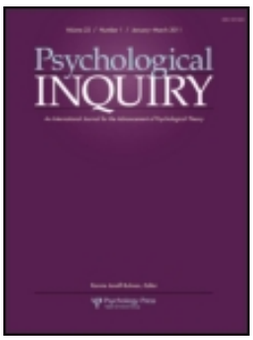

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Rethinking Future Directions of the Mindfulness Field

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It has been suggested that mindfulness meditation includes at least three components that interact closely to constitute a process of enhanced self-regulation: *enhanced attention control, improved emotion regulation*, and *altered self-awareness* (e.g., diminished self-referential processing, enhanced body awareness and equanimity; Tang, Holzel, & Posner, 2015b).

Consistent with many other studies in mindfulness, in a series of randomized controlled trials, we have tested whether a short-term mindfulness training (Integrative Body–Mind Training [IBMT]) could improve attention control, emotion regulation, stress response, and immune function, as well as brain plasticity of functional and structural changes. Relaxation training served as an active control.

In one study, Chinese college students were randomly assigned to an IBMT ($N = 40$) or a relaxation training group ($N = 40$) for 5 days of short-term training (20 min per day). The IBMT group showed significantly greater improvement of performance in executive attention as measured by the Attention Network Test (Fan et al., 2002) than did the relaxation group. Meanwhile, individuals in the IBMT condition also had lower negative affect and fatigue, and higher positive feelings on the Profile of Mood States (Tang et al., 2007). In addition, a few hours of IBMT also decreased levels of the stress hormone cortisol and increased immune reactivity (Tang et al., 2007). In another randomized controlled trial study using the measurement of Positive and Negative Affect Schedule, short-term IBMT showed significantly increased positive mood and reduced negative mood states compared to relaxation (Ding, Tang, Tang, & Posner, 2014). A similar study showed that in comparison with a waitlist control group, an 8-week mindfulness training program significantly reduced negative moods (Robins et al., 2012). These results indicated that mindfulness meditation can improve attention and emotion regulation effectively, as well as reduce stress hormone and increase immune function.

What's the underlying mechanism of these changes following brief mindfulness training? Using neuroimaging and physiological measurements, college students were randomly assigned to IBMT or relaxation groups and assessed before, during, and after 5 days of training (Tang et al., 2009). Neuroimaging data demonstrated that IBMT group showed stronger subgenual and adjacent ventral anterior cingulate cortex (ACC) activity compared to relaxation control. Based on previous research, this brain area often involves in emotional regulation (Bush, Luu, & Posner, 2000; Posner et al., 2007) and is also linked to autonomic nervous system (ANS; Critchley et al., 2003). We thus measured the heart rate variability, an index of sympathetic and parasympathetic activity, and found that compared to relaxation training, 5 days of IBMT significantly improved high-frequency heart rate variability, suggesting better parasympathetic regulation. To test whether body (ANS) and mind (central nervous system [CNS]) work together during mindfulness meditation, we further investigated the interaction between ANS and CNS. Our results indicated the frontal midline ACC theta measured by EEG is correlated with high-frequency heart rate variability, suggesting control by the ACC over parasympathetic activity, and that both the CNS (via ACC) and ANS interact to coordinate and maintain the meditation state. These results indicated that after 5 days of training, the IBMT group showed better regulation of the ANS through a ventral midfrontal brain system than does the relaxation group (Tang et al., 2009).

Previous studies have shown the behavioral, physiological, and brain changes following 5 days of training (within 1 week). *What will happen following longer mindfulness practice?* Our results indicated that 2 to 4 weeks (10–20 sessions) of IBMT showed greater improvements in attention control, stress response (lower basal cortisol concentration), and immune function (greater basal secretory immunoglobin A) compared to 1 week of training (Fan, Tang, Ma, & Posner, 2010; Fan, Tang, & Posner, 2014; Tang, Yang, Leve, & Harold, 2012). These results suggested the dose dependent fashion as the training amount increases. Using MRI diffusion tensor imaging, previous studies have shown that training results in changes in white matter efficiency as measured by fractional anisotropy (FA). We randomly assigned 45 U.S. undergraduates to either IBMT or relaxation

group and acquired brain images at rest using diffusion tensor imaging for analysis of white matter before and after training. Results showed that around 10 hr of IBMT can (within 4 weeks) increase FA in the corona radiata, an important white-matter tract connecting the ACC to other structures (Tang et al., 2010).

