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ORIGINAL PAPER

Enhancing Human Cognition Through Vajrayana Practices

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Abstract
Phenomenological studies suggest the existence of enhanced cognitive states, termed flow or peak experiences, in which specific cognitive processes (e.g., attention, perception) can be dramatically increased for limited durations. Here we review new scientific evidence that shows that specific types of meditation that developed out of certain religious traditions such as Vajrayana (Tantric Buddhism) and Hindu Tantra lead to the enhanced cognitive states, characterized by heightened sympathetic activation and phasic alertness (a significant temporary boost in focused attention). This is in contrast to the meditation practices (Shamatha, Vipassana) from other traditions such as Theravada and Mahayana that elicit heightened parasympathetic activity and tonic alertness. Such findings validate Buddhist scriptural descriptions of heightened arousal during Vajrayana practices and a calm and alert state of mind during Theravada and Mahayana types of meditation. The finding demonstrates the existence of enhanced cognitive states—the unique and energized states of consciousness characterized by a dramatic boost in focused attention.

Keywords Enhanced cognitive state · Vajrayana Buddhism · Meditative practices · Creativity · Autonomic nervous system · Arousal

Phenomenological studies suggest the existence of enhanced cognitive states in which specific cognitive processes (e.g., attention, perception) can be dramatically increased for limited durations (Csikszentmihalyi 1990; Maslow 1999; Wilson 1972). Csikszentmihalyi (1990) termed such experience as *flow* and defined it as a unique, energized yet effortless, state of consciousness, characterized by a number of qualities, such as the merging of action and awareness (the awareness is entirely focused on the activity, and all the distracting stimuli are ignored), the loss of awareness of oneself, intense concentration, and distorted sense of time. Phenomenological studies (e.g., Csikszentmihalyi 1975) have emphasized the following situational

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conditions for an individual to experience flow: (1) the direct involvement in the activity, so individual must not just be an observer, but "actively engaged in some form of clearly specified interaction with the environment"; (2) the presence of significant challenge (termed optimal challenge), which pushes one's skills to their limit, but not beyond one's capacities, and (3) intense concentration on the task. The phenomenon of enhanced cognitive states has been reported during the creative processes of visual artists (Getzels and Csikszentmihalyi 1976) as well as during various gaming experiences, for example, basketball, chess, and video gaming (Keller and Bless 2008; Moller et al. 2010).

Despite numerous phenomenological reports on the existence of enhanced mental states, contemporary cognitive psychology and neuroscience have focused primarily on clinical states, where cognition is impaired rather than on the mental states, where cognition is enhanced. There have been only few experimental studies on this topic. For example, listening for 10 min to a Mozart sonata significantly improved performance on spatial reasoning tasks (Rauscher et al. 1993), as well as on the selective attention as measured by the attentional blink task (Ho et al. 2007). The enhancing effect of the music condition was temporary, however, and did not extend beyond a 15-min period (Rauscher et al. 1993). Furthermore, Kozhevnikov et al. (2009) reported the existence of similar short-term enhanced mental states after specific types of Tibetan Tantric (Vajrayana) practices. In particular, they found that meditation that required holding the focus of attention on an internally generated image of a Tibetan deity resulted in a temporary boost of participants' performance on a number of visual–spatial working memory tasks as well as the tasks tapping object and spatial visualization capacities. May et al. (2011, p. 144) also reported improved performance on the attentional blink task following "loving-kindness" meditation, which involves focusing attention on specific "mental images of selected people."

Recent study of Kozhevnikov et al. (2018) demonstrated that, in addition to such situational requirements as direct involvement in the activity and presence of significant challenge, another important condition for reaching an enhanced cognitive state is the state of arousal—a physiological and psychological state of being awake or reactive to stimuli. Arousal is characterized by an increase in the activity of the sympathetic system, which is followed by the release of epinephrine and norepinephrine from the endocrine system (Camm et al. 1996), which can result in the state of *phasic alertness*, a significant temporary boost in cognitive capacities (Weinbach and Henik 2011). Thus, enhanced cognitive states could be described as the state of phasic alertness, inducing by the activation of sympathetic nervous system, when an individual is actively engaged in and focused on a task (Kozhevnikov et al. 2018).

The goal of this review is to show that types of meditation that developed out of certain traditions such as Vajrayana and Hindu Tantra lead to such enhanced cognitive states, characterized by the state of heightened sympathetic activation (arousal) and phasic alertness induced by complex visualization (e.g., focus on an image of a religious figure) and/or somatic means (e.g., breathing). This is in contrast to meditative practices from other Buddhist traditions such as conventional types of practices (e.g., Shamatha—concentration on breath, Vipassana, insight meditation, or mindfulness), which elicit the state of relaxation, characterized by heightened parasympathetic activity and *tonic alertness* (vigilance or sustained attention on a stimuli). First, we will provide an overview of the autonomic system and the manner in which it underlies psychological and physiological states of relaxation and arousal and influences attentional processes that relate to phasic and tonic alertness. Lastly, we will review studies that demonstrate that Vajrayana and Hindu Tantric practices generate enhanced cognitive states through the practices that are based on arousing activities (e.g., generating an emotionally significant image of a Tibetan deity with intense concentration (focus on an image)).

Measuring Relaxation and Arousal, as Well as Tonic and Phasic Alertness

Anatomically, the autonomic nervous system (ANS) consists of neurons from within both the central nervous systems (CNS) and the peripheral nervous system (PNS) and receives input from anatomic regions that integrate information from within the body and the external environment, such as the hypothalamus, nucleus of the solitary tract, reticular formation, amygdala, hippocampus, and olfactory cortex (Low 2013). The functional role of the ANS is to monitor important visceral processes that operate largely below the level of conscious awareness, such as heart rate, breathing, and digestion (Low 2013).

The ANS is comprised of two major neurobiological subsystems that function both independently and in concert: the parasympathetic nervous system and the sympathetic nervous system. These two systems often elicit opposing actions, so that when one system enhances or activates a physiological response, the other system inhibits it. The sympathetic nervous system is often called the “fight or flight” system, which accelerates the heart rate, constricts blood vessels, and raises blood pressure in order to enable a quick and mobilizing response, often as a reaction to an immediate threat. On the other hand, the parasympathetic system is often referred to as the “rest and digest” system, which slows down the heart rate, lowers blood pressure, increases intestinal and gland activity, and relaxes sphincter muscles (Berntson et al. 1997). As mentioned, the increased capacity to respond to stimuli that is generated by the sympathetic system coupled with active engagement of attention on a cognitive task has been termed phasic alertness (Petersen and Posner 2012; Sturm et al. 1999; Weinbach and Henik 2011). Therefore, phasic alertness is consistent with the notion of enhanced cognitive states, and it requires the activation of the sympathetic system and cannot co-occur with a physiological state of parasympathetic dominance, which is the relaxation response. On the other hand, although tonic alertness is inconsistent with drowsiness and sleep, it can nevertheless occur concurrently with a moderate level of parasympathetic activation and relaxed states.

There are numerous experimental methods that have been used to demonstrate the activity of the sympathetic (arousal) and parasympathetic (relaxation) systems. One commonly used method is related to the heart rate variability (HRV), which is determined by the autonomic system (Camm et al. 1996) and is assessed through electrocardiographic measures (abbreviated as EKG or ECG).

