a series of hierarchical regression analyses in two steps, controlling for age and sex in the first step, and meditation experience in the second step.

Appraisals. It was hypothesized that meditation experience would predict greater challenge appraisals, as indicated by a lower appraisal ratio score, in response to the stressor. Table 6 shows that the first block included the covariates and explained a significant proportion of the variance in appraisals, $R^2 = .10$, $F(2,105) = 5.87$, $p < .01$, with sex driving the effect. The second block added meditation experience, but did not explain significant incremental variance in appraisals, $\Delta R^2 = .01$, $p = .50$, leaving Hypothesis 1a unsupported.

Appraisal components. Given that meditation experience was positively correlated with secondary appraisals (see Table 7), follow-up regression analyses were conducted on appraisal components. The outcome of the first analysis was primary appraisals. Table 6

shows that the first block included the covariates and explained a significant proportion of the variance in primary appraisals, R^2 = .09, F(2,105) = 5.34, p < .01, with sex driving the effect. The second block added meditation experience, but did not explain significant incremental variance in appraisals, ΔR^2 = .01, p = .37.

The outcome of the next analysis was secondary appraisals (see Table 8). As before, the first block included the covariates and explained a significant proportion of the variance in secondary appraisals, R^2 = .11, F(2,105) = 6.38, p < .01, with age and sex driving the effect. The second block added meditation experience, but did not explain significant incremental variance in appraisals, ΔR^2 = .01, p = .29.

Affect.

Positive affect (PA). It was hypothesized that meditation experience would predict greater PA in response to the stressor. Baseline PA was controlled for in this analysis, as it was highly correlated with stressor PA (r = .87, p < .01) and to ensure any influence of meditation was independent of pre-stressor state positive affect. Table 9 shows that the first block included the covariates and explained a significant proportion of the variance in stressor PA, R^2 = .71, F(3,104) = 84.25, p < .01, with sex and baseline PA driving the effect. The second block added meditation experience and explained significant incremental variance in stressor PA, ΔR^2 = .02, p < .05. Sex and baseline PA maintained their predictive utility. In addition, meditation experience predicted significantly greater stressor PA in this step, supporting Hypothesis 1b.

Negative affect (NA). It was hypothesized that meditation experience would predict

less NA in response to the stressor. Baseline NA was controlled for in this analysis, as it was correlated with stressor NA ($r = .40$, $p < .01$) and to ensure any influence of meditation was independent of baseline state negative affect. Table 10 shows that the first block included the covariates and explained a significant proportion of the variance in stressor NA, $R^2 = .21$, $F(3,103) = 9.32$, $p = .01$, with sex and baseline NA driving the effect. The second block added meditation experience, but did not explain significant incremental variance in stressor NA, $\Delta R^2 = .01$, $p = .27$, leaving Hypothesis 1c unsupported.

Performance. It was hypothesized that meditation experience would predict better performance while engaging with the stressor. Performance was analyzed below using several indicators.

Reponses. In the first set of hierarchical regression analyses, the total number of responses made served as the outcome measure. Table 11 shows that the first block included the covariates and explained a significant proportion of the variance in number of responses, $R^2 = .17$, $F(2,105) = 10.43$, $p < .01$, with sex driving the effect. The second block added meditation experience, but did not explain significant incremental variance in responses, $\Delta R^2 = .00$, $p = .84$.

Errors. The next analysis regressed age, sex, and meditation experience on the total number of errors made. Table 12 shows that the first block included the covariates and did not explain a significant proportion of the variance in errors, $R^2 = .02$, $F(2,103) = 1.25$, $p = .29$. The second block added meditation experience and explained significant incremental variance in total errors made, $\Delta R^2 = .40$, $p < .01$. Meditation experience predicted

significantly fewer errors.

Percent correct. Percent correct served as the outcome measure in the last performance analysis. Table 13 shows that the first block included the covariates and explained a significant proportion of the variance in percent correct, $R^2 = .09$, $F(2,103) = 5.30$, $p < .01$, with age and sex driving the effect. The second block added meditation experience and explained incremental variance in percent correct, $\Delta R^2 = .06$, $p < .01$. Sex maintained its predictive utility. In addition, meditation experience predicted significantly higher percentage correct. Taken together, the hypothesis (1d) that meditation experience predicts better performance was partially supported, predicting fewer errors and higher percent correct, but not number of responses.

Physiology.

Stressor engagement. Before examining cardiovascular hemodynamics, analyses were computed to ensure physiological task engagement via increases in heart rate (HR), using dependent measures *t*-tests (Schneider, 2004). Heart rate should increase from the last minute of baseline to the first task minute equally for meditators and non-meditators. We found physiological engagement in the meditating sample, $t(52) = -4.36$, $p = .00$, and non-meditating sample, $t(52) = -5.81$, $p = .00$. These results indicate that participants were engaged by the stressor, allowing the examination of specific psychophysiological indexes of challenge and threat.

Challenge physiology. It was hypothesized that meditation experience would predict challenge physiology during the stressor, as indicated by greater CO reactivity,

coupled with less TPR reactivity. Table 14 shows that the first block included the covariates and did not predict a significant proportion of the variance in challenge physiology, R^2 = .02, $F(2,93) = .69$, $p = .50$. The second block adding meditation experience was also non-significant, $\Delta R^2 = .00$, $p = .79$, leaving Hypothesis 1e unsupported.[4]

Exploratory physiology analyses. Exploratory analyses were conducted to better understand whether meditation influences acute psychophysiological changes during stress. Group differences (meditators versus nonmeditators) in physiological indicators over time (i.e., the last minute of baseline through the recovery period) were examined in a repeated-measures analysis of covariance (ANCOVA) framework, as this is another valid way of examining physiological responses in the literature (e.g., Baumgartner et al., 2018; Brown et al., 2012; Chida & Steptoe, 2010; Schneider, 2004, 2008; Stroud, Salovey, & Epel, 2002). In addition to cardiovascular reactivity, pre-ejection period (PEP), a systolic time interval, was also examined because it is considered a pure measure of sympathetic (i.e., beta-adrenergic) influences on myocardial contractility. As a cardiac time interval, lower values indicate quicker cardiac contractility and thus less time to eject blood from

[4]Much biopsychosocial model stress research examines the influence of appraisal groups on outcomes, including CO and TPR reactivity in a multivariate analysis of variance (MANCOVA) framework (see Baumgartner et al., 2018; Blascovich, Mendes, Salomon, & Hunter, 1999; Schneider 2004, 2008). For this reason, meditation experience was dichotomized into meditating or non-meditating groups, and then entered in a MANCOVA, with CO and TPR reactivity as the dependent variables, controlling for age and sex. A marginal overall multivariate effect was found on cardiovascular reactivity, Wilks' $\lambda = .93$, $F(2, 77) = 2.87$, $p = .06$ (the covariates were non-significant). However, there was no multivariate effect of meditation group on cardiovascular reactivity, $p = .86$.

the left ventricle into the aorta, or increased sympathetic activity (Newlin & Levenson, 1979; Sherwood, Allen, Obrist, Langer, 1986). In accordance with past research, participants who reported daily meditation practice of at least 30-minutes or more for at least 3-years or longer constituted the meditator group ($N = 40$), whereas participants who have never meditated constituted the nonmeditator group ($N = 55$) (Rosenkranz et al., 2016; Zanesco, King, McClean, & Saron, 2013).

CO and TPR. A repeated-measures multivariate analysis of covariance (MANCOVA), controlling for age and sex, was used to account for the interdependent nature of the hemodynamics parameters, cardiac output (CO) and total peripheral resistance (TPR). Group (2 levels: meditator, nonmeditator) was entered as the between-subjects factor, and time (5 levels: last minute of baseline, task minutes 1-2, and recovery minutes 1-2) was entered as the with-subjects factor. The mean CO and TPR values for each minute were the dependent variables (see Table 15). There was a significant multivariate between-subjects effect of time, Wilks' $\lambda = .23$, $F(2, 74) = 122.30$, $p < .01$, partial $\eta^2 = .77$ and a marginal within-subjects effect of time, Wilks' $\lambda = .81$, $F(8, 68) = 1.95$, $p = .07$, partial $\eta^2 = .19$. There were no effects for the covariates, nor did they interact with the other independent variables. Importantly, a significant within-subjects Time x Group interaction was found, Wilks' $\lambda = .78$, $F(8, 68) = 2.13$, $p < .05$, partial $\eta^2 = .22$, with CO driving the effect, $F(8, 68) = 2.38$, , $p = .06$, partial $\eta^2 = .03$. Follow-up analyses revealed a significant mean difference by group for the first minute of recovery, $t(1) = -6.59$, $p < .05$, such that the meditating group had higher blood flow during that minute. All

other Time x Group mean differences were non-significant. The data for CO and TPR are represented graphically in Figures 3 and 4, respectively.

Pre-ejection period (PEP). A repeated-measures ANCOVA, controlling for age and sex, examined PEP responses over the duration of the stressor. As before, group was entered as the between-subjects factor, and time was entered as the with-subjects factor. The mean PEP values for each minute were the dependent variables (see Table 16). The between-subjects effect for group was marginal, $F(1, 59) = 3.48$, $p = .07$, partial $\eta^2 = .06$, such that the meditating group had slower PEP time intervals and thus less sympathetic activation over time. There was no within-subjects effect of time, $F(4, 56) = .05$, $p = .99$, partial $\eta^2 = .00$, nor was there an effect for the covariates or their interaction with the other independent variables. However, there was a significant within-subjects Time X Group interaction, $F(4, 56) = 4.03$, $p < .05$, partial $\eta^2 = .06$. Follow-up analyses revealed a significant mean group difference for baseline, $t(1) = -14.11$, $p < .05$, first task minute, $t(1) = -31.14$, $p < .01$, second task minute, $t(1) = -33.73$, $p < .01$, and first recovery minute, $t(1) = -8.57$, $p < .05$, such that the meditating group had slower cardiac time intervals. The mean group difference for the last minute of recovery was non-significant. The data are graphed in Figure 5.

Empathy. Hypotheses concerning the relationship between meditation experience and empathy were examined with a series of hierarchical regression analyses, controlling for age and sex in the first step, and meditation experience in the second step.

Trait empathy. It was hypothesized that meditation experience would predict greater trait empathy. Table 17 shows that the first block included the covariates and explained a significant proportion of the variance in trait empathy, $R^2 = .20$, $F(2,106) = 13.34$, $p < .01$, with age and sex driving the effect. The second block added meditation experience, but did not explain significant incremental variance in trait empathy, $\Delta R^2 = .00$, $p = .60$.

Perspective taking. The next series of regression analyses examined the influence of meditation on relevant subcomponents of trait empathy, with the first being perspective taking. Table 18 shows that the first block included the covariates and did not explain a significant proportion of the variance in perspective taking, $R^2 = .02$, $F(2,106) = .83$, $p = .44$. The second block adding meditation experience predicted marginally significant incremental variance in perspective taking, $\Delta R^2 = .04$, $p = .052$. Meditation experience predicted marginally greater perspective taking, $p = .052$.

Empathic concern. Empathic concern served as the outcome measure in the next regression analysis. Table 19 shows that the first block included the covariates and explained a significant proportion of the variance in empathic concern, $R^2 = .10$, $F(2,106) = 5.80$, $p < .01$, with sex driving the effect. The second block added meditation experience, but did not explain significant incremental variance in empathic concern, $\Delta R^2 = .01$, $p = .36$.

Personal distress. The final subcomponent was personal distress. Table 20 shows that the first block included the covariates and explained a significant proportion of the

variance in personal distress, R^2 = .13, F(2,106) = 8.22, p < .01, with age and sex driving the effect. The second block added meditation experience and explained incremental variance in personal distress, ΔR^2 = .04, p < .05. Sex maintained its predictive utility. In addition, meditation experience predicted significantly less personal distress. Taken together, the hypothesis (2a) that meditation experience predicts higher trait empathy was largely unsupported. Meditation experience predicted significantly less personal distress only.

Empathic accuracy. The next regression analysis tested the hypothesis (2b) that meditation experience would predict greater empathetic accuracy, as defined by the degree of correspondence between target and observer affect ratings. Table 21 shows that the first block included the covariates and did not explain a significant proportion of the variance in empathic accuracy, R^2 = .01, F(2,103) = .67, p = .51. The second block adding meditation experience was also non-significant, ΔR^2 = .00, p = .72, leaving hypothesis 2b unsupported.

Selflessness. It was hypothesized that meditation experience would predict greater selflessness, as indicated by high levels of connectedness, coupled with less perceived body boundaries. Collectivism was controlled for given its conceptual overlap with selflessness. Table 22 shows that the first block included the covariates and explained a significant proportion of the variance in selflessness, R^2 = .16, F(3,104) = 6.60, p < .01, with collectivism driving the effect. The second block added meditation experience and explained incremental variance in selflessness, ΔR^2 = .15, p < .05. Collectivism maintained its predictive utility in this step. In addition, meditation experience predicted significantly

greater selflessness, supporting Hypothesis 3.

Although exploratory, the relationship between meditation experience and the phenomenological experience of an expanded self, as indicated by post-stressor and post-empathic accuracy thought listings, were examined using partial correlations, controlling for the number of statements written. There was a significant partial correlation between meditation experience and statements reflecting an expanded self during the stressor, r = .20, $p < .05$, but not during the empathic accuracy task, r = -.01, p = .91. Thus, it appears that meditation experience is related to more self-expansive experiences during personal stress encounters, but not when explicitly instructed to relate to another person.

Mediation analyses. A series of mediation analyses tested hypotheses 4 and 5, which predicted an indirect effect of meditation on stress responses and empathy via selflessness. Models were computed with PROCESS Macro version 3.0 by Hayes (www.processmacro.org). The PROCESS Macro uses an ordinary least squares path analytic framework for mediation analysis. An advantage of this technique is that the macro generates accelerated bootstrapped 95% confidence intervals (CI) based on 5,000 bootstrap draws. Bootstrapping is a nonparametric resampling procedure used to assess the significance of indirect effects by approximating the sampling distribution by repeated random resampling with replacement from the data (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). It uses this distribution to calculate *p*-values and construct confidence intervals. Another advantage of this technique is that it does not require initial evidence of a relationship between an independent variable (IV) and dependent variable

(DV), as advised by other procedures (i.e., Baron and Kenny 1986). Instead, evidence for mediation requires an initial relationship between the IV and DV with the mediator (Preacher & Hayes, 2004; 2008). The total effect of the independent variable was decomposed into direct and indirect effects (MacKinnon et al., 2002). The direct effect represents the association of an independent variable with a dependent variable, whereas the indirect effect corresponds to the effect of a mediating variable in that relationship. An indirect effect was considered significant when zero was not within the range of its confidence interval. All reported results represent standardized coefficients.

Model 1: The indirect effect of meditation experience on challenge appraisals via selflessness. The first model tested the indirect effect of meditation experience on challenge appraisals via selflessness. In this model, the IV was meditation experience, the DV was stressor appraisals, and the mediator was selflessness (see Figure 6).

Model 2: The indirect effect of meditation experience on positive affect via selflessness. In this model, the IV was meditation experience, the DV was positive affect (PA), and the mediator was selflessness (see Figure 7). The full regression model explained a significant amount of variance in PA, $R^2 = .15$, $F(2, 106) = 9.08$, $p < .01$. Analyses revealed a significant total effect of meditation experience on PA when the mediator, selflessness, was not included in the model, $\beta = .26$, $p < .05$. A significant positive relationship was found between meditation experience and the mediator, selflessness, $\beta = .66$, $p < .01$. When testing the full model, selflessness remained a significant predictor of PA after controlling for meditation experience, $\beta = .23$, $p < .01$. Of greater theoretical

importance, there was a significant indirect effect of meditation experience on PA through selflessness, β = .15, 95% CI [0.05, 0.27]. In addition, the direct effect of meditation experience on PA was non-significant in the model, β = .18, p = .35, indicating that the relationship between meditation and PA was fully accounted for by selflessness. In summary, Hypothesis 4 predicting that selflessness is a pathway through which meditation experience drives PA in response to stress was supported.

Model 2: The indirect effect of meditation experience on perspective taking via selflessness. Regarding empathy, selflessness was unrelated to overall trait empathy and personal distress, but was significantly and positively related to perspective taking (PT) and empathic concern (EC: see Table 5). As a result, mediation analyses were conducted with PT (Model 2) and EC (Model 3). In the first model, the IV was meditation experience, the DV was PT, and the mediator was selflessness (see Figure 8). The full regression model explained a significant amount of variance in PT, R^2 = .10, $F(2, 107) = 5.86$, $p < .01$. Analyses revealed a non-significant total effect of meditation experience on PT when the mediator, selflessness, was not included in the model, β = .13, $p = .13$, rendering further analysis unwarranted.

Model 3: The indirect effect of meditation experience on empathic concern via selflessness. In the last model, the IV was meditation experience, the DV was EC, and the mediator was selflessness (see Figure 9). The full regression model explained a significant amount of variance in EC, R^2 = .06, $F(2, 107) = 3.32$, $p < .05$. Analyses revealed a non-significant total effect of meditation experience on EC when the mediator, selflessness,

was not included in the model, $\beta = .05$, $p = .39$, rendering further analysis unwarranted. In summary, Hypothesis 5 specifying that selflessness is a pathway through which meditation experience influences empathy was unsupported. Any relationship with empathy, and in this case perspective taking and empathic concerns, appears to be driven by selflessness, independent of meditation experience.

IV. DISCUSSION

The purpose of the present research was to investigate the influence of meditation experience on mitigating suffering caused by personal stress, while simultaneously inviting prosocial qualities, such as empathy. It was hypothesized that meditation experience confers flexibility in the stressor appraisals process that lends toward challenge appraisals and associated biopsychosocial stress outcomes (Blacovich & Tomaka, 1993; Lazarus & Folkman 1984; Schneider, 2004; 2008). The next set of hypotheses specified a positive relationship between meditation experience and the propensity to understand the affective states of others – trait empathy – as well as a behavioral indicator of empathy – empathic accuracy. Finally, Buddhist tenets detail a capacity of meditation to expand the sense of self in fundamental ways (Dambrun & Richard, 2011; Shiah, 2016). The present research empirically examined this tenet, and as a potential mechanism of action.

Meditation Experience and Stress Responses

The influence of meditation experience was examined from a biopsychosocial perspective, which has robustly shown that appraisals influence affective, behavioral, and psychophysiological stress responses. The question as to whether meditation experience modulates stress responses was partially supported. Findings suggest that meditation experience is related to greater positive affect in response to an acute psychosocial stressor, as well as fewer errors and a higher percentage correct while engaging with the stressor. However, meditation experience was unrelated to appraisals, negative affect, number of responses made, and cardiovascular reactivity.

Appraisals. It is interesting that meditation experience did not predict challenge appraisals in the present study, although it did predict aspects of the challenge constellation, including positive affect and some aspects of performance. Research concerning the link between meditation and appraisals predominately focuses on outcomes of trait mindfulness or mindfulness-based interventions (e.g., Baumgartner & Schneider, 2017; Vago & Nakamura, 2013), rather than meditation experience, as in the present research. For example, one study found that trait mindfulness predicted less feelings of stress and anxiety after engaging with a psychosocial stressor, as well as less threat-like cognitions and affect in anticipation of a course examination (Weinstein et al., 2009). Threat was measured using an instrument of challenge and threat construal, which represents perceived opportunities of positive or negative consequences, somewhat akin to Lazarus' notion of gain/mastery and harm/loss (Lazarus & Folkman, 1984; Lazarus, 1999). These findings suggest that people who are higher in trait mindfulness, regardless of their actual participation in meditation, are more likely to anticipate positive consequences in potentially stressful situations. Although trait mindfulness and meditation experience should theoretically be correlated, this is not always the case (for a review see Grossman, 2011).

In light of the present findings, an alternative explanation is that greater meditation experience relates to more objectively-informed evaluations, rather than subjectively-informed evaluations, as the latter is true of challenge/threat stressor appraisals. Although meditation experience was positively correlated with secondary appraisals, or evaluations of coping resources, this effect was non-significant once age and sex were accounted for.

As a result, with meditation experience, situations are evaluated in more positive (i.e., positive reappraisal: see Garland, Gaylord, & Fredrickson, 2011; Garland, Gaylord, & Park, 2009) or neutral, benign terms. Theory and research do support the claim, suggesting that meditation promotes dereification, a process by which thoughts lose their representational value and are experienced simply as mental events (Lutz et al., 2007; Desborges et al., 2015). Indeed, 'mindful awareness' is frequently described as a focus on present sensory input without cognitive elaboration or emotion reactivity (see Vago & Zeidan, 2016). In a series of experiments, participants who engaged with a mindfulness procedure that focused on observing reactions to stimuli as transient mental events rather than objectively real experiences were slower to approach attractive foods during an implicit approach-avoidance task, compared to control participants who merely completed the task (Papies, Barsalou, & Custers, 2012). Other research shows that meditation reduces emotional reactivity to negative internal stimuli. Participants instructed to meditate experienced less negative affect in response to a sad mood induction, compared to participants in a rumination or distraction condition (Broderick, 2005). Thus, meditation experience may promote positive stress outcomes and a generalized approach-orientation not by influencing challenge appraisals specifically, but by attenuating or neutralizing negative evaluations of events more generally.

