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# Yoga as Advanced Cognitive Training: How Kirtan Kriya In Kundalini Yoga Changes the PTSD Brain

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**Abstract**

Research on yoga interventions for post-traumatic stress disorder (PTSD) is plentiful, but none to date have studied the neural effects and benefits of a yogic practice on the default mode network (DMN) in PTSD. Common features of PTSD, such as mind-wandering and emotional dysregulation, are linked to altered neural functioning of the DMN due to initial trauma exposure. Symptom severity is also related to decreased neural connectivity of the DMN. This review explores Kirtan Kriya (KK), a series of repetitive, sequential movements that are synchronized with self-produced mantra in Kundalini Yoga, as a powerful intervention for symptoms and neural repair associated with altered functioning of the DMN due to PTSD. Future direction regarding the application of KK to PTSD are discussed.

**Keywords:** Focused Attention Meditation, Kirtan Kriya, Kundalini Yoga, PTSD, Post-Traumatic Stress Disorder, Default Mode Network

## Introduction

Post-traumatic stress disorder (PTSD) is a mental illness caused by exposure to threat, or involvement in a traumatic event [1]. Symptoms include mind-wandering, rumination, depression, flashbacks, and anxiety that are associated with the initial trauma stimuli [2,3]. In recent years, research has supported yoga as a strong alternative treatment for PTSD [4-10]. Yoga interventions have yielded similar benefits to that of psychotherapy for individuals with PTSD. While there are variations of yoga that can be applied to PTSD, certain yogic practices engage the same neural networks as mental training, which can strengthen the mind-body connection through practice overtime [8,9,11]. This article suggests that the practice of Kirtan Kriya (KK) in Kundalini Yoga (KY) may offer the most effective yogic exercise for brain change in the PTSD population through its recruitment of brain regions associated with the attentional network, default mode network, and mastery levels of learning.

KY is a distinct branch of yoga that uses repetitive, action orientated intervals called "kriyas" to target specific regions of the nervous and endocrine systems to positively affect mental, emotional, and physical change [12-18]. Kriyas are forms of focused attention meditation, which constantly redirect the practitioner to focus on a meditative object, visualization, or breath when distracted [16-18]. This form of sustained attention when combined with repetitive, self-produced sound and chronological, sequential movement, engage the default mode network (DMN) and recruits brain regions associated with skill mastery [19].

KK, in particular, is a kriya that uses repetitive, sequential finger-movements coordinated with self-produced mantra while sitting in easy-pose with closed eyes for 11-12 minutes [11-18,20-23]. To begin KK, an individual sits with their eyes closed and focuses on the horizon of darkness between their brow-point. Next, they repetitively chant "Sa, Ta, Na, Ma" while chronologically touching their fingers to each sound and continuously repeating the movement for 11-12 minutes [22]. The mantra "Sa, Ta, Na, Ma" is defined as "birth, life, death, and rebirth" [15]. The movement is as follows: the individual touches their first finger to their thumb and chants "Sa", their second finger to their thumb and chants "Ta", their third finger to their thumb and chants "Na", and their fourth finger to the thumb and chants "Ma". During the 11 to 12 minutes, the mantra is whispered, spoken out loud, and repeated silently in 3-4-minute segments [11]. This movement occurs in both hands at the same time.

Yogic philosophy explains the benefits of KK as producing an increased awareness of sensation, equanimity, and consciousness [11,15,18,22]. Neurological observations include increased neural connectivity, cerebral blood flow, and DMN deactivations as sustainable benefits [24]. In line with these observations, focused attention meditation engages the prefrontal cortex, anterior cingulate cortex, thalamus, dorsolateral prefrontal cortex, ventrolateral prefrontal cortex, insula, and precuneus [12,18,22,23,25]. These regions are implicated in the DMN's role of attention sustainment during KK and associated with self-referential processing, mind wandering, and internal narratives [12,15,22,23,25-28].

Researchers studying the effects of a single KY class observed a decrease in perceived stress following the conclusion of one class session [17]. Other researchers studying the effect of KK, KY, or KK as a component of KY have reported elevated mood, enhanced cognitive performance, and stronger feelings of empathy associated with increased neural connectivity in regions linked to the DMN following 8 week and 12 week practices [3,11,22,23,25]. In healthy individuals, the DMN functions as relatively inactive when engaging in a task because it is taking in information, active when at rest, and decreasing in activity during tasks requiring increased or constant attention [12,18,23,25,29]. In PTSD, the DMN functionality is altered and decreased connectivity between the DMN and the attentional control networks has been observed [2]. This results in activity peaks of the DMN during resting state when an individual is unaware of mind wandering, which leads to disengagement in daily activities, rumination, depression, and other symptoms common to PTSD [2,30]. Alternatively, increased connectivity between the DMN and attentional networks is correlated with decreased hyperarousal and avoidant behavior observed in mindfulness-based training research studying the PTSD population [2].

## How KK Initiates Changes in the PTSD Brain

Mantra is Sanskrit for "mind" (manas) "tools" (tra) and is a word, sequence of words, or self-produced sound used to focus attention to create a state of equanimity [26,31]. Mantra repetition has been shown to slow racing thoughts, decrease psychological stress, ease sleep disturbances, and improve emotional intelligence in PTSD [32]. In a study researching the effects of six 90-minute, weekly sessions of mantra repetition in veterans with PTSD, an increase of calmness and sense of grounding was experienced by all participants [32]. Interestingly, many participants in this study referred to the mantra as a "security blanket" they used when distressed, before bed, or in the morning to begin the day [33]. A "security blanket" is typically associated with an attachment object that relieves stress and anxiety [34]. Since attachment objects are considered to be effective when in one's possession or presence, this suggests that being in possession and control of a mantra has the potential to evoke the same benefits of an attachment object. Benefits include a greater attention span, resilience, and mediation of arousal.

Mantra repetition is linked to deactivations in the DMN regions of the precuneus, posterior cingulate cortex (PCC), anterior cingulate cortex, and medial prefrontal cortex [29]. Deactivation in these regions is associated with decreased self-judgment and emotional narratives, resulting in heightened awareness in the present moment. The PCC, a central region of the DMN, acts a switchboard that mediates a person's focus towards external (engaging in real-time tasks) or internal (memory retrieval, ruminating) engagement during daily activities [35]. In PTSD, the PCC connectivity to the dorsolateral prefrontal cortex (DLPFC), an area of the DMN associated with emotion and stress regulation, is weakened [2]. During KK, the PCC is constantly "exercised" in order to sustain the cognitive control needed for focused attention and suppression of distracting sensory inputs [28].

During KK mantra recitation, an individual must synchronize their self-produced sound to sequential, repetitive finger movements [11,18]. These voluntary movements activate regions of the brain associated with embodiment and psychological resilience, a key factor influencing symptom severity and proclivity to developing PTSD [12,14,15,24,25,36,37]. The DLPFC, in particular, was activated during self-initiated finger movements in Jenkin et al. [38] study, indicating that concentration on self-produced cues correlated with movements.

The DLPFC acts as a gate to the DMN and mediator between sensory areas [2,38-41]. It is associated with shifting and sustaining attentional awareness to the present moment [38-41]. The DLPFC also plays a significant role in decision making processes and the selection of socially appropriate behavior [23,36]. Increased connectivity between the DMN and DLPFC is linked to enhanced emotional regulation and ability to shift awareness from introspective to extrospective states. In PTSD, increases in DLPFC connectivity correlate with decreases in hyperarousal [2]. This results in significant changes in impulsivity, aggressiveness, hypersensitivity, and hyper-excitability [42].