Relaxation and Tonic Alertness in Meditative Practices

Providing scientific conceptualizations of meditation practices has been one of the major concerns of recent scientific studies of meditation (e.g., Gethin 2011; Grossman and Van Dam 2011). One of the first scientific conceptualizations of meditation was proposed by Herbert Benson, who defined meditation as a technique that generates a "relaxation response" (Benson and Proctor 2011, p. 56]). Benson conducted his studies on transcendental meditation (TM), where the meditator recites a mantra provided to him or her by the meditation instructor, as well as on mindfulness meditation, which is a form of meditation that emphasizes the stabilization of attention by acknowledging discursive sensory events as momentary and observing them without affective reaction or attachment. Benson showed that TM and mindfulness meditation result in physiological changes indicative of a heightened activation of the parasympathetic nervous system and lowered sympathetic activity, such as decreased oxygen consumption and carbon dioxide elimination, lowering of heart and respiratory rates, and a marked decrease in arterial blood lactate concentration (e.g., Benson et al. 1974; Wallace and Benson 1972) as well as psychological outcome measures that indicate relaxation (e.g., Kutz et al. 1985). As these physiological and psychological results are characteristic responses that occur during relaxation, Benson termed the responses that occur during meditation as a relaxation response. Importantly, the attainment of a relaxation response during meditation has been confirmed by many subsequent studies and consistently reported in the scientific literature (e.g., Chiesa and Serretti 2009, 2010; Zeidan et al. 2014).

It is important to note that even though the characterization of meditation as a wakeful hypometabolic state is supported by empirical findings, the scientific studies that have led to conceptualizing meditation as relaxation response were conducted on very specific types of meditation. Specifically, most previous scientific studies have been conducted on TM and types of meditation from the Theravada and Mahayana traditions, such as Shamatha, Vipassana, or modern mindfulness meditation. In particular, a large number of scientific studies were conducted on Shamatha or Vipassana (Morse et al. 1997; Lutz 2007) that emphasize avoiding discursive thought by letting the practitioner concentrate on an object of meditation (Shamatha) or examine and generate insight out of his/her own mental activity (Vipassana) Tipitaka: The Pali Canon (2005). Also, many studies were conducted on mindfulness meditation (e.g., Chiesa and Serretti 2009; Grossman et al. 2004; Zeidan et al. 2014), which was developed by Jon Kabat-Zinn, who defined it as "mostly Vipassana practice… with a Zen attitude" (Kabat-Zinn email cited in Gilpin 2008, p. 238), where elements from Theravada and Mahayana practices are taught alongside Vipassana meditation in order to create a secularized practice that would appeal to people who might not possess a genuine interest in Buddhist culture or philosophy (Gilpin 2008).

Moreover, Britton et al. (2014) hypothesized that meditation would promote not only relaxation but also a state of tonic alertness. In line with this hypothesis, Britton et al. (2014) reviewed over 20 studies that demonstrate that certain types of meditation, mostly from the Theravada and Mahayana traditions, can activate neural areas that are associated with tonic alertness. Their review incorporated mostly mindfulness and Zen practices, but also a Vipassana and Shamatha meditation study, as well as studies on non-Tantric Tibetan practices that are different from Vajrayana (e.g., focusing on a single dot: Brefczynski-Lewis et al. 2007). Importantly, Britton et al. (2014) reviewed studies that showed that Theravada and Mahayana types of meditation can activate the dACC, DLPFC, the anterior insula, the inferior parietal lobule, the thalamus, and the brain stem, which are areas that are implicated in tonic alertness (Britton et al. 2014; Sturm and Willmes 2001).

Along with the large number of studies that confirmed that certain types of meditation can lead to a relaxation response, recent scientific evidence suggests that the generation of a relaxation response might not characterize meditative practices of other traditions. Specifically, meditative practices of the Vajrayana and Hindu Tantric traditions, which will be detailed in a subsequent section of the review, have been demonstrated to elicit a state of arousal and not relaxation (Amihai and Kozhevnikov 2014, 2015; Kozhevnikov et al. 2009, 2013) and corresponding enhanced cognitive states (Amihai and Kozhevnikov 2014), characterized by phasic alertness, which is inconsistent with the state of relaxation.

