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A single session of meditation reduces of physiological indices of anger in both experienced and novice meditators

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ABSTRACT

The goal of the present study was to explore how anger reduction via a single session of meditation might be measured using psychophysiological methodologies. To achieve this, 15 novice meditators (Experiment 1) and 12 practiced meditators (Experiment 2) completed autobiographical anger inductions prior to, and following, meditation training while respiration rate, heart rate, and blood pressure were measured. Participants also reported subjective anger via a visual analog scale. At both stages, the experienced meditators' physiological reaction to the anger induction reflected that of relaxation: slowed breathing and heart rate and decreased blood pressure. Naïve meditators exhibited physiological reactions that were consistent with anger during the pre-meditation stage, while after meditation training and a second anger induction they elicited physiological evidence of relaxation. The current results examining meditation training show that the naïve group's physiological measures mimicked those of the experienced group following a single session of meditation training.

1. A single session of meditation reduces of physiological indices of anger in both experienced and novice meditators

Anger can be defined as a state that is elicited through frustration, threats to one's authority or reputation, disrespect, and/or a sense of injustice or violation of norms or rules (Spielberger & Reheiser, 2010). It is normal and healthy to experience occasional anger (Tyson, 1998), but excessively frequent and/or intense angry periods can be harmful (Bushman, 2002; Bushman, Bonacci, Pedersen, Vasquez, & Miller, 2005). There are numerous interventions shown to reduce harmful levels of anger (Beck & Fernandez, 1998; Hofmann, Grossman, & Hinton, 2011). One such intervention is meditation (Hofmann et al., 2011), or "the intentional self regulation of attention from moment to moment" (Kabat-Zinn, 1982, p. 82). Explorations using psychophysiological and/or neuroimaging techniques have begun to elucidate the mechanisms underlying the benefits of meditation and its link to anger reduction.

One possible explanation for the role of meditation in reducing anger proneness is that it improves general cognitive functioning (Lutz, Jha, Dunne, & Saron, 2015; Lutz, Slagter, Dunne, & Davidson, 2008; Tang & Posner, 2013; Tang et al., 2007). More specifically, routine meditation is associated with reduced neural activity during resting brain states (e.g., within the default mode network) and enhancement in the neurocognitive mechanisms involved in emotion regulation (e.g., cognitive flexibility, cognitive control) (Ainsworth, Eddershaw, Meron, Baldwin, & Garner, 2013; Chiesa, Calati, & Serretti, 2011; Denson, 2013; Desbordes et al., 2012; Ivanovski & Malhi, 2007; Kang, Gruber, & Gray, 2012; Luders, Toga,

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Lepore, & Gaser, 2009; Lutz et al., 2008, 2015; Taylor et al., 2011). Compared to non-meditators, habitual practitioners of meditation elicit reduced activity in areas of the default mode network associated with self-reported *mind-wandering*, or the tendency to think about events of the future and past (Berkovich-Ohana, Glicksohn, & Goldstein, 2012; Brewer et al., 2011; Pagnoni, 2012). Mind-wandering is positively associated with self-reported unhappiness and the use of meditation reduces this tendency (Brewer et al., 2011; Killingsworth & Gilbert, 2010). The introduction of meditative practice to inexperienced meditators reduced mind-wandering frequency (Chambers, Lo, & Allen, 2008; Keng, Smoski, & Robins, 2011; Robins, Keng, Ekblad, & Brantley, 2012).

There is evidence that meditation can show immediate improvements in functioning for individuals who are naïve to meditation. New practitioners of mindfulness meditation report reduced rumination, reduced negative emotional reactivity, and reduced depressive symptoms (Borders, Earleywine, & Jajodia, 2010; Chambers et al., 2008; Paul, Stanton, Greeson, Smoski, & Wang, 2013; Shapiro, Oman, Thoresen, Plante, & Flinders, 2008). In naïve meditators, four meditation training sessions were associated with a broad range of cognitive and affective improvements (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). There is also evidence that a single session of meditation in naïve individuals can have analogous effects to habitual meditation practice (Carlson, Bacaseta, & Simanton, 1988; Fabes & Eisenberg, 1997; Rausch, Gramling, & Auerbach, 2006), though most studies of novel meditation practice explore training protocols that typically last ten days or more (Shapiro et al., 2008). The psychophysiological mechanisms of these improvements are not yet fully known.