Affect. The present research found that meditation experience was related to more positive affect in response to the stressor. This corroborates with a wealth of research showing that meditation related to greater positive affectivity across a variety of situations.

A meta-analysis conducted on 163 studies showed that effect sizes for meditation were strongest for changes in emotionality ($\hat{r}$ = .24-.37), which could not be explained by mere relaxation or cognitive restructuring effects (Sedlmeier et al., 2012). These benefits are also observed in functional changes in positive emotion-related brain activity. Participants were randomized to MBSR or waitlist control and underwent electroencephalogram (EEG) monitoring while they wrote about positive and negative life events (Davidson, et al., 2003). Participants were vaccinated post-intervention with an influenza vaccine to measure production of antibody titers. Findings revealed that the MBSR group displayed greater increases than controls in left-sided anterior brain activation during both writing tasks, which is an area of the brain reliably linked with positive, approach-oriented emotions (for a review see Davidson, 2000). Moreover, the MBSR group showed a more robust immune response to the influenza vaccine as indicated by increases in antibody titer production. Interestingly, the magnitude of increase in left-sided anterior brain activation positively predicted the magnitude of antibody titers. These findings are of interest because they demonstrate increases in positive emotion-related brain activity during positive and negative affect inductions. The present research extends this work by showing that meditation also promotes positive affect in response to psychosocial threat. The Davidson et al. findings and the current findings suggest that the upregulation of positive affect during positive and negative events may be pathway through which meditation practitioners are psychologically resilient to negative health consequences (Fredrickson et al., 2008; Fredrickson & Losoda, 2005; Pressman & Cohen, 2005).

Performance during stress. Under some circumstances, acute stress or prolonged stress exposure can impair performance. This is especially the case on tasks that require complex and flexible thinking (see Arsten, 2009 for a review). The present research showed that meditation experience benefits some aspects of performance during an acute stress episode. Specifically, participants were instructed to make vocal serial subtractions by steps of 7 from a 4-digit number. Meditation experience predicted a higher percentage of correct responses and fewer errors, but did not predict number of responses. Thus, it appears meditation practitioners were more careful and accurate in the responses they gave. Research in the domain of meditation and cognitive functioning may provide insight. Past research has shown that meditation training reduces mind wandering during the GRE and a working memory task (Mrazek, Franklin, Phillips, Baird, & Schooler, 2013). An intensive meditation retreat improved performance during a response inhibition task, which was correlated with phenomenological reports of enhanced concentration during the task (Zanesco et al., 2013). There is also research to suggest that meditation reduces impulsivity. In a sample of people trying to lose weight, participants who were instructed to meditate for 6-weeks improved on a measure of impulsivity, compared to control participants (Mantzios & Giannou, 2014). These qualities of meditation practice, such as attending to a task without distraction, as well as heightened concentration and self-control, may have contributed to better performance during the stressor or protected against potential performance decrements due to stress.

Physiological responses during stress. The hypothesis that meditation experience contributes to cardiovascular reactivity was largely unsupported. Although both the meditating and non-meditating groups were physiologically mobilized during the stressor, as indicated by increases in heart rate (HR), meditation experience did not predict the characteristic challenge physiology pattern. This is not entirely surprising, as the relationship between meditation experience and challenge appraisals was also non-significant. Therefore, it appears psychological and psychophysiological changes induced by meditative practice do not fit entirely within a biopsychosocial framework of arousal regulation. Instead, another model may provide a better explanatory framework to understand the effect of meditation on physiological stress responses.

Aspects of the biopsychosocial (BPS) model were influenced from Dienstbier's (1989) model of psychophysiological toughness (Blascovich & Tomaka, 1996; Blascovich et al., 2004). The BPS model borrowed from Dienstbier's toughness model to specify differential activation of the sympathetic and hypothalamic-pituitary-adrenal (HPA-axis) axes as resulting in challenge and threat states (Blascovich & Tomaka, 1996; Dienstbier, 1989). According to the BPS model, both challenge and threat states result in heightened sympathetic activation, but threat also results in heightened HPA activation, promoting vasoconstriction (i.e., increased TPR). As such, both models were a departure from more negative views of peripheral physiological arousal, to a more positive view. However, the psychophysiological toughness model delineates other patterns of "toughened" physiological responses that span the entire duration of the acute stress

episode. Specifically, people are considered toughened and resilient if they exhibit low baseline physiological activity with strong and responsive activity to acute stress, followed by a quick decline to baseline levels of activity. A toughened response is also resistance to catecholamine depletion upon changes in the environmental context, supplying a persistent amount of blood flow and glucose to the brain (Dienstbier, 1989).

This toughening model provides a unique interpretation of the exploratory psychophysiology findings from the present study. These analyses compared meditators and non-meditators on CO, TPR, and PEP over the course of the stressor – from baseline to task performance, followed by recovery. Focusing on CO, blood flow activity did not proceed to dampen into the recovery period in the meditating sample as it did in the non-meditating sample. Instead, meditators responded with significantly greater blood flow during the first minute of the recovery period, followed by habituation. This effect is interesting because there were no corresponding differences in TPR, suggesting that meditation influences blood flow activity specifically and without cost. It is noteworthy that participants were unaware that the recovery period constituted the end of the stressor. Thus, it appears meditators were responding to perturbations in the situational context by redistributing blood flow to the body without any impact on vascular resistance, constituting what may partially be considered a toughened response pattern (Diestbier, 1989). The emphasis is on *partially* because HPA functioning, an important aspect of the toughened response profile, was not assessed in the present study. Although past research has shown that trait mindfulness and meditation training predict lower cortisol reactivity

in response to acute psychosocial stress (Brown, Weinstein, & Creswell, 2011; Rosenkranz et al., 2016).

Wakefulness. Early research on the underlying peripheral psychophysiology of meditation focused on physiological changes that occurred in long-term practitioners of transcendental meditation (TM). Like many types of meditation, the goal of this practice is a relaxed yet aware state of mind. The coupling of relaxation and bliss with alertness and awareness constitutes a quality of meditation that previous authors referred to as 'wakefulness' (for a review see Jevning, Wallace, & Beideback, 1992). The authors detailed physiological patterns of wakefulness orchestrated by meditation, with blood flow being a key contributor. Wakefulness was considered an integrated response of increased peripheral circulation of blood flow and associated metabolic changes to support increased central nervous system activity (Jevning et al., 1992; Jevning, Anand, Biedebach, & Fernando, 1996). One of their earliest studies examined blood flow distribution in long-term practitioners of TM and demographically similar non-meditators during states of meditation and relaxation (Jevning, Wilson, Smith, & Morton, 1978). Their analysis also estimated renal (i.e., kidney) and hepatic (i.e., liver) blood flow localization. Cardiac output rose significantly during meditation in TM practitioners relative to non-meditators. In addition, a persistent decrease of hepatic and renal blood flow was observed in TM practitioners during meditation, leading the authors to conclude that blood flow during TM was targeted toward the muscles and brain. The current research extends this body of work by showing that meditation also predicts increased

blood flow during potentially stressful encounters. In consideration of the findings of the above-mentioned studies, it is possible that meditators attempted to enter meditation during the first minute of the recovery period. These findings also demonstrate more generally the importance of not viewing meditation simply as a state of relaxation or as inducing a 'relaxation response,' (Benson, 1975). Rather, meditation affords both relaxation and alertness across a variety of situations, including those of stress.

The present research also found that compared to non-meditators, meditators were less sympathetically active (higher PEP) during all phases of the stress episode, excluding the last recovery minute. Prolonged or recurrent sympathetic activation in response to stress can be costly to health, including increased risk of atherosclerosis, pre-mature aging, and depression (Chida & Hamer, 2008; Kaplan, Manuck, Williams, & Strawn, 1993). Conversely, a well-regulated sympathetic response to stress is protective. Consequently, the current findings suggest that having a meditation practice may protect against future stress-related health ailments, although a longitudinal or prospective design is needed to confirm this speculation. Meditation training does appear to contribute to positive health outcomes. A meta-analysis conducted across a wide spectrum of clinical populations (cancer, pain, heart disease, and psychiatric), as well as distressed nonclinical populations found a significant effect size for meditation training and physical and mental health outcomes, suggesting a mechanistic link may exist (Grossman, Niemann, Schmidt, & Walach, 2004). Still, research examining the relationship between meditation and acute stress responses are sparse, highlighting the need for more work in this area. Taken

together, although the CO and PEP analyses were exploratory in nature, they are worthy of attention given that the patterns of findings fit within current and accepted theory of psychophysiological stress responding and extend past research in important ways.

Meditation experience and empathy

A second goal of the present research was to examine meditation experience as a way to promote empathy, as centuries of Buddhist teachings and an incipient body of research would suggest (Davidson & Harrington, 2002; Ricard, 2015). Buddhist contemplative traditions have long regarded meditation as a key promoter of virtuous behavior, including those intended to alleviate the suffering of others (Davidson & Harrington, 2002; Walsh & Shapiro, 2006). In support of this, much research has demonstrated a positive relationship between meditation and prosocial outcomes (see Condon, 2017 for a review). Despite this, the hypothesis that meditation experience is related to the tendency to be empathetic (trait empathy), and an enhanced ability to discern the mental states of others (empathic accuracy) was partially supported in the present study.