Arousal and Phasic Alertness in Meditative Practices

Vajrayana Buddhist scriptures emphasize the realization of "self-existing wakefulness" or "an awake quality" of the mind and warn against excessive tranquility (e.g., Tulku Urgyen Rinpoche 1999), in contrast to Theravada scriptures that emphasize quiescence and tranquility [Bhikkhu 2012, pp. 1287–1288 (IV.410)] as well as Mahayana meditation instructions that also emphasize calmness (Buksbazen 2002, p. 57). Furthermore, empirical evidence also suggests that arousal is generated during specific meditative practices. For instance, the generation of arousal during meditation has been observed in Hindu Tantric practices [e.g., (Corby et al. 1978; Telles and Desiraju 1993) as well as in several Vajrayana practices (Kozhevnikov et al. 2013)], although overall there have been far fewer studies on Vajrayana and Hindu Tantric practices than on Theravada and Mahayana.

Based on Theravada Buddhist scriptures that emphasize calmness and relaxation and Vajrayana scriptures that emphasize "wakefulness," Amihai and Kozhevnikov (2014) hypothesized that Deity and Rig-pa practices of the Vajrayana tradition would generate cognitive and physiological responses of arousal, while Vipassana and Shamatha practices of the Theravada tradition would generate a relaxation response. In order to investigate the autonomic activation that is generated during these types of practices, Amihai and Kozhevnikov (2014) compared the EKG activity of experienced Theravada and Vajrayana meditators (with 8 and 7.4 years of meditation experience, resp.) as they practiced meditation. The Theravada types of meditation that were investigated were Vipassana meditation and Kasina meditation, which is a visualization type of Shamatha meditation in which the meditator focuses his or her attention on "Kasina objects" that are described in the Pali Tipitaka and are typically colored disks. The Vajrayana practices studied were Deity and Rig-pa practices. In this study, the participants performed a 10-min rest condition that was followed by Shamatha and Vipassana meditation (15 min each) for the Theravada meditators and Deity and Rig-pa meditation (15 min each) for the Vajrayana meditators. Moreover, the participants' EKG activity was monitored throughout the experiment. Amihai and Kozhevnikov (2014) showed that Theravada types of meditation elicited increased HF (Vipassana) and decreased LF/HF (both Vipassana and Kasina) relative to the rest control condition, which is consistent with a relaxation response. On the other hand, Vajrayana practices produced increased arousal, as indexed by decreased HF (both Deity and Rig-pa) during the meditation relative to the control condition.

Additional studies that demonstrated that Vajrayana practices can increase the activity of the sympathetic system and generate an arousal response were conducted on practitioners of g-Tummo meditation, which, as mentioned, is associated with intense sensations of bodily heat in the spine. Interestingly, Benson himself reported a phenomenon that was unclear to him at the time, that two of the three g-Tummo practitioners that participated in his study exhibited an activation of the sympathetic system as evidenced by increased metabolism and oxygen consumption (Benson et al. 1990), which is consistent with arousal and not a relaxation response. Moreover, in Kozhevnikov et al. (2013), it was demonstrated experimentally that g-Tummo meditation can indeed raise the temperature of the body, which indicates a sympathetic response. Non-shivering generation of body heat—thermogenesis—is mediated by the sympathetic nervous system (Nedergaard et al. 2007). In humans, thermogenesis is caused mainly by brown adipose tissue, which shunts the energy obtained from the oxidation of free fatty acids into heat, which is then distributed throughout the body via the adipose tissue vasculature (Morrison and Blessing 2011). Importantly, brown adipose tissue activity in humans is stimulated by the sympathetic nervous system (Nedergaard et al. 2007). Specifically, an increased discharge from supraspinal sympathetic premotor pathways results in the sympathetic activation of brown adipose tissue, which leads to thermogenesis (Morrison and Blessing 2011). By attaching a small thermometer in the armpit of highly experienced g-Tummo meditators (6–32 years of experience), Kozhevnikov et al. (2013) were able to demonstrate for the first time that g-Tummo meditators can increase not only their peripheral but also, more importantly, core body temperature during the meditation, demonstrating that the activity of the sympathetic nervous system significantly increases as a consequence of this practice. Notably, the thermogenesis induced during g-Tummo was so substantial that it raised the body temperature of the meditators above the normal body temperature range and into the range of slight or moderate fever (up to 38.3 °C), reflecting an enhanced arousal response due to sympathetic activation. Similar findings were reported by Minvaleev et al. (2014) who evaluate the hemodynamic effects of the g-Tummo practice in the Himalayan mountains in India and reported a massive increase in sympathetic activity with the activation of brown adipose tissue and marked heat production. It should be noted that increases in the peripheral body (meditators' fingers and toes) temperature during g-Tummo were also found in Benson et al. (1982); however, the authors did not attribute such changes to increased sympathetic activation. In contrast, Benson et al. (1982) speculated that increased sympathetic activation during meditation is "unlikely," as it would be inconsistent with the parasympathetic activation that they observed in Theravada and TM types of meditation.

