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Impact of long-term meditation practice on cardiovascular reactivity during perception and reappraisal of affective images

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ABSTRACT

Meditation has been found to be an efficient strategy for coping with stress in healthy individuals and in patients with psychosomatic disorders. The main objective of the present study was to investigate the psychophysiological mechanisms of beneficial effects of meditation on cardiovascular reactivity. We examined effects of long-term Sahaja Yoga meditation on cardiovascular reactivity during affective image processing under "unregulated" and "emotion regulation" conditions. Twenty two experienced meditators and 20 control subjects participated in the study. Under "unregulated" conditions participants were shown neutral and affective images and were asked to attend to them. Under "emotion regulation" conditions they down-regulated negative affect through reappraisal of negative images or up-regulated positive affect through reappraisal of positive images. Under "unregulated" conditions while anticipating upcoming images meditators vs. controls did not show larger pre-stimulus total peripheral resistance and greater cardiac output for negative images in comparison with neutral and positive ones. Control subjects showed TPR decrease for negative images only when they consciously intended to reappraise them (i.e. in the "emotion regulation" condition). Both meditators and controls showed comparable cardiovascular reactivity during perception of positive stimuli, whereas up-regulating of positive affect was associated with more pronounced cardiac activation in meditators. The findings provide some insight into understanding the beneficial influence of meditation on top-down control of emotion and cardiovascular reactivity.

1. Introduction

Recent years have seen a growing interest in meditation as a tool for alternative therapy of stress-related and psychosomatic diseases (for reviews see Barnes and Orme-Johnson, 2012; Chen et al., 2012; Hagins et al., 2013; Khoury et al., 2013). For instance, relatively specific effects of meditation have been identified in relation to cardiovascular diseases. It has been shown that meditation, in short-term trainings and long-term practice, prevents elevated baseline blood pressure and heart rate in healthy individuals and reduces them in hypertensive patients (Anderson et al., 2008; Ankad et al., 2011; Astin et al., 2003; Barnes et al., 2004; Goldstein et al., 2012; Hughes et al., 2013; Nidich et al., 2009), and also decreases symptoms of angina pectoris, cholesterol levels, myocardial ischemia and left ventricular hypertrophy in patients (Barnes et al., 2012; Barnes and Orme-Johnson, 2012; Schneider et al., 2006; Walton et al., 2004). In this regard, the main aim of the present study was to investigate the possible psychophysiological mechanism of beneficial effects of long-term meditation practice on the cardiovascular system. It can be assumed that this mechanism is related not only to beneficial changes in the cardiovascular system during the meditation process, but also to less prominent cardiovascular activation in response to negative stimuli. A lessened impact of negative stimuli on practitioners of mindfulness meditation has been confirmed on attentional and neurophysiological levels. For instance, mindfulness-oriented intervention reduced attentional bias for pain-related stimuli in patients with chronic pain (Garland and Howard, 2013) and long-term mindfulness meditators showed attenuated brain response upon viewing negative pictures (Sobolewski et al., 2011; Taylor et al., 2011). Thus, reduced sensitivity to negative information allows meditators to prolong periods of cardiovascular "silence" leading to adaptive functional and morphological changes in the cardiovascular system. Probably, *changing* the *appraisal* of the significance of incoming aversive stimuli is one of the possible mechanisms for reducing the psychophysiological reactivity to negative information. This assumption is strongly supported by the mindful coping model, proposed by E. Garland et al., which argues for the role of mindfulness, inherent in many meditative styles, in positive reappraisal coping (Garland et al., 2009). Mindfulness practices involve monitoring the content of experience (thoughts, feelings, or sensations) occurring in the present moment while maintaining a

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specific attentional stance: awareness of the phenomenal field as an attentive and nonattached observer (for reviews see Cahn and Polich, 2006; Wadlinger and Isaacowitz, 2011). According to Garland's model, when a given event is "appraised as a threat, harm, or loss that exceeds one's capabilities, the individual may initiate an adaptive response by decentering from this stress appraisal into the mode of mindfulness, wherein one attends to the dynamic process of consciousness itself rather than its contents. From the vantage point of this expanded, metacognitive awareness, one can then reappraise the given event in a positive manner by attributing to it new meaning" (Garland et al., 2009, p. 8). Therefore it is likely that the ability to reappraise negative stimuli can be developed as a consequence of meditation practice and acts as an automatic and effortless emotion regulation strategy, allowing meditators to make less negative appraisals of stressful stimuli, thereby reducing the intensity and duration of concomitant cardiovascular activation.

Thus, the main aim of the present study was to investigate the influence of long-term Sahaja Yoga meditation practice,[1] largely related to a mindfulness type of meditation (Manocha et al., 2012), on the dynamics of the cardiovascular response to affective images, eliciting negative emotions. Considering that cardiovascular responding is multi-dimensional, particular care was taken to assess multiple measures of cardiovascular responding, including heart rate (HR), stroke volume (SV), cardiac output (CO), total peripheral resistance (TPR), and mean arterial blood pressure (MBP).