The present research showed that meditation experience was related to less personal distress, a sub-component of the broader empathy construct (Zaki & Ochsner, 2012). Empathic distress entails feelings of negative affect that arise in response to the suffering of others and during emergency situations more generally. One of the main tenets of Buddhist philosophy is the recognition and acceptance of the commonality of suffering. Indeed, some Buddhist teachings suggest that holding suffering in compassionate awareness through meditation facilitates the extension of compassionate feelings towards

others (Dalai Lama & Tutu, 2016; Hoffman, Grossman, & Hinton, 2011). The tendency toward less empathic distress may protect meditation practitioners from negative emotions experienced as a result of witnessing suffering in others. In support of this idea, one study examined the influence of a 3-month intensive meditation retreat on emotional responses to scenes of human suffering (Rosenberg et al., 2015). Participants viewed film scenes relevant to human suffering, such as war, injury, and death at pre- and post-training, during which facial and subjective measures of emotion were collected. Compared to a wait-list control group, the retreat group was less likely to show facial expressions of negative emotions anger, contempt, and disgust. In addition, reports of sympathy inversely predicted negative emotions in response to the film scenes. These results suggest that meditation reduces aversion to the suffering of others, and promotes more other-focused emotions like sympathy. The underlying propensity to experience less empathic distress could be a key driver of this effect.

Meditation experience and selflessness

Much Buddhist philosophy and practices are centered on the idea of impermanence, such that everything in the known universe is in a constant state of change. This appreciation of impermanence is what ultimately facilitates interconnectedness on a broad scale (Nhat Hanh, 1999). The self is also in a constant state of change and is thus intimately connected with other entities of the environment (Olendzki, 2011). Informed by psychological and contemplative literatures (e.g., Aron, Aron, Tudor, & Nelson, 1991; Dambrun & Ricard, 2011), this selflessness was defined in the present study as a

generalized propensity and momentary experience of the self as expanded and fundamentally connected. The hypothesis that meditation experience predicts greater selflessness was supported, predicting a generalized propensity to be selfless, as well as phenomenological reports reflecting an expanded sense of self during a potentially stressful encounter.

These findings add to a growing body of work showing that meditation influences self-referential processing (Ataria et al., 2015; Berkovich-Ohana, 2011, 2013; Dambrun, 2016, Dorjee, 2016; Dor-Ziderman et al., 2013; Hadash et al., 2016; Sedlmeier et al., 2012). However, where the present research differs is in its focus on elucidating selflessness as a mechanism of change in the relation between meditation and stress outcomes. Findings revealed that selflessness fully mediated the relationship between meditation experience and increased positive affect in response to stress. This suggests that selflessness may be an effective emotion regulatory strategy that enables the upregulation of positive affectivity in response to stress. Moreover, these findings are consistent with Buddhist psychology suggesting that selflessness is responsible for the generation of benevolent emotions due its inherent nonattachment to egotistic pursuits (Dambrun & Richard, 2011). However, the present research did not find any evidence of an indirect effect of meditation experience on empathy through selflessness. Past research has shown that Buddhist nonattachment is positively related to empathic concern and perspective taking, and negatively related to personal distress (Sahdra, Shaver, & Brown, 2010). Convergently, our mediation analyses revealed similar patterns, such that selflessness predicted significantly greater perspective

taking and empathic concern. Nonetheless, it appears to do so independent of meditation practice.

Self-affirmation theory. The finding that selflessness mediates the relationship between meditation and positive affect is theoretically interesting in consideration of the social psychological literature on self-affirmation theory. According to self-affirmation theory, people are more likely to respond with defensiveness when exposed to information that threatens the social self, such as information that represents the self and one's values in a negative light (Steele, 1988). From this theoretical framework, a large and reliable body of research shows that self-affirmation manipulations that display the self in a positive light reduce downstream defensiveness to threat (see McQueen & Klein, 2006; Sherman & Cohen, 2006 for reviews). The thought is that these manipulations reduce defensives because they reaffirm the integrity of the self and boost self-worth (Sherman & Cohen, 2006). Moreover, self-affirmation manipulations appear to have an influence on affect – reducing negative affect during some situations (Tesser, 2000) and increasing positive affect in others (McQueen & Klein, 2006; Sherman & Cohen, 2006).

One study attempted to answer the question as to why the self-affirmation paradigm decreases defensiveness in response to self-threatening information (Crocker, Niiya, & Mischkowski, 2008). Participants were randomly assigned to write about their most important value (value affirmation manipulation) or least important value (control), and why the value was meaningful. Participants retrospectively rated emotions experienced

during the writing task. It was found that the value affirmation manipulation compared to control had the largest effect on other-focused positive emotions such as love, connectedness, and sympathy, with the greatest influence on love. A second study repeated this method, and added a task were smokers and non-smokers evaluated an ostensible research article about the health risks of smoking. Findings showed that writing about an important value increased acceptance of the article, but only among smokers, for whom the article contained the most self-threatening information. In addition, mediation analysis revealed that love and connectedness explained the relationship between values affirmation and acceptance of threatening information for smokers. The authors interpreted these findings as meaning that self-affirmation reduces defensiveness to threat by engaging self-transcendent feelings. The psychosocial stressor used in the present research was designed to evoke threat to the social self – increasing potential feelings of evaluation and embarrassment upon poor performance (Dickerson & Kemeny, 2004; Kelsey, 1991; Kelsey et al., 1998). Thus, the present research expands on this large base of work by showing that meditation experience upregulates positive affect in response to threat through its influence on other-focused self orientation. It is possible that such a model enables people with a higher level of meditation practice to engage with threatening information, rather than experience the negative affect typically associated with self-threatening situations.

Future research

Although avenues for future research are detailed throughout, there remains additional theoretical and empirical directions of work that are worthy of attention. On a broad level, there is much research to suggest that meditation has widespread benefits for psychological functioning. Indeed, most of the general population is at least aware of these presumed benefits. However, research in the contemplative sciences has yet to catch up with this growth of research, which has manifested in a relative lack of unified theories of meditation-related benefits. This is especially the case in the domain of meditation and self referentially processing and self-construal (see Dorjee, 2016). The present research attempted to assimilate contemplative thinking regarding the virtues of meditation practice with robust social psychological theory on stress processing, emotion regulation, and the expanded self in hopes of bridging this gap. The highly interdisciplinary nature of this work requires the development of more comprehensive theories that uniquely contribute to the understanding of the specific influence of meditation on psychological constructs of interest. Although promising strides have been made on this front (e.g., Chambers et al., 2009; Dahl, Lutz, & Davidson, 2015; Dorjee, 2016; Lutz et al., 2015), more work is needed.

The present investigation provided some evidence that higher levels of meditation experience influences intra- and interpersonal functioning. As mentioned, much research in this area focuses on pre/post changes on outcomes of interest due to trait mindfulness, mindfulness-based interventions (MBIs), and single intensive meditation retreats. Few investigations examine meditation experience as a continuous independent variable, although there are exceptions (Rosenkranz et al., 2016; Baer et al., 2009, 2012). Instead,

the present research sought to investigate the influence of meditation as it is commonly practiced – independent of MBIs and across different types of meditation practices (e.g., mindfulness, loving kindness, transcendental, etc.). Because findings from the present investigation were not uniformly positive, it appears there are differential effects of meditation based on meditation modality. For example, personal distress was the only component of empathy linked to meditation experience in the present study. There may a common underlying mechanism that can account for baseline levels of interest in contemplative practices *and* a propensity to be empathic towards others. Future research should attempt to disentangle this potential confound when investigating any relation between meditation and prosocial outcomes. Similarly, given that the present research used a sample of participants who expressed interest in meditation, it is possible that much of the positive influence of meditation is due instead to demand characteristics of general interest in and awareness of meditation benefits, as articulated elsewhere (Davidson & Kaszniak, 2015). These points suggest that future research should attempt to disentangle these discrepancies by recruiting advanced meditation practitioners and employing methods that control for demand characteristics. Finally, it is possible that there is an upper bound for the benefits of meditation, and further practice only maintains practitioners at the levels achieved early on. It would be interesting to investigate outcomes associated with the diminishment or discontinuation of meditation practice with the question of whether effects are influenced.

Limitations

The present research has noteworthy limitations. First, the cross-sectional nature of the study design cannot be discounted. That is, all assessments were obtained at the same point in time, obscuring casual inferences. For this reason, it cannot be claimed that meditation experience causes observed changes – any relationships should be considered co-emergent. On a similar note of generalizability, the present research was a non-randomized investigation of people with experience in different types of meditation. Meditation experience was used as an umbrella term to represent the diversity of meditative practices. Research suggests that meditation types are not created equal with regards to their effects on psychological and biological functioning (see Cahn & Polich, 2006; Lutz et al., 2015; Sedlmeier et al., 2012). This is almost certainly due in part to the underlying focus of any given meditation – from a focus on cognitive and affective phenomenology, spiritual or self-transcendence, generating benevolent emotions towards others, to ongoing breath sensation. Thus, generalization across meditation types should be exercised with caution. Despite these limitations, the present research is still unique in its contributions, in that it is a step toward understanding associations of meditation experience with various biopsychosocial and interpersonal outcomes using a multi-method approach.

Conclusion

The experience of stress is inevitable. It is indeed one of those rare experiences that everyone can relate to. There is much variability in how people respond to stress. Much of the variability in stress responses is captured by one's initial appraisal, or evaluation of the potentially stressful situation (Lazarus & Folkman, 1984; Schneider,

2004). These appraisals are known to be malleable – that is, people have some control in how they engage or disengage from stressful episodes and the stress outcomes that follow. Therefore, an understanding of the factors and practices that modulate the stress process in a way that leads to positive outcomes for health and well-being is of critical importance. However, in an increasingly interdependent world, this focus needs to be widened to include an understanding of the interpersonal pathways toward well-being. The question then becomes, what practices show promise for building personal stress resilience while also have the potential to build social resilience. It is within this framework that the present research investigated the influence of meditation on stress responses and empathy, as well as on a central feature of psychologically functioning – the sense of self.

From a biopsychosocial perspective, it was expected that greater meditation experience would relate to challenge appraisals in response to an impending psychosocial stressor, and the affective, behavioral, and psychophysiological outcomes that follow. Although there was no benefit of meditation on challenge appraisals, meditation was related to some affective and behavioral stress outcomes. Specifically, meditation experience predicted increased positive affect in response to the stressor and better performance in terms of fewer errors made and a higher percentage correct. Mediation analysis revealed that perceiving the self as expanded and connected fully accounted for the relationship between meditation and positive affect in response to stress. This novel finding suggests that greater meditation experience influences self structure in such a way

that one feels more interconnected, which is a pathway through which meditators experience positive emotions in response to threat.

Meditation experience did not predict challenge psychophysiological patterns in the present study, but when physiological responses were examined over time, interesting findings emerged. Relative to the nonmeditating sample, the meditating sample distributed increased blood flow during each perturbation in the situational context. This may reflect an increased capacity to engage the whole body without cost, as there were no differences in vasoconstriction. Moreover, the meditating sample was less sympathetically active during the stressor, which over time may protect against negative health consequences of stress. In concert with other findings, meditation does appear to be a viable stress management technique, although the upper limit of its benefit remains elusive.