To further demonstrate the time-course of white matter neuroplasticity from 2 weeks to 4 weeks of mindfulness meditation, we measured two indexes of radial diffusivity (RD) and axial diffusivity (AD). Reductions in RD have been interpreted as improved myelin, but reductions in AD involve other mechanisms, such as axonal density. We found that 2-week IBMT reduced AD. However, after 4-week training with IBMT, both RD and AD decreases were accompanied by increased FA, indicating improved efficiency of white matter involves increased myelin, as well as other axonal changes (Tang, Lu, Fan, Yang, & Posner, 2012). This dynamic pattern of white matter change involving the ACC, a part of the brain network related to self-regulation, could provide means for intervention to improve or prevent mental disorders.

Does behavior change such as emotion regulation correlate with brain structure following mindfulness? In the study of diffusion tensor imaging (Tang et al., 2012), 2-week IBMT (not the relaxation training) showed significant reductions in anger-hostility, confusion-bewilderment, depression-dejection, fatigue-inertia, and total mood disturbance in Profile of Mood States. Most important, after a 2-week IBMT, correlation between total mood disturbance change (an index of emotion regulation) and AD decrease in the left posterior corona radiata was significant, indicating that the training-induced change in emotion was correlated with the ACC structural changes, the self-regulation network in the brain. These results raised an important question of state and trait changes following mindfulness—in other words, *when mindfulness state will develop and transfer to trait following training*. Research has shown that brain function and especially brain structure correlate with and support certain traits of temperament and personality (Haas & Miller, 2015; Whittle, Allen, Lubman, & Yücel, 2006; Whittle et al., 2014). Although our results showed that 2 weeks of IBMT training induces brain structure changes and correlates with trait-related changes of emotion regulation, this warrants further investigation in other domains of characteristics in temperament and personality (Tang, Holzel, & Posner, 2015a).

In combination with other studies, our work has raised more new questions in the mindfulness field. The first query involves the implicit and explicit emotion regulation in mindfulness and the brain networks involved. Emotion regulation refers to strategies that can influence which emotions arise and when, how long they occur, and how these emotions are experienced and expressed (Gross, 2014, 2015). Recent research has shown that emotion regulation is not always deliberate but can also operate in nonconscious or implicit levels (Bargh, Gollwitzer, Lee-Chai, Barndollar, & Troetschel, 2001; Koole et al., 2015). These implicit processes may allow people to decide whether to engage in emotion regulation, guide people in selecting suitable emotion regulation strategies, and facilitate the enactment of emotion regulation strategies (Koole et al., 2015; Tang et al., 2015b). In addition to cognitive appraisals, mindfulness may involve a range of implicit and explicit emotion regulation processes that exert conscious control and unconscious regulation (Tang et al., 2015b). Research indicates that the ACC is involved in both cognitive control and emotional regulation. Neuroimaging studies show that the ventral part of ACC and its adjacent medial prefrontal cortex (mPFC) are mainly associated with emotional regulation (Bush et al., 2000; Posner et al., 2007). *It remains elusive whether early or advanced stages of mindfulness, short-term or long-term mindfulness, or different mindfulness techniques involve similar or different brain networks*.

The second query involves cognitive control and autonomic control in mindfulness. In the field of mindfulness research, mind or thought control is emphasized, but the role of body regulation has often been underemphasized. In practices, like IBMT or yoga, mind–body interaction facilitates the mindfulness process and outcomes. Thus, mindfulness can be achieved in two ways: through mental processes (e.g., mindfulness) and through bodily processes (e.g., bodifulness; Tang & Tang, 2015). Bodifulness refers to the gentle adjustment and exercise of body posture with full awareness, which leads to an aliveness and presence in our bodies. This is in line with the literature that body posture and state can affect mental processes (Carney, Cuddy, & Yap, 2010). Mindfulness often involves an explicit process (e.g., counting your breath, body scan) through the central nervous system (brain/mind), but bodifulness mainly involves implicit process (e.g., visceral or interoceptive awareness) that is regulated by ANS. Autonomic control needs less of the effort supported by the ACC and adjacent mPFC in normal and patient studies (Critchley et al., 2003; Naccache et al., 2005). Mindfulness requires conscious cognitive control with effort in its early stage and is supported by the ACC and PFC but may move to less effort as the practice becomes more skillful (Tang, Rothbart, & Posner, 2012). Cognitive control (doing state) and autonomic control (being state) are both important components of self-control, which may drive behavior and habit formation. We thus propose an integrative framework

of mindfulness practice that mainly involves bodifulness and mindfulness (Tang & Tang, 2015). Further investigation will explore other potential factors involving in mindfulness mechanisms.

The third query involves self-transformation or growth in mindfulness. As Garland, Farb, Goldin, and Fredrickson (this issue) propose, "the practice of mindfulness evokes a metacognitive state that transforms how one attends to experience, thereby promoting positive reappraisals that facilitate positive affect and adaptive behavior" (p. 295). Positive reappraisal may "involve broadening the scope of appraisal to appreciate that even aversive experiences are potential vehicles for self-transformation and growth" (p. 295). In other words, the process of positive reappraisal may "involve a reframing of stressful events as inherently meaningful for personal growth and development—a means of learning and developing resilience out of the encounter with adversity" (Garland et al., this issue, p. 297).