Generally, cardiovascular response to negative images is characterized by a large initial HR deceleration, sustained for several seconds and accompanied by subsequent CO and blood pressure (BP) decrease, which is indicative of heightened orienting and continued attention to a threatening stimulus (Bradley et al., 2001, 2012; Dan-Glauser and Gross, 2011; Minati et al., 2009). Excessively long bradycardia may diminish oxygen recourses, depress central nervous system function, reduce behavioral complexity and compromise the fight–flight potential of mammals (Porges, 1995, 2009). Thus, the cardiac component of the orienting response must be of short duration, providing a rapid recovery of hemodynamics. We hypothesized that meditators in contrast to controls would diminish threat patterns of cardiovascular activity in the early phase of emotional processing and would be characterized by less prominent orienting bradycardia, and, therefore, reduced subsequent CO and BP decreases in response to negative images. Since we and other authors recently showed that anticipation of negative stimuli was characterized by increased vascular resistance and decreased cardiac output (Pavlov et al., 2014; Zanstra et al., 2010), we also examined the impact of meditation practice on cardiovascular activity in the pre-stimulus periods. We hypothesized that meditators as compared to controls would be characterized by lower TPR and larger CO during anticipation of negative stimuli.

It should be noted, that there is growing evidence that positive emotion has beneficial effects on endocrine, immune and cardiovascular systems (Davidson et al., 2010; Dockray and Steptoe, 2010; Fredrickson, 2000, 2004; Kubzansky and Thurston, 2007; Steptoe et al., 2009; Tindle et al., 2010). So we have included positive stimuli in the experimental procedure. Early hemodynamic changes in response to positive images are usually characterized by a triphasic (deceleratory, acceleratory, deceleratory) heart rate response where HR and CO decreases are less pronounced than for negative stimuli (Bradley et al., 2001, 2012; Pavlov et al., 2014). Taking into account that long-term meditation practice and meditation trainings contribute to developing positive affectivity (Sridevi et al., 1998), we assume that meditators in comparison to controls would show more pronounced cardiac activation in response to positive images, indexed by greater HR and CO. Increased cardiac activation in the absence of vasoconstriction may characterize the challenge state, associated with the cognitive effort, approach motivation and positive emotion (Blascovich, 2008) and accompany up-regulation of positive affect (Pavlov et al., 2014; Giuliani et al., 2008).

Returning to the mechanisms of beneficial effects of meditation on the cardiovascular system, we may assume that long-term meditation practice not only contributes to automatic changes of appraisals, but also to the development of voluntary reappraisal, associated with deliberate attempts to down- or up-regulate emotion through reappraising the meaning of the emotion-eliciting situation or stimulus (Gross, 2002). Reappraisal, as a voluntary emotion regulation strategy, is implemented through different higher cognitive processes, such as memory, selective attention and response selection, which may be used to direct attention to reappraisal-relevant stimulus features and hold in mind reappraisal goals as well as the content of one's reappraisal (for review see Ochsner et al., 2012). Since mindfulness meditation practice significantly improves attention regulation, including selective attention (for review see Chiesa et al., 2011) we predict developed voluntary reappraisal skills in experienced Sahaja Yoga meditators. Therefore, we also investigated the impact of meditation on cardiovascular response to affective images during down-regulating negative affect through reappraisal of negative images and up-regulating positive affect through reappraisal of positive images. Instructions for increasing positive affect were used, because the ability to increase it seemed to be more actual for health outcomes than, for example, down-regulating of positive emotions.

We hypothesized that meditators would be more effective than controls in down-regulating, demonstrating lower TPR in the anticipatory period along with reduced orienting decreases of HR, CO and BP in comparison to natural perception of negative images. Based on our recent study (Pavlov et al., 2014) we expect that controls would only decrease TPR and increase CO in the anticipatory period, but would fail to reduce cardiac orienting response. But as we have mentioned above, meditators may change negative appraisals automatically, i.e. without any conscious efforts. In this case the hypothesized effects of down-regulation would be already manifested during natural perception of negative images and the additional attempts of meditators to decrease negative affect would not be reflected in cardiovascular activity. As for up-regulating, we hypothesized that meditators in comparison to controls could be more effective in regulating positive affect and would exhibit more pronounced cardiac (HR and CO increase), but not vascular (TPR increase) activation during viewing of positive stimuli. Thereby, we investigated the impact of long-term meditation practice on cardiovascular response under conditions contributing to the implementation of either automatic or deliberate reappraisal. Such an approach seems promising since it makes it possible to ascertain whether automatic or voluntary emotion regulation strategies are mainly developed during the long-term meditation practice.

2. Material and methods

2.1. Participants

Two groups of healthy right-handed males participated in our study. The experimental group included 22 experienced long-term Sahaja Yoga meditators (meditators, mean age = 36.23, SD = 8.96; mean meditation experience = 12.3 years, SD = 4.53) and 20 age-matched healthy controls with no meditation experience (controls, mean age = 33.55, SD = 5.48). None reported suffering from cardiovascular, respiratory, or psychiatric diseases and taking any drugs. All participants were normotensive. The differences between meditators and controls in age, systolic and diastolic blood pressure were insignificant (two tailed *T*-test, all $t < 1.47$, all $p > .1$). All the subjects gave written informed consent and were paid for participation. The research received approval of

[1] Sahaja Yoga meditation is characterized by the mental states of "thoughtless awareness", or "mental silence" and is accompanied by the experience of bliss. In general, the outcome of this meditative technique, as most others, is a sense of relaxation and positive mood and a feeling of benevolence toward oneself and others (Aftanas and Golocheikine, 2001; Aftanas and Golosheykin, 2005; Rai, 1993).