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A neurobehavioral account for decentering as the salve for the distressed mind

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Abstract

Distress is commonly characterized by prolonged internal suffering that can range from self-focused processing of negative emotions and stressors, to highly intensely aversive and prolonged emotional states thereby worsening or complicating emotional and physical conditions. Decentering represents a metacognitive capacity thought to reflect three interrelated processes: *meta-awareness, disidentification* from internal experience, and *reduced reactivity* to thought content–which is reliably increased with mindfulness-based interventions. In this essay, we seek to link the clinical presentation of distress disorders to known or hypothesized disruptions in neural networks that underlie emotion, cognition, and goal directed behavior, and offer a neurobehavioral account for how and why treatments imbued with mindfulness meditation might ameliorate these conditions, in part through increases in decentering.

Keywords

distress; decentering; mindfulness-based interventions; intrinsic connectivity networks; cross-network connectivity

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Conflict Statement:

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property. We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author and which has been configured to accept email from (samadhi@med.umich.edu) Signed by all authors as follows: David M. Fresco 6 Dec 2018 Anthony P. King 6 Dec 2018

Distress is commonly characterized by prolonged internal suffering that can range from self-focused processing of negative emotions and stressors, to highly intensely aversive and prolonged emotional states [1, 2]. Distress typifies a set of psychiatric conditions including major depressive disorder (MDD), generalized anxiety disorder (GAD), and post-traumatic stress disorder (PTSD), which are highly prevalent, often comorbid with one another [3], and frequently treatment refractory [4, 5]. Although expressing different constellations of symptoms, distress disorders also appear to share important underlying transdiagnostic characteristics that may contribute to the profound impairment, suffering, and treatment challenges [6]. For instance, distress disorders often exhibit intense emotionality [7-9] that affects both the experience of negative emotions as well as cognitive and behavioral factors that actually cause, worsen, and prolong the stressful situations they struggle to tolerate. This intense emotionality is often accompanied by negative self-referentiality including worry, rumination [6, 10], self-criticism [11], and loneliness [12, 13], which further complicates clinical presentation and treatment responsiveness [14].

Decentering represents a metacognitive capacity to observe items that arise in the mind (e.g., thoughts, feelings, memories) with healthy psychological distance, greater self-awareness and perspective-taking [15] and is thought to reflect three interrelated processes: *meta-awareness, disidentification* from internal experience, and *reduced reactivity* to thought content [16]. Gains in decentering predict acute and enduring improvement in distress disorders following treatment with mindfulness-based interventions (MBIs) [17-20] as well as mindfulness enriched CBTs [21-24]. Theoretical accounts [16, 25, 26] and empirical findings [27, 28] are beginning to reveal the neurobehavioral underpinnings of decentering and suggest MBIs lead to engagement and enduring alterations in large-scale neural networks associated with attention, executive control, and self-referential processing [29-31]. However, as the science of decentering continues to mature [32], more work is need to carefully elucidate how mindfulness acts on the distressed brain possibly via increases in decentering [20].

In this essay, we seek to identify known or hypothesized patterns of normative neural network function that are disrupted in MDD, GAD, and PTSD and that may underlie the decentering model of Bernstein and colleagues [16] and offer a neurobehavioral account for how and why treatments imbued with mindfulness meditation contribute to the effective and durable treatment of these conditions, in part through increasing a metacognitive capacity commonly known as decentering [15, 16].

Distributed Connectivity Networks in the Normative Human Brain

The human brain is functionally organized in distributed intrinsic connectivity networks that collectively, account for the majority of normative brain activity [33, 34]. The Default Mode Network (DMN) refers to a reliable pattern of neural activity in the absence of a task, i.e. “at rest”, and consists of nodes in the posterior cingulate cortex (PCC), ventral and dorsal medial prefrontal cortex (vmPFC, dmPFC), subgenual ACC (sgACC), precuneus, and temporal and lingual gyrus [35, 36]. Computational fMRI work reveals functionally separable DMN subsystems [37, 38]: a “core” (PCC, vmPFC), associated with self-referentiality including the construction of a temporally-extended, static, “narrative self” [39,

40]; a medial temporal lobe (MTL) sub-system (vmPFC, hippocampus, parahippocampal gyrus, and inferior parietal lobule [IPL]), associated with episodic memories and self-prospection simulations ("mental time travel"); and a dorsomedial PFC (dmPFC) subsystem (dmPFC, temporoparietal junction [TPJ], and temporal pole), associated with metacognitive capacities including forms of psychological distancing, mentalizing, theory of mind, and other person perspective [37, 38].

Networks corresponding to task-related connectivity patterns underlie attention, cognitive control, and sensory processes [33, 34]. The Dorsal Attention Network (DAN, frontal eye field (FEF) and superior parietal lobule) underlies volitional deployment of attention toