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Attentional orienting and executive control are affected by different types of meditation practice

Min-Hui Tsai, Wei-Lun Chou *

Department of Psychology, Fo Guang University, No. 160, Linwei Rd., Jiaosi, Yilan County 26247, Taiwan

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ABSTRACT

Several studies have demonstrated the beneficial effects of meditation on attention. The present study investigated the relationship between focused attention (FA) and open monitoring (OM) meditation skills and the various functions of attention. In Experiment 1, we executed the attention network test and compared the performance of experts on *dandao* meditation with that of ordinary people on this test. The results indicated that the experts specializing in OM meditation demonstrated greater attentional orienting ability compared with those specializing in FA meditation and the control group. In addition, both expert groups registered improvements in their executive control abilities compared with the control group. In Experiment 2, we trained beginners in FA meditation for 3 months. The results showed that the experimental group exhibited significantly enhanced executive control ability. We infer that FA meditation skills promote executive control function and OM meditation skills promote both executive control and attentional orienting functions.

1. Introduction

Because of their limited cognitive resources, humans require attention for selecting and processing essential information from a collection of highly complex information (Simons & Chabris, 1999). Attention also influences people's perception of a scenario and enables them to respond to the scenario adequately (Klin, Jones, Schultz, & Volkmar, 2003; Pelphrey, Morris, & McCarthy, 2005). In the *Principle of Psychology*, William (1890) described the characteristic of attention as follows: *Everyone knows what attention is. It is the taking possession by the mind in clear and vivid form of one out of what seem several simultaneous objects or trains of thought* (pp. 404). Attention mechanisms are cognitive processes that enable people to mentally select and clarify a specific target among numerous stimuli.

Posner and his colleagues (Posner & Petersen, 1990; Posner & Rothbart, 2007) have proposed a tripartite model of attention, asserting that selective attention can be divided into three subfunctions: alerting, orienting, and executive control. These functions are regulated in distinctive parts of the brain (Corbetta & Shulman, 2002; Fan, McCandliss, Fossella, Flombaum, & Posner, 2005; Posner & Rothbart, 2007; Westlye, Grydeland, Walhovd, & Fjell, 2011). Alerting refers to the ability to effectively detect stimuli under a state of internal readiness, and it allows an individual to stay alert to an upcoming stimulus. This function is related to the right frontal cortex, fronto-parietal cortex, thalamus, anterior intraparietal, inferior parietal, and right temporal parietal junction (Fan et al., 2005; Marrocco & Davidson, 1998; Posner & Petersen, 1990).

* Corresponding author.
E-mail address: chouweilun@ntu.edu.tw (W.-L. Chou).

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Orienting involves the ability to select and focus on a specific stimulus among numerous stimuli, and it comprises three mechanisms: a disengagement process that entails shifting attention away from the current focus, movement process that involves shifting attention to a new target, and engagement process that entails reengaging attention to the new target (Posner, Walker, Friederiech, & Rafal, 1984). The superior and inferior parietal lobule, frontal eye field, and temporal parietal junction constitute the brain cortex regions related to attentional orienting (Fan et al., 2005; Paus, 1996). Executive control refers to the ability to regulate resources and exclude conflicts during a cognitive process, and it is related to planning and decision-making processes; this subfunction is associated with the anterior cingulated cortex and lateral prefrontal cortex (Bush, Luu, & Posner, 2000; Fan et al., 2005; MacDonald, Cohen, Stenger, & Carter, 2000; Matsumoto & Tanaka, 2004).

The literature reveals that experience changes attentional ability, indicating the plasticity of attentional ability. Evidence regarding the plasticity of attentional functioning can be demonstrated by the effect of physical activity experience. For example, after undergoing 6 months of contemporary dance training, elderly adults demonstrated improved capability in attention switching (Coubard, Duretz, Lefebvre, Lapalus, & Ferrufino, 2011). Cognitive activity experience, such as video gaming, also affects attentional ability (Green & Bavelier, 2003; Montani, De Grazia, & Zorzi, 2014). In addition, previous studies have confirmed that meditation, a type of awareness training, influences attentional ability (Jha, Krompinger, & Baime, 2007; van den Hurk, Giommi, Gielen, Speckens, & Barendregt, 2010); hence, the present study focused on the effect of meditation on attention.

1.1. Meditation

Meditation enables people to practice attentional focus to regulate their physical and mental state and maintain a nonjudgmental and neutral emotion toward a perceived experience (Brown, Ryan, & Creswell, 2007; Cahn & Polich, 2006; Kabat-Zinn, 2003; Thera, 2001). Meditation has been extensively applied to clinical procedures involving stress relief and relaxation training (Atin, 1997; Baer, 2003; Grossman, Niemann, Schmidt, & Walach, 2004; Kabat-Zinn et al., 1992, Kabat-Zinn, 2003; Tang et al., 2007). Furthermore, previous studies have confirmed the positive benefits of meditation such as improving cognitive flexibility (Cahn & Polich, 2006; Kozasa et al., 2012; Moore & Malinowski, 2009; Slagter et al., 2007) as well as enhancing positive emotion and reinforcing immune function (Davidson et al., 2003). These studies have indicated that meditation is a mental training method (Bishop et al., 2004; Lutz, Slagter, Dunne, & Davidson, 2008; Lutz et al., 2009; van den Hurk et al., 2010). Pagnoni and Cekic (2007) also verified that long-term meditation training prevented the thickness of the brain grey matter from thinning over time. Moreover, Lazar et al. (2005) reported that meditators' brain regions associated with attention, interoception, and sensory processing were thicker than those of the control group, implying the effect of meditation on the physical structure of the brain.

Meditation can be classified into at least two categories according to distinctive training methods: focused attention (FA) meditation and open monitoring (OM) meditation (Lippelt, Hommel, & Colzato, 2014; Lutz et al., 2008). FA meditation entails voluntarily focusing attention on a specific object or breathing in a sustained manner, and it involves β and γ brain waves (Travis & Shear, 2010). OM meditation involves nonreactively and impassively monitoring the content of experience without focusing on any explicit object momentarily, primarily as a means to recognize the nature of emotional and cognitive patterns. OM meditation involves θ brain waves (Travis & Shear, 2010). Generally, beginners in meditation can practice only FA meditation, and only those who have trained for an extensive period can master the technique of OM meditation (Malinowski, 2013).

1.2. Meditation and attention

Meditation training involves attention regulation (Hölzel et al., 2011; Lutz et al., 2008; Slagter, Davidson, & Lutz, 2011; Wallace & Shapiro, 2006), and studies investigating meditation models have focused on attention as the core component of such models (Hölzel et al., 2011; Malinowski, 2013; Shapiro, Carlson, Astin, & Freedman, 2006). Although empirical studies have confirmed that experience in meditation influences attention, the specific types of attention influenced are not clearly understood. Jha et al. (2007) verified that participants practicing long-term meditation demonstrated greater skills in regulating their executive control attention compared with those in the control group. They also reported that participants who took a mindfulness-based stress reduction (MBSR) program for 2 months exhibited greater attentional orienting abilities compared with those in the control group. van den Hurk et al. (2010) also confirmed that meditation experts demonstrated more desirable orienting and executive attention as reflected by differences in reaction times (RTs) and error scores, respectively, compared with those in the control group. Furthermore, previous studies have shown that short-term meditation can facilitate achieving enhanced executive control attention (Elliott, Wallace, & Giesbrecht, 2014; MacLean et al., 2010; Tang et al., 2007). The inconsistency in the results of the aforementioned studies may be because the participants of these studies had dissimilar meditation skill levels and because the various types of meditation were not clearly distinguished (e.g., FA meditation and OM meditation were not separately discussed).

Distinctive types of meditation skill may exert dissimilar effects on attentional functions (e.g., Colzato, Sellaro, Samara, Baas, & Hommel, 2015; for a review see Lippelt et al., 2014). FA meditators are trained to focus and sustain attention on an intended object or their own breathing. Because FA meditation training mainly involves focusing attention on a specific object while disregarding surrounding disturbances, we assumed that this type of meditation is related to executive control attention. By contrast, OM meditation involves monitoring a meditator's ongoing stream of experience and disengaging