Long-term training in sequential movement has been linked to the same neurological changes observed when reaching "expert" level of performance for a given task [19]. During a 2011 study researching the change in resting state connectivity of the motor system during a 4-week sequential finger movement practice, increased connectivity in the right postcentral gyrus and bilateral supramarginal gyri was observed after 2-weeks of learning the practice [37]. Increased cerebral blood flow and neural connectivity in the right precentral gyrus, left precentral gyrus, and parietal regions were observed as sustained changes following the conclusion of the 4-week study. Ma et al. associated these activations with "motor cognition", which refers to a state of embodiment. Motor cognition is the process of knowledge


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informing action whereby the motor system assists in the learning process behind understanding a movement. This type of training is considered "domain specific" because it involves motor and mental learning [19]. In embodiment, an individual interprets the meaning of words and expresses the interpretation [43]. Activations associated with embodiment were observed in KK where participants experienced greater self-awareness, empathy, and self- expression following practice [14,23,25,44].

Overall, studies using KK interventions have consistently observed positive effects on emotional health [3,11,23,25,40]. Individuals with PTSD often fail to recognize internally produced cues because they operate in constant state of anticipation [45]. In an 8-week fMRI study researching the effect of KK on mood and anxiety on individuals with memory loss, cerebral blood flow increases to the right amygdala and right caudate correlated with improved mood and reduced depression [25]. Behavioral improvements occurring with increased cerebral blood flow to the amygdala are also linked to enhanced memory, which is illustrative of gaining a deeper capacity for emotional understanding that effects mood. These benefits are even more pronounced for experienced meditators. In PTSD, increased cerebral blood flow to the amygdala strengthens the down-regulation process when confronted by trauma stimuli so an individual's capacity for emotional processing and fear extinction is not impaired by previously learned emotional narratives [46].

Abnormal functioning of the amygdala has been observed in PTSD as a long-term change in the brain's response to stress and anxiety [47]. During hyper-arousal in PTSD, there is an increased activation in the amygdala and decreased activation in the prefrontal cortex and the anterior cingulate cortex [48]. In Newberg's 2010 study, activity in the amygdala decreased nearly 5 times more from its pre-meditative state in the group practicing KK [22]. Newberg's 2010 study also observed increased cerebral blood flow to the prefrontal lobe regions associated with executive functioning and attentional processes. Reduced connectivity in these regions is associated with impaired fear response, fear learning, and fear extinction [49]. This results in avoidant behavior, dissociation, and decreased social interaction in PTSD.

## Conclusion and Future Direction

Previous studies have investigated the effects of various branches of yoga on PTSD, including Sudarshan Kriya yoga (SKY), Kripalu-based yoga, trauma-informed yoga, Krishnamacharya Healing and Yoga, and KY, but none to date have studied the effects of KK on neural connectivity or brain plasticity in individuals with PTSD[4-6,10]. Research focused on the benefits of a complex focused attention meditation like KK is valuable when considering the disruption and anxiety caused by intrusive thoughts and flashbacks, as well as the inability to sustain focus symptomatic of PTSD [2]. Further research is also needed to explore the comparison between the effects of mantra with meaning and the effect of Sanskrit words (in the circumstance where the practitioner is unaware of the meaning) on the brain. For KK, this research would center on the question of whether it is the power of the sound in the KK mantra, the movement of the tongue against the upper palate, or the meaning of the KK mantra that affects the brain [15]. It would also be useful to study KK for a period longer than 12-weeks on a group.

It also worth noting that to date, only four studies researching the neural and cognitive benefits of KK have defined the meaning of the KK mantra in their study [11,12,18,50]. Eyre et al.'s 2017 study [11] defined the mantra and used KK as part of a larger 60-minute KY session for participants over 55-years old with cognitive impairment. The study concluded that the KK component provided "mind exercise" while the KY provided physical exercise [11,12,18,50]. When mantra carries meaning as it does in KK, it integrates spirituality into the practice and enables a practitioner to experience feelings of transcendence and connectedness to a greater life force [51]. This can lead to a deeper understanding of emotions and cognitive reframing of traumatic events. These elements influence psychological resilience, a key factor affecting proclivity to PTSD and symptom severity [36].

Lastly, none of these studies nor any yoga research to date focusing on neurological, cognitive, or behavioral changes have considered the effect of meditating or practicing yoga on a full or empty stomach, or a general timed duration from eating to practicing yoga when collecting data. This consideration could provide more definitive results on symptom relief and cognitive performance post-practice.

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