The autonomic nervous system (specifically, respiration, blood pressure, and heart rate) can be used as an index for different emotional states. Within the autonomic nervous system, anger has been found to be highly related to increased sympathetic nervous system activity (Critchley et al., 2005). Respiration rate (RR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) increase when anger is induced (Ax, 1953; Rainville, Bechara, Naqvi, & Damasio, 2006; Sinha, Lovallo, & Parsons, 1992). These same measures decrease during meditation (Ditto, Eclache, & Goldman, 2006; Hussain & Bhushan, 2010; Nyklíček, Mommersteeg, Van Beugen, Ramakers, & Van Boxtel, 2013; Rubia, 2009; Travis, 2001), perhaps because the parasympathetic nervous system (PNS) becomes more engaged during a meditative state (Craig, 2010; Tang & Posner, 2013).

Heart rate variability (HRV), the variance of inter-beat intervals during cardiac activity, has been receiving attention for its potential in exploring emotional states and ability to discriminate sympathetic from parasympathetic influence in the central nervous system (Appelhans & Luecken, 2006). According to Polyvagal Theory, emotional experience is a result of multiple physiological states (Porges, 1995, 2001, 2007). There is also evidence that physiological reactivity can be modified in a top-down manner, such as through meditation or other effortful methods to regulate emotion (Craig, 2010; Taylor, Goehler, Galper, Innes, & Bourguignon, 2010). Greater PNS input results in more pronounced acceleration and deceleration of respiration and more variable intervals between heartbeats due to the rapid activity of the vagus nerve's metabolic control; these changes are measured as higher HRV (Berntson, 1997; Berntson, Cacioppo, & Quigley, 1993; Brindle, Ginty, Phillips, & Carroll, 2014; Somsen, Jennings, & van der Molen, 2004). HRV may be expressed as a function of frequency: high frequency bands (.15–.40 Hz) are indicative of parasympathetic influence corresponding to vagal influence on the sino-atrial node; low frequency bands (.05–.15 Hz) are affected by both sympathetic and parasympathetic domains of the baroreceptor influence on heart rate (Berntson, 1997).

High frequency heart rate variability (HF-HRV) is negatively correlated with self-reported anger (Appelhans & Luecken, 2006; Marci, Glick, Loh, & Dougherty, 2007); thus decreased parasympathetic influence is associated with increased anger. There is emerging evidence that HF-HRV increases as a result of the meditative state, which is suggestive of increased PNS activity (Burg, Wolf, & Michalak, 2012; Takahashi et al., 2005). Whereas it is generally believed that HF-HRV is influenced by the PNS, it is debated whether the sympathetic system influences this measure. One proposed solution has been to calculate a ratio of both high frequency and low-frequency heart rate variability, referred to as the Sympathovagal Balance ratio (Berntson, 1997; Pagani et al., 1986; Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996), though the validity, utility, and effectiveness of this solution has long been controversial (Billman, 2013; Eckberg, 1997). Previous research has shown that the Sympathovagal Balance improved with meditation interventions (Kharya et al., 2014; Pal, 2015; Pal, Agarwal, Karthik, Pal, & Nanda, 2014; Sarang & Telles, 2006), so we included it as a variable in the present study.

The present pair of experiments had three primary aims regarding meditation and anger: (a) to determine if an acute meditative state will decrease an anger response both subjectively and physiologically; (b) to examine emotional reactivity in individuals naïve to meditation to determine if a relatively short exposure to meditation training can lead to significant changes both in perceived anger and in the physiological markers of anger; (c) to compare the reactivity of naïve meditators to that of practiced meditators, both as a point of comparison for the naïve group and extend current psychophysiological research examining the benefits provided by meditation during anger regulation. For both experiments, we utilized a modified A–B–C–A–B experimental design. We induced anger in two sessions: a baseline-anger condition and one following meditative training while physiological measures (HRV, RR, SBP, DBP) were recorded throughout. Following the initial anger reduction, we expected similar patterns of physiological reactivity (i.e. increased RR, SBP, & DBP; and decreased HF-HRV) and subjective report of anger (i.e., VAS) in both Experiment 1 and Experiment 2, though the effect sizes for the experienced meditators would be smaller than for the naïve group. We also hypothesized that both groups would show improvement in these same measures following meditation training, though the effect sizes for the naïve group would be greater than for experienced meditators.