Self-transformation is one of specific and significant "awakening" human experiences that may include different domains such as higher levels of self-awareness, equanimity, self-transcendence, and enlightenment (Davis & Vago, 2013; Tang & Tang, 2014), and it's hard to have a consensus on the definition of self-transformation because of its complexity and different stages, as well as a lack of scientific research. Research has suggested that mindfulness meditation includes at least three components that interact closely to constitute a process of enhanced self-regulation: *enhanced attention control, emotion regulation*, and *self-awareness* (Tang et al., 2015b). Through persistent practice, a practitioner could experience a systematic change in body, mind, and behavior. For instance, growing empirical evidence indicates that mindfulness has potential to develop self-transcendence—a positive relationship between self and others that transcends self-focused needs to harmonize with nature or feeling oneness with others or the self as an integral part of the whole universe, as well as increased prosocial characteristics (Hölzel et al., 2011; Tang et al., 2012; Tang & Tang, 2014; Vago & Silbersweig, 2012). Although we have not fully understood this unique human experience, it seems that a higher level of self-awareness has been developed and the understanding of the self, self-others, and self-nature has dramatically changed. Therefore, a very different but holistic perspective of "positive and adverse," "good or bad" happens with "equanimity." According to Desbordes et al. (2015), equanimity is "an even-minded mental state or dispositional tendency toward all experiences or objects, regardless of their origin or their affective valence" (pleasant, unpleasant, or neutral; Desbordes et al., 2015). This objective and balanced view, attitude, thinking, and action could help see the thing as it is and cultivate happiness, engagement, compassion, and wisdom (see Mindfulness to Self-transformation Framework shown in Figure 1). Future studies should examine the relationship between self-transformation and short-term or long-term mindfulness and how mindfulness shapes the perspectives on the self, self–other relationship, and its underlying mechanisms using multimodal neuroimaging, physiological, psychosocial, and genetic methods (Tang & Tang, 2014; Tang et al, 2015b).

According to Buddhist philosophy, the identification with a static concept of "self" causes psychological distress. Dis-identification from such static self-concept results in the freedom to experience a more genuine way of being such as happiness, peace, compassion, and wisdom (Tang et al., 2015b). Through enhanced meta-awareness (making awareness itself an object of attention), mindfulness practice is thought to facilitate a detachment from identification with the self as a static entity, and a tendency to identify with the phenomenon of "experiencing" itself is said to emerge (Fresco et al., 2007; Hart, 1987; Josipovic, 2014; Kerr, Josyula, & Littenberg, 2011; Olendzki, 2010; Shapiro, Carlson, Astin, & Freedman, 2006; Tang et al., 2015b). Currently, empirical research into this area is only just emerging (Dor-Ziderman, Berkovich-Ohana, Glicksohn, & Goldstein, 2013; Tang et al., 2015b), and more studies are needed to address the nature of self, self-referential processing, and self-transformation.

Mindfulness practice has been applied to develop better attention control and emotion regulation, develop a higher level of self-awareness with equanimity, and even cultivate the human ability to see the cause of suffering and find the path to relief of suffering and achieve eudaimonic well-being (Brown & Ryan, 2003; Garland et al., this issue; Wallace, 2003). *Is mindfulness practice alone sufficient for the alleviation of suffering?* The classic texts suggest that Buddhist scholars did not believe this, as Garland et al. (this issue) summarized. Instead, mindfulness was seen as facilitative of other forms of mental training designed to modify cognitive processes

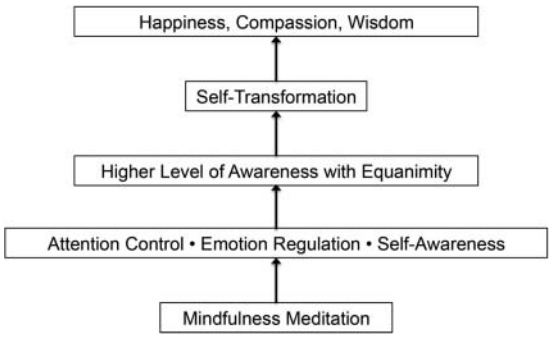

Figure 1. Framework of mindfulness to self-transformation.

underlying self-centeredness and generate happiness (Wallace, 2003). This mental training involves positive mental qualities like equanimity, tenacity, and compassion, as well as a deep understanding of the interdependence between self and others. With open-minded and equanimous attitude and action, we believe scientific exploration and direct experience can help human beings achieve happiness, peace, compassion, wisdom, and self-growth.

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