In addition to Vajrayana practices, several studies conducted on Hindu Tantric meditators demonstrated increased arousal. In an early but influential and often-cited study, Corby et al. (1978) recorded the GSR and heart rate during a Dharana type of meditation called Ananda Marga, which incorporates a focus on breathing while repeating a two-syllable word and ignoring external stimuli. They recruited 30 experienced Ananda Marga meditators (an average of 2.1 years and 3.1 h of practice a day) as well as 10 subjects without meditation experience that served as controls. The GSR and heart rates were recorded during 3 experimental conditions: (1) a relaxation control; (2) an Ananda Marga meditation preparation condition, which involves paying attention to the breath while ignoring external stimuli; and (3) Ananda Marga meditation, where the subjects were told to ignore external stimuli, pay attention to their breathing, and silently repeat a two-syllable word in phase with their breathing. In the control group, the participants chose their own word, while meditators used a personal mantra that they received from their meditation instructor. The results of Corby et al. (1978) demonstrated that a state of arousal occurred during Ananda Marga meditation: (1) skin conductance (GSR) increased from the relaxation baseline to the meditation condition, but only for the meditators group; (2) a small heart rate increase was observed during the meditation condition relative to the baseline for the meditators group. Both of these measures indicated that sympathetic activation occurred during the meditation, demonstrating an arousal response.

Additionally, Telles and Desiraju (1993) measured heart rate and GSR during a different type of meditation which requires concentration on a light source while contemplating a universal force. They recruited 18 experienced meditators (with an average of 10.1 years of experience) and compared the physiological measures obtained during meditation to those obtained by the same subjects during a control condition, which was similar to the meditation condition, but where random thinking was allowed and effortful concentration was not required. The findings of Telles and Desiraju (1993) demonstrated that although there were no significant changes in GSR, an increase in heart rate occurred during the meditation condition, but not during the non-meditation condition, relative to the baseline heart rate obtained prior to each condition. Hence, the findings of this study are indicative of increased sympathetic activation and an arousal response during this type of meditation.

Furthermore, research with experienced Vajrayana meditators demonstrated that Vajrayana practices not only lead to sympathetic activation, but also elicit enhanced cognitive states, characterized by the boost in phasic alertness (Kozhevnikov et al. 2009; Amihai and Kozhevnikov 2014). For example, Amihai and Kozhevnikov (2014) presented experienced Theravada (an average of 8–12.3 years of experience) and Vajrayana meditators (an average of 7.4–13 years of experience) with 2 visual tests [the mental rotation test (MRT) and visual memory test (VMT: [123]), see Kozhevnikov et al. (2013) for details], which were performed before and immediately following a 20-min session of Theravada meditation (Vipassana and Kasina: Amihai and Kozhevnikov 2014) or Vajrayana practices (Deity: Kozhevnikov et al. 2009, and Rig-pa: Amihai and Kozhevnikov 2014). As mentioned, the dramatic improvements on visual tasks immediately following a stimulus or activity are indicative of enhanced phasic alertness. The experimental results showed that only Vajrayana practices led to a large and immediate increase in performance on these tasks, while Theravada meditators did not demonstrate any improvement in their performance following the practice. Hence, these studies demonstrate that improved performance on the visual tests immediately after the meditation practice would indicate the existence of enhanced cognitive states, characterized by arousal and phasic alertness occurred during the meditation.