The ability to accurately perceive and engage in behavior that aims to mitigate the suffering of others depends largely on empathy (Batson, 1991a; Batson 1991b; Batson, 2011). A common element that transects all meditative practices is on the cultivation of benevolent feelings towards others. Despite past researching showing a positive relationship between meditation and prosocial outcomes, the present research found limited effects. Findings revealed that greater meditation experience was related to less empathic distress, defined as the propensity to experience negative emotions in response to the suffering of others. This link suggests that meditators are less averse to suffering, which may be a mechanism through which meditation influences prosocial action (see

Condon et al., 2013). Taken together, the present research provides insight into how meditation influences stress responses over time, while also provides scientific credence to ancient Buddhist teachings suggesting that meditation expands the sense of self. A sense of self that is more expanded and interconnected affords psychological resilience in the face of stress.

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Tables

Table 1

Demographic characteristics of mediating and nonmeditating samples

	Mediators	Nonmediators	*t* or x^2	*p*
Age in years (M, SD)	35.04 (15.95)	28.31 (11.04)	$t = 2.57$	.01
Sex (% female)	49.1%	50.9%	$x^2 = .04$	.85
Ethnicity (% Caucasian)	54.4%	45.6%	$x^2 = 9.46$	.09
Education (% Bach. Degree)	50%	50%	$x^2 = 8.16$	.32
Income (% < 20k)	44.8%	55.2%	$x^2 = 5.42$	.37

Table 2

Bivariate correlations among meditation experience variables

	1	2	3
1. Times a week	-		
2. Minutes daily	.64**	-	
3. Years of practice	.39**	.40**	-
4. Lifetime hours	.52**	.53**	.74**

Note. $^{**}p < .01$.

Table 3

Bivariate correlations among IOS and VAS variables at various timepoints

	1	2	3	4	5
1. Baseline IOS	-				
2. Baseline VAS	-.31**	-			
3. Stressor IOS	.91**	-.28**	-		
4. Stressor VAS	-.27**	.45**	-.29**	-	
5. Empathy IOS	.81**	-.30**	.81**	-.24*	-
6. Empathy VAS	-.03	.42**	.00	.30**	-.06

Note. **$p < .01$, *$p < .05$. IOS = Inclusion of Other in the Self Scale. VAS = Visual Analog of Body Boundaries. Stressor and empathy IOS/VAS were measured post-stressor and post-empathic accuracy task, respectively.

Table 4

Internal Consistency and Number of Items for Study Scales

Scale	Cronbach Alpha	# of items
Baseline Positive and Negative Affect Scale (PANAS)		
Positive Affect (PA)	.90	10
Negative affect (NA)	.82	10
Interpersonal Reactivity Index	.80	28
Perspective Taking	.80	6
Empathic Concern	.70	6
Personal Distress	.77	6
Baseline Inclusion of Other in the Self Scale (IOS)	.87	9
Baseline Visual Analog of Body Boundaries (VAS)	N/A	1
Individualism/Collectivism Scale		
Horizontal Collectivism	.73	10
Stressor Appraisals Scale		
Primary Appraisals	.81	6
Secondary Appraisals	.81	3
Stressor PANAS		
Stressor PA	.93	10
Stressor NA	.87	10
Post-Stressor IOS	.91	9
Post-Stressor VAS	N/A	1
Post-Empathic Accuracy Task IOS	.90	9
Post-Empathic Accuracy Task VAS	N/A	1

Table 5

Descriptive statistics and bivariate correlates among key study variables

	M	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. zMed	.00	.81	-													
2. Primary	2.99	.72	-.11	-												
3. Secondary	3.55	.82	.20*	-.66**	-											
4. PA	2.96	.94	.22*	-.09	.37**	-										
5. NA	1.53	.58	-.17	.64**	-.55**	-.05	-									
6. Reponses	17.88	9.07	.12	-.24*	.35**	.10	-.29**	-								
7. Correct	14.87	9.72	.25**	-.28**	.35**	.10	-.28**	.94**	-							
8. Errors	2.99	3.31	-.41**	.15	-.05	-.02	.03	-.02	-.36**	-						
9. CO react.	.78	1.25	.03	.13	-.08	.19	-.01	.01	-.02	.07	-					
10. TPR react.	-512.91	1304.74	.09	-.09	.09	-.12	-.03	.21*	.22*	-.06	-.52**	-				
11. Empathy	3.49	.42	-.10	.16	-.13	.31**	.18	-.18	-.21*	.13	.18	-.19	-			
12. PT	3.74	.70	.15	-.01	-.01	.22*	.04	-.07	-.01	-.14	.21*	-.24*	.58**	-		
13. EC	4.10	.53	.08	-.03	.13	.30**	-.00	-.23*	-.19*	-.06	.03	-.20*	.65**	.47**	-	
14. PD	2.58	.73	-.32**	.29**	-.23*	.08	.15	-.16	-.22*	.21*	.13	-.09	.47**	-.17	.01	-
15. Emp accur.	.43	.24	.06	-.13	.06	.13	-.15	-.28**	-.25**	-.01	-.01	-.01	.03	.11	.13	-.04
16. Selflessness	.00	1.4	.38**	-.16	.24*	.37**	-.11	-.00	.04	-.12	.08	.05	.13	.31**	.24*	-.15

Note. $^{**}p < .01$, $^{*}p < .05$. zMed = meditation experience, PA = stressor positive affect, NA = stressor negative affect, CO react = cardiac output reactivity, TPR react = total peripheral resistance reactivity, PT = perspective taking, EC = empathic concern, PD = personal distress, Emp accur = empathic accurac

Table 6

Hierarchical Regression Analysis for Variables Predicting Appraisals

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		$.10^{**}$	
Age	-.12		
Sex	$-.29^{**}$		
Step 2		$.11^{**}$	.01
Age	-.08		
Sex	$-.29^{**}$		
Zmed	-.07		

Note. $^{**}p < .01$, $^{*}p < .05$. Lower scores denote challenge appraisals. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 7

Hierarchical Regression Analysis for Variables Predicting Primary Appraisals

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		$.09^{**}$	
Age	-.02		
Sex	$-.30^{**}$		
Step 2		$.10^{*}$	.01
Age	.02		
Sex	$-.30^{**}$		
Zmed	-.10		

Note. $^{**}p < .01$, $^{*}p < .05$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 8

Hierarchical Regression Analysis for Variables Predicting Secondary Appraisals

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		$.11^{**}$	
Age	$.20^{*}$		
Sex	$.26^{**}$		
Step 2		$.12^{**}$	.01
Age	.15		
Sex	$.25^{**}$		
Zmed	.11		

Note. $^{**}p < .01$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 9

Hierarchical Regression Analysis for Variables Predicting Positive Affect

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		$.71^{**}$	
Age	-.04		
Sex	$.13^{*}$		
bPA	$.83^{**}$		
Step 2		$.72^{**}$	$.02^{*}$
Age	$-.11^{\dagger}$		
Sex	$.12^{*}$		
bPA	$.81^{**}$		
Zmed	$.14^{*}$		

Note. $^{**}p < .01$, $^{*}p < .05$, $^{\dagger}p < .10$. Sex was coded as female = 1 and male = 2. bPA = baseline positive affect, Zmed = meditation experience.

Table 10

Hierarchical Regression Analysis for Variables Predicting Negative Affect

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		$.21^{**}$	
Age	-.05		
Sex	$-.23^{*}$		
bNA	$.42^{**}$		
Step 2		$.22^{**}$	.01
Age	.00		
Sex	$-.22^{*}$		
bNA	$.41^{**}$		
Zmed	-.11		

Note. $^{**}p < .01$, $^{*}p < .05$. Sex was coded as female = 1 and male = 2. bNA = baseline NA, Zmed = meditation experience.

Table 11

Hierarchical Regression Analysis for Variables Predicting Number of Responses

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		$.41^{**}$	
Age	.13		
Sex	$.39^{**}$		
Step 2		$.41^{**}$	.00
Age	.12		
Sex	$.39^{**}$		
Zmed	.02		

Note. $^{**}p < .01$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 12

Hierarchical Regression Analysis for Variables Predicting Number of Errors

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		.02	
Age	-.15		
Sex	-.02		
Step 2		.41**	.40**
Age	.05		
Sex	.02		
Zmed	-.44**		

Note. $^{**}p < .01$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 13

Hierarchical Regression Analysis for Variables Predicting Percentage Correct

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		$.09^{**}$	
Age	$.21^{*}$		
Sex	$.22^{*}$		
Step 2		$.15^{**}$	$.06^{*}$
Age	.09		
Sex	$.19^{*}$		
Zmed	$.27^{*}$		

Note. $^{**}p < .01$, $^{*}p < .05$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 14

Hierarchical Regression Analysis for Variables Predicting Challenge Physiology

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		.02	
Age	-.12		
Sex	-.05		
Step 2		.02	.00
Age	-.12		
Sex	-.05		
Zmed	.03		

Note. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 15

Descriptive Statistics Across Time and Group for Cardiac Output (CO: upper) and Total Peripheral Resistance (TPR: lower)

		CO	
Timepoint	Group	*M*	*SD*
Baseline			
Minute 5	Mediator	2.73	1.38
	Nonmediator	2.56	.99
Task			
Minute 1	Mediator	3.50	2.01
	Nonmediator	3.26	1.27
Minute 2	Mediator	2.96	1.11
	Nonmediator	3.09	1.23
Recovery			
Minute 1	Mediator	3.61	2.27
	Nonmediator	2.91	1.25
Minute 2	Mediator	3.18	1.99
	Nonmediator	2.83	1.08
		TPR	
Baseline			
Minute 5	Mediator	3208.52	1587.33
	Nonmediator	3148.58	1604.25
Task			
Minute 1	Mediator	2675.72	1490.35
	Nonmediator	2671.32	1323.83
Minute 2	Mediator	3040.52	1228.11
	Nonmediator	3181.74	1830.78
Recovery			
Minute 1	Mediator	2932.78	1839.04
	Nonmediator	3215.35	1775.08
Minute 2	Mediator	3261.05	2030.63
	Nonmediator	3073.08	1558.67

Note. Mediating group $N = 33$, Nonmeditating group $N = 46$.