Conclusions and Future Directions

The aim of this review was to examine the scientific studies of meditation while focusing on the unique influences that different types of meditative traditions have on the activation of the autonomic system and cognitive states. We have presented evidence that as opposed to Theravada and Mahayana types of meditation that demonstrate enhanced relaxation and tonic alertness, investigations of Vajrayana and certain Hindu Tantric practices demonstrated increased arousal and phasic alertness, associated with enhanced cognitive states. In addition, we outlined the cultural and philosophical motivations that have influenced these meditative practices. While Theravada and Mahayana scriptures emphasize that the purpose of meditation is to cultivate tranquility along with mental stability, Vajrayana scriptures describe practices whose purpose is to elicit states of enhanced wakefulness. Future studies, however, should investigate a variety of practices from Theravada, Mahayana, and Vajrayana traditions to determine whether all Theravada and Mahayana practices lead to a relaxation response and Vajrayana practices to arousal, or some exceptions could be found.

It is also important to stress that the influences of Vajrayana and Hindu Tantric practices on physiology and behavior are only beginning to receive their due attention from the scientific community, and the long-term impact of Tantric practices is still not well understood. Hence, while it has been demonstrated that Vajrayana and Hindu Tantric practices can lead to immediate physiological changes that are coupled with improved cognitive performance, future studies should investigate the long-term cognitive and physiological changes that occur as a consequence of such practices. As previously mentioned, in contrast to Vajrayana and Hindu Tantric practices, many scientific studies have been conducted on Theravada or Mahayana types of meditation, and there is evidence that they can lead to long-term improvements on attentional tasks (e.g., Britton et al. 2014; MacLean et al. 2010). It is thus prudent that similar long-term studies would be conducted on Tantric practices.

Related to the above, another important research direction that has yet to be explored is the long-term influence of Vajrayana and Hindu Tantric meditation on stress and well-being. As mentioned, the finding that Theravada types of meditation produce relaxation has resulted in their incorporation into clinical practices as stress reduction techniques (e.g., Agee et al. 2009; Grossman and Van Dam 2011; Jain et al. 2007). Conversely, the finding that Vajrayana and Hindu Tantric types of meditation produce arousal suggests that they could be more problematic for people who are under a high level of stress. However, it is also likely that as they gain additional meditation experience, Vajrayana and Hindu Tantric meditators develop unique strategies to help them cope with stressful situations that could arise during their meditation practice, for instance, by transforming their negative emotions into the positive emotional states of the visualized Deity. Such possibilities should be examined in future studies.

In summary, our results suggest that enhanced cognitive states do exist and could be and that they can be induced intentionally and systematically, as in the case of Vajrayana practices. This has a lot of theoretical and practical implications for different domains of human performance. First, Vajrayana practices might help contemporary psychology and neuroscience to expand the focus from clinical application to understanding limits and potential of human mind. Furthermore, they can help to design a systematic step-by step training of training enhanced cognition and exceptional human performance while avoiding possible pitfalls (e.g., inducing excessive stress). Although it is transient, a temporary boost in attention can nevertheless be utilized in order to enhance performance during critical periods. Furthermore, they can help us boost creativity and learning (Csikszentmihalyi 1990).

Compliance with Ethical Standards

Conflict of interest The author declares that he has no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were approved by the IRB committee of the National University of Singapore, NUS-IRB Ref Code: N-17-007.

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