Table 16

Descriptive Statistics Across Time and Group for Pre-ejection Period

Timepoint	Group	*M*	*SD*
Baseline			
Minute 5	Mediator	113.00	25.58
	Nonmediator	104.21	23.49
Task			
Minute 1	Mediator	104.65	36.36
	Nonmediator	85.98	25.67
Minute 2	Mediator	109.85	34.19
	Nonmeditator	89.96	25.28
Recovery			
Minute 1	Mediator	103.15	29.40
	Nonmediator	98.42	22.38
Minute 2	Mediator	104.10	32.97
	Nonmediator	101.09	22.68

Note. Mediating group $N = 20$, Nonmeditating group $N = 43$.

Table 17

Hierarchical Regression Analysis for Variables Predicting Trait Empathy

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		.20**	
Age	-.23*		
Sex	-.39**		
Step 2		.20**	.00
Age	-.25*		
Sex	-.39**		
Zmed	.05		

Note. $^{**}p < .01$, $^{*}p < .05$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 18

Hierarchical Regression Analysis for Variables Predicting Perspective Taking

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		.02	
Age	-.02		
Sex	-.12		
Step 2		.05	.03†
Age	-.12		
Sex	-.14		
Zmed	.21†		

Note. †$p < .10$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 19

Hierarchical Regression Analysis for Variables Predicting Empathic Concern

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		$.10^{**}$	
Age	.07		
Sex	$-.31^{**}$		
Step 2		$.11^{*}$	.01
Age	.02		
Sex	$-.31^{**}$		
Zmed	.10		

Note. $^{**}p < .01$, $^{*}p < .05$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 20

Hierarchical Regression Analysis for Variables Predicting Personal Distress

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		$.13^{**}$	
Age	$-.29^{*}$		
Sex	$-.22^{**}$		
Step 2		$.17^{**}$	$.04^{*}$
Age	$-.19^{\dagger}$		
Sex	$-.21^{*}$		
Zmed	$-.22^{*}$		

Note. $^{**}p < .01$, $^{*}p < .05$, $^{\dagger}p < .10$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 21

Hierarchical Regression Analysis for Variables Predicting Empathic Accuracy

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		.01	
Age	.08		
Sex	-.08		
Step 2		.01	.00
Age	.06		
Sex	-.09		
Zmed	.04		

Note. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Table 22

Hierarchical Regression Analysis for Variables Predicting Selflessness

Variable: $N = 110$	β	R^2	ΔR^2
Step 1		.16**	
Age	.08		
Sex	.06		
Collectivism	.39**		
Step 2		.31**	.15**
Age	-.13		
Sex	.02		
Collectivism	.39**		
Zmed	.44**		

Note. $^{**}p < .01$. Sex was coded as female = 1 and male = 2. Zmed = meditation experience.

Figures

Figure 1

Illustration of the study design

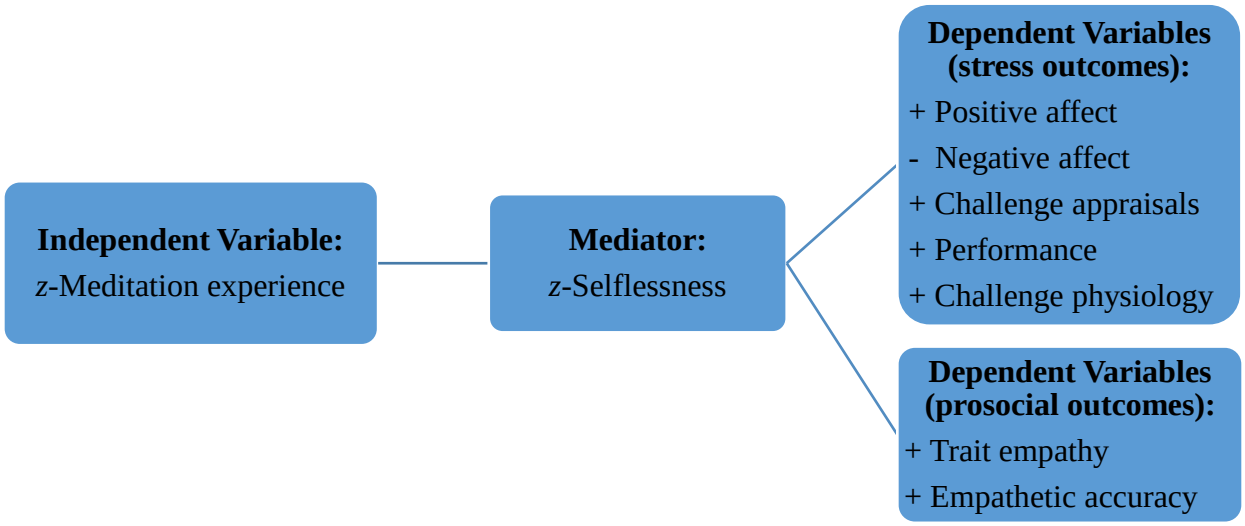


Figure 2

Illustration of participant flow and measurement timepoints

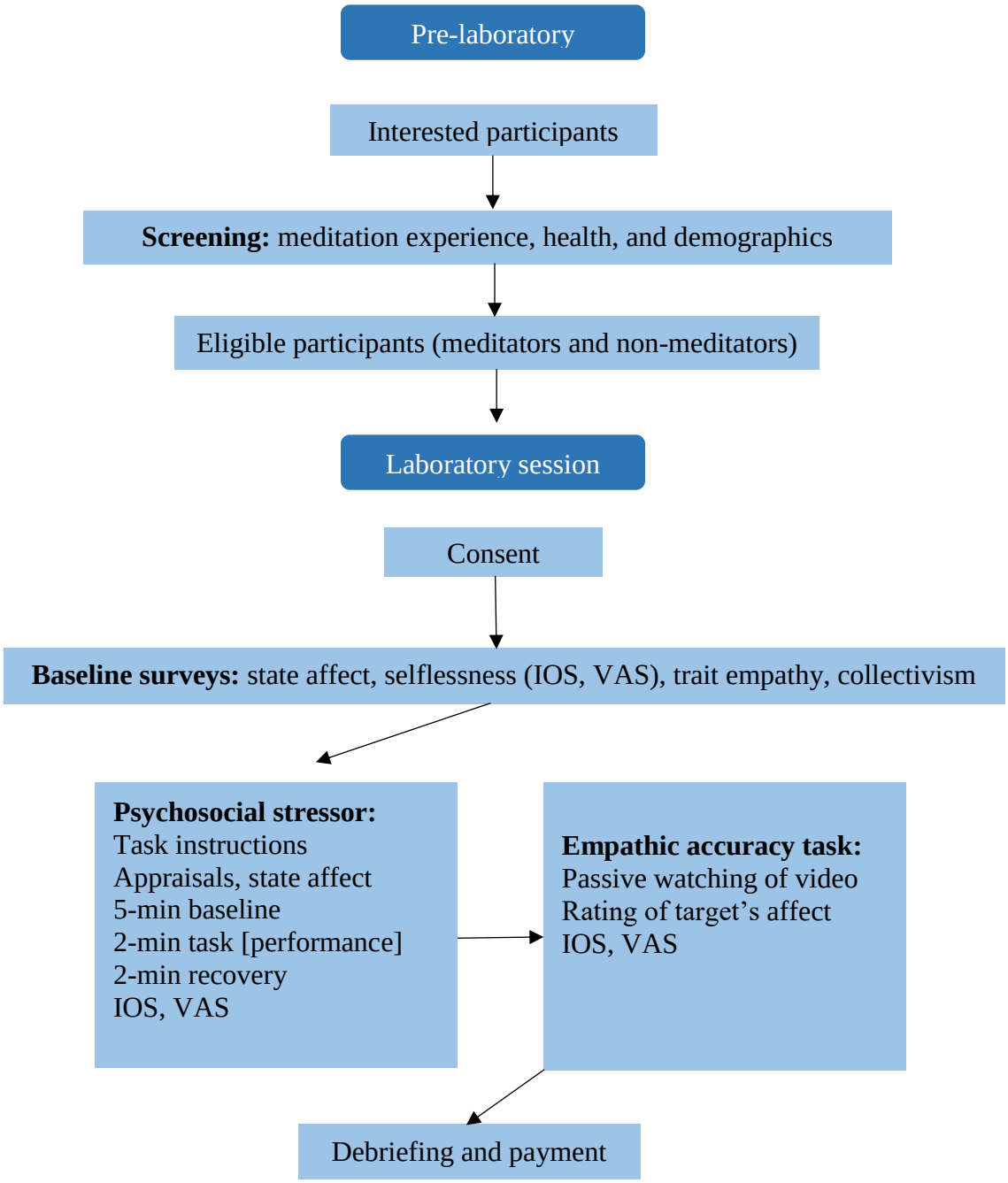
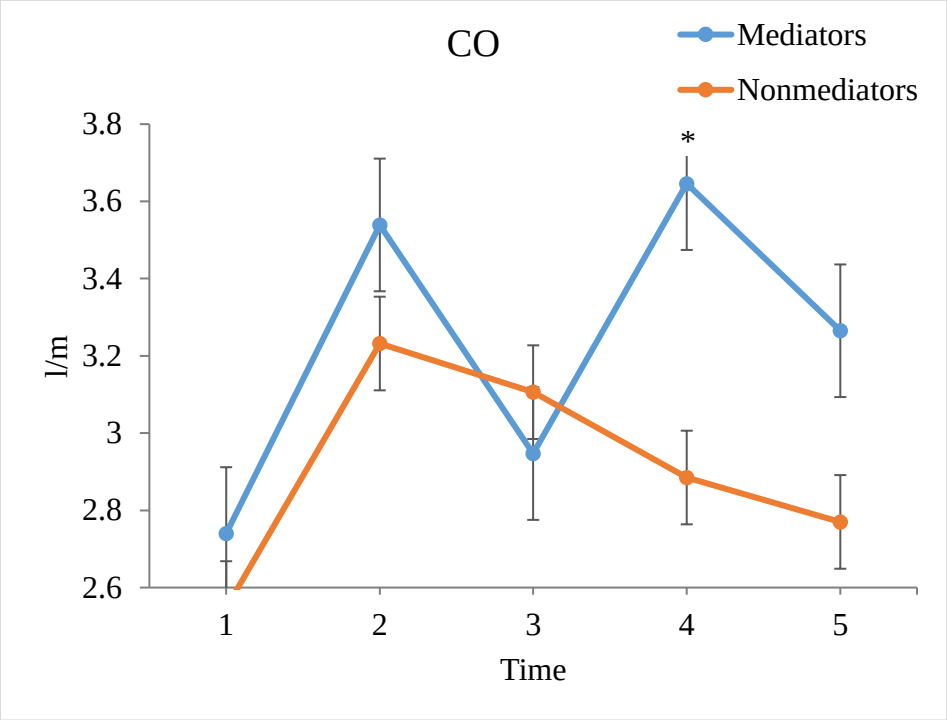


Figure 3

Cardiac output responses over time

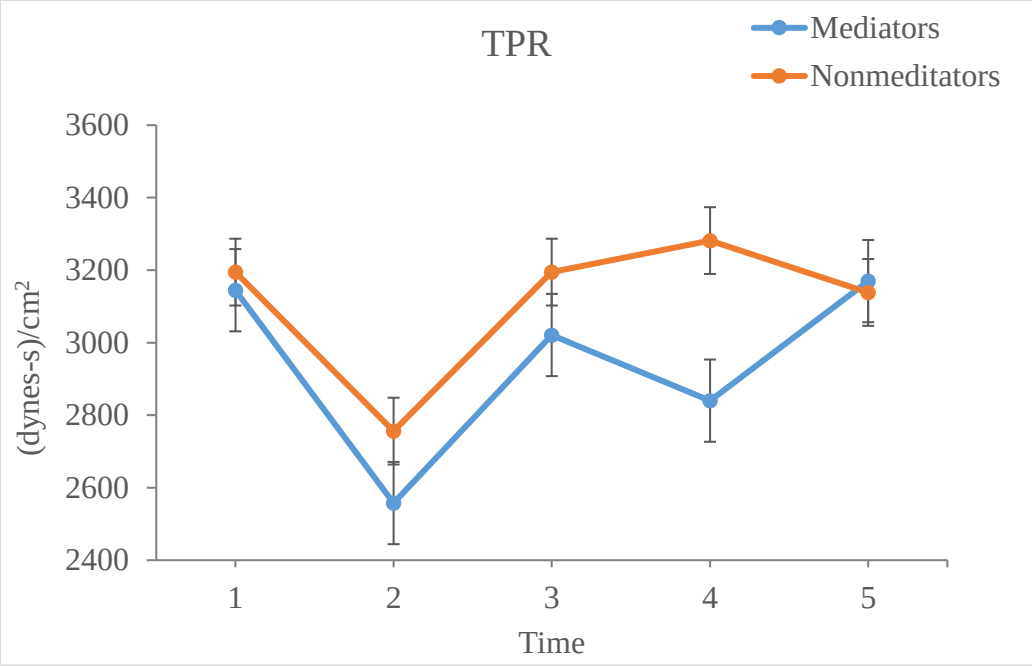


Note. Values indicate mean cardiac output (CO) responses to the stressor by mediation groups. Five timepoints are shown: last minute of baseline, task minutes 1 and 2, and recovery minutes 1 and 2.

*denotes significant mean different at the $p < .05$ level.

Figure 4

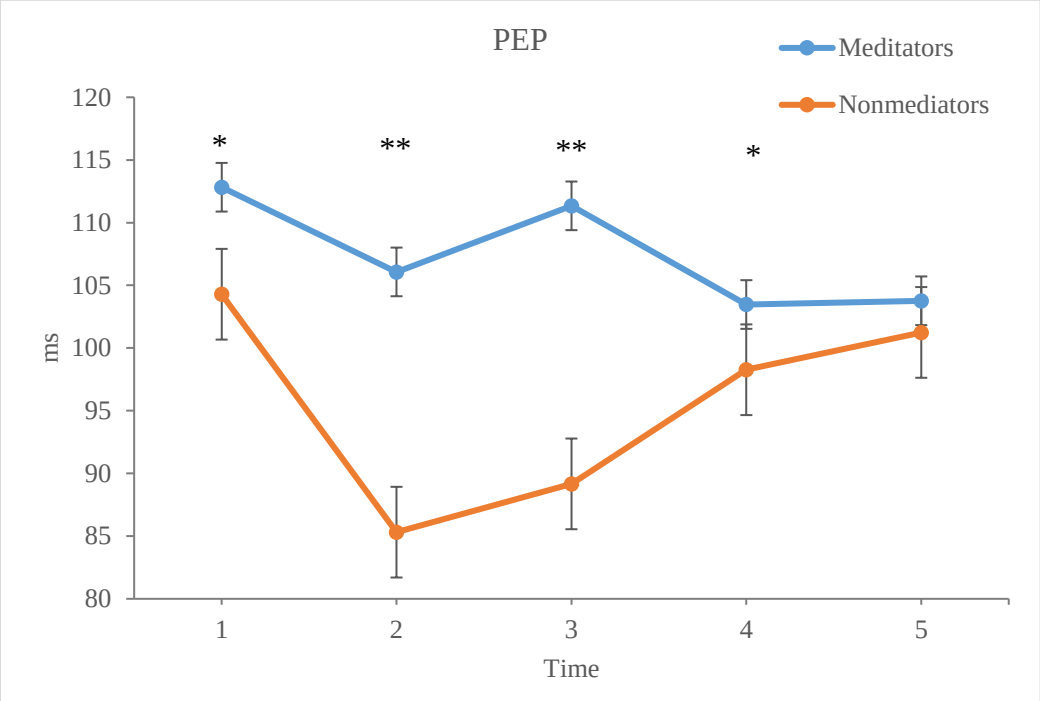
Total peripheral resistance responses over time



Note. Values indicate mean total peripheral resistance (TPR) responses to the stressor by mediation groups. Five timepoints are shown: last minute of baseline, task minutes 1 and 2, and recovery minutes 1 and 2.

Figure 5.

Pre-ejection period responses over time



Note. Values indicate mean pre-ejection period (PEP) responses to the stressor by mediation groups. Five timepoints are shown: last minute of baseline, task minutes 1 and 2, and recovery minutes 1 and 2.

** denotes significant mean different at the $p < .01$ level and * denotes significance at the $p < .05$ level.

Figure 6

Path model of the indirect effect of meditation experience on positive affect via selflessness.

Note. All values are beta coefficients. Values in parentheses represent the addition of selflessness into the model.

** denotes significance at the $p < .01$ level and * denotes significance at the $p < .05$ level.

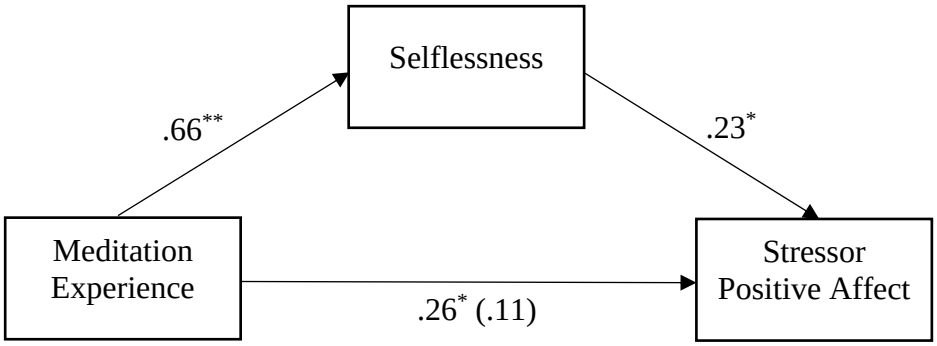


Figure 7

Path model of the indirect effect of meditation experience on perspective taking via selflessness.

Note. All values are beta coefficients. Values in parentheses represent the addition of selflessness into the model.

* denotes significance at the $p < .05$ level.

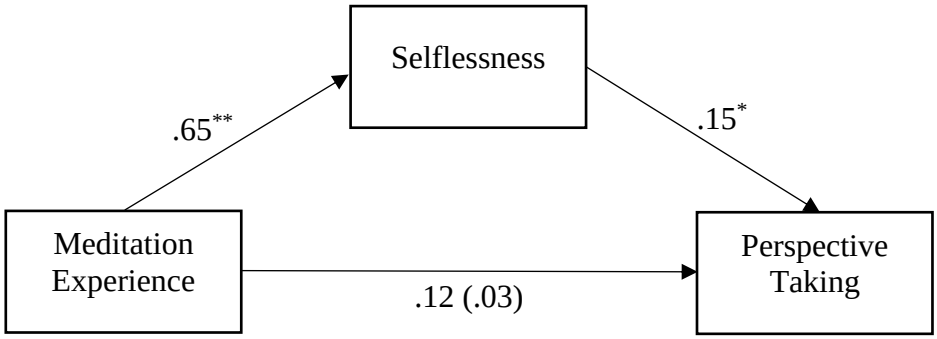
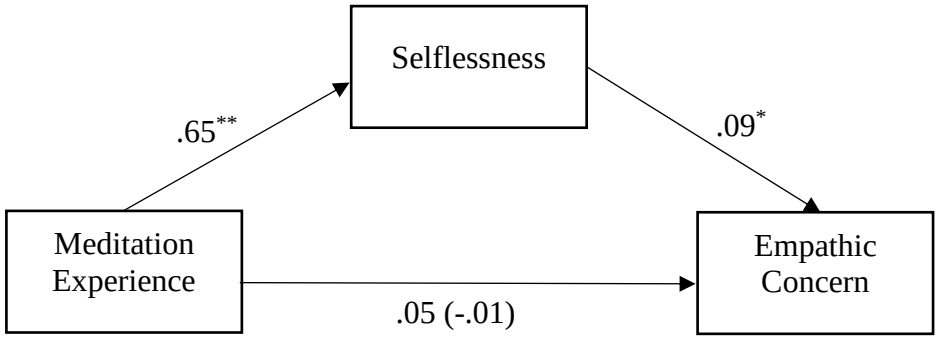


Figure 8

Path model of the indirect effect of meditation experience on empathic concern via selflessness.

Note. All values are beta coefficients. Values in parentheses represent the addition of selflessness into the model.

* denotes significance at the $p < .05$ level.



Appendix

Appendix A

Recruitment Survey

We would like to get an idea of your experience, if any, with meditation. Answer the following questions as honestly and accurately as possible.

1. Do you currently practice meditation? (Choose one) Yes OR No
2. If you indicated No to question 1, are you interesting in practicing meditation? (Choose one) Yes OR No

If you indicated NO to questions 1, you may stop completing this survey. Otherwise, continue.

3. Approximately how many times a week do you practice meditation of any kind?
4. Approximately how many minutes daily do you practice meditation of any kind?
5. Approximately how many years have you practiced meditation of any kind?
6. Approximately how many lifetime hours have you practiced meditation of any kind?
7. Do you currently practice *mindfulness* meditation? (Choose one) Yes OR No

   Approximately how many times a week do you practice mindfulness meditation?

   Approximately how many minutes daily do you practice mindfulness meditation?

   Approximately how many years have you practiced mindfulness meditation?

   Approximately how many lifetime hours have you practiced mindfulness meditation?
8. Do you currently practice *loving-kindness* meditation? (Choose one) Yes OR No

   Approximately how many times a week do you practice loving-kindness meditation?

   Approximately how many minutes daily do you practice loving-kindness meditation?

   Approximately how many years have you practiced loving-kindness meditation?

Approximately how many lifetime hours have you practiced loving-kindness meditation?

9. Do you currently practice *compassion* meditation? (Choose one) Yes OR No

   Approximately how many times a week do you practice compassion meditation?

   Approximately how many minutes daily do you practice compassion meditation?

   Approximately how many years have you practiced compassion meditation?

   Approximately how many lifetime hours have you practiced compassion meditation?

10. Do you currently practice *transcendental* meditation? (Choose one) Yes OR No

    Approximately how many times a week do you practice transcendental meditation?

    Approximately how many minutes daily do you practice transcendental meditation?

    Approximately how many years have you practiced transcendental meditation?

    Approximately how many lifetime hours have you practiced transcendental meditation?

11. Do you currently practice any *other* type of meditation not listed in this survey? If yes, provide the name of the meditation, how many times a week you practice it, how many minutes daily you practice it, how many years you have practiced it, and how many lifetime hours you have practiced it.

12. What is your meditation tradition?

    Zen Theravada Vipassana Insight Not sure Other

13. What is the main motivation for your meditation practice?

    Wellness Treatment of illness Self-improvement Self or spiritual transcendence Enlightenment Other

14. Have you ever attended a meditation retreat? (Choose one) Yes OR No

    Approximately how many years ago was your last retreat?

    How many days was your last retreat?

We would like to better understand you as a person.

15. What is your age?

16. What is your sex? Female Male

17. What is your ethnicity?

    ____ African American

    ____ American Indian or Alaskan Native

    ____ Asian or Pacific Islander

    ____ Hispanic/Latino

    ____ Caucasian (White, non-Hispanic)

    ____ Other (please specify): _____

18. What is the highest level of education you have received?

    ____ Some high school, no diploma

    ____ High school graduate, diploma or the equivalent (for example: GED)

    ____ Some college, no degree

    ____ Trade/technical/vocational training, certificate or degree

    ____ Associate's degree

    ____ Bachelor's degree

    ____ Master's degree

    ____ Professional degree

    ____ Medical or Doctorate degree

19. What is your annual income combined from all sources?

    ____ Less than $20,000

    ____ $20,000 to $34,999

____ $35,000 to $49,999

____ $50,000 to $74,999

____ $75,000 to $99,999

____ Over $100,000

20. What is your height in feet and inches?

21. What is your weight in pounds?

22. Can you read and write fluently in English?

23. Do you have normal or corrected to normal vision?

Exclude if indicated No.

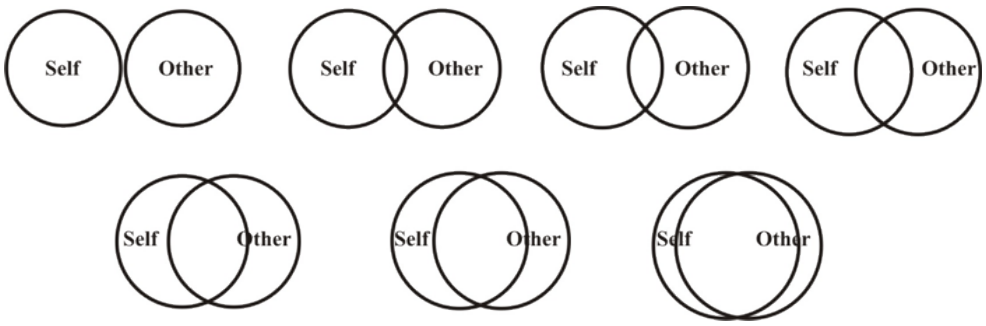
24. Are you currently pregnant?

Exclude if indicated Yes.

25. Do you or a parent have a history of hypertension or cardiovascular disease?

Appendix B

Inclusion of Other in the Self Scale

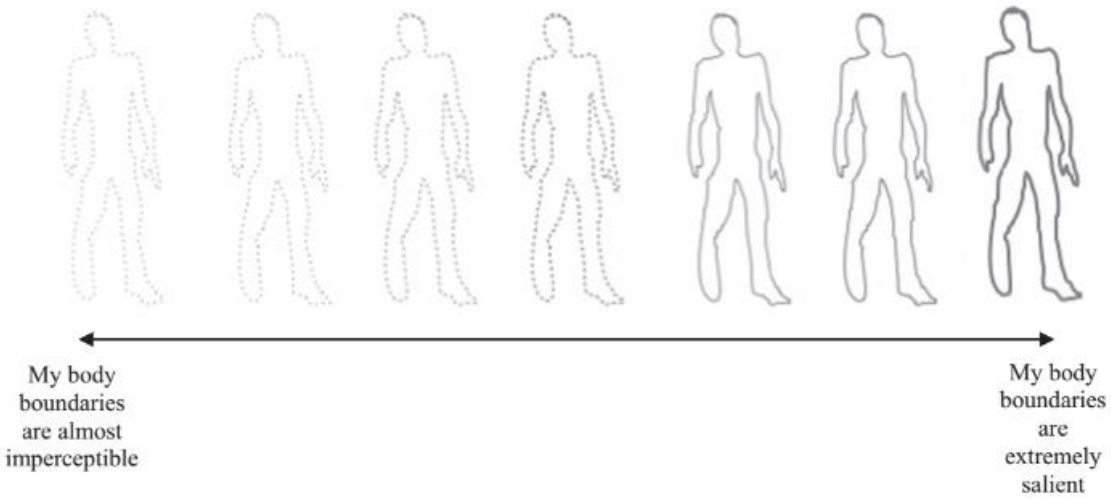


Pictorial representation of including the self in a close relationship.

For baseline, post-stressor, and post-empathetic accuracy task, “other” was replaced with the following referents: “strangers,” “friends,” “family”, “community”, “humanity”, “other beings”, “the environment”, “the world,” and “the universe.”

Appendix C

Visual Analog of Body Boundaries



Pictorial representation of a visual analog scale measuring perceived body boundaries. Instructions: Take a moment to examine the bodies and notice that some are more or less salient. A salient body is a body in which one feels enclosed, that is highly distinct from the bodies of others, and that sets a marked boundary between one and the rest of the world. Conversely, a body low in salience is strongly connected to its surroundings, without any marked boundaries between one and the rest of the world. Indicate which of the bodies best represents their current body state. If the boundaries of your body are highly salient, draw a line on the extreme right of the double-headed arrow. If the boundaries of your body are almost imperceptible, draw a line at the extreme left of the double-headed arrow. An intermediate state is indicated by drawing a line somewhere between the two poles of the double-headed arrow.

For the baseline assessment, participants rated the general saliency of their body boundaries.

For the post-stressor and empathetic accuracy task assessment, participants retrospectively rated how salient their body boundaries were while engaging with the tasks.

Appendix D

Written responses given by meditators and non-meditators post-stressor (top) and post-empathic accuracy task (bottom).

Note: written responses from the same 3 meditators and non-meditators are used for purposes of comparison. Responses are rank ordered by level of meditation experience.

Post-stressor (meditators)

1. "I was most focused on the task at hand, so my concentration was more in one direction and that was the ceiling. I also felt a little colder."
2. "I felt myself in the chair, and I heard the humming above me and some shuffling about outside the room. I had a visual representation of the number that was being subtracted and noticed a pattern. At the same time of noticing that, I observed how doing so allowed that part of my mind to run itself while I forgot that I was doing it, hence the incorrect answers towards the end."
3. "Conscious awareness. Noticed the increase in heart rate of the body and shift in breathing. Noticed the mind wondering about the humor in the seemly fear response which was triggering the bodily responses. Noticed the thinking at the beginning of the countdown where mind/brain was looking for a convention to perform the countdown in an efficient manner as if mind were going to be judged on the performance."

Post-stressor (non-meditators):

1. "It was a good experience, I never had this kind of task in my life. I am very good in math but this task which I done is neither difficult nor easy. I was very focused on doing the task without any errors, but somehow I lost the numbers in the middle. When I go to home I try

to do the task correctly without any mistakes along with my friends and ask them to do the task. On the whole I am not very disappointment, I tried my level best."

2. "I guess I didn't feel my body while calculating. I didn't feel any sensation over my body, I was just focusing in solving."
3. "I was majorly focused on picturing the numbers so I could subtract correctly, but I also realized I was looking up in the air, trying to pull them out of thin air. When I got stuck I was afraid to repeat the number because I felt that I wasn't supposed to even though that wasn't stated. I really wanted to do well and was excited when I got some right but felt like a child learning my multiplication tables and getting them wrong at some points."

Post-empathic accuracy task (mediators)

1. "I understood what she was going through having just completed the task myself. Focusing on her emotions and reactions even though she had to start over. Made me wonder if other people got angry or frustrated at the task. Didn't pay too much attention to other things in the room.
2. "I watched the person's breathing and facial expressions. I felt that she was daunted by the task at hand. I noticed that she transposed the numbers immediately."
3. "I noticed the humor of someone else undergoing the same experiment I was doing. Second thought was a reflection of conversation with researcher who asked if I was comfortable with being recorded - AND knowing the reason why it (answer one above) was funny. Noticed my attentiveness with trying to witness the subject's emotions and feelings for the survey I was asked to complete."

Post-empathic accuracy task (non-mediators)

1. “While watching the video I felt for the lady. I could relate to the stress she was going through. I was impressed she actually threw out more numbers than I did. I felt like I could have done better if I could have stayed focus more on the numbers and not worrying so much. The task by far was a challenge. Also in seeing this video I wonder who will see mine and how will they react.”
2. “I tried to judge the person in the video through her facial and vocal expression so I was focusing on that video.”
3. “I didn't feel the electrodes or that my shirt is partially up because I was focused on her. I wasn't sure when I should start the worksheet, I didn't want to get the answers wrong even though there is no wrong answer (I think). I think I was grinding my teeth (which I do unconsciously) because I was nervous for her, but also laughed with her in the beginning because I could relate to how she seemed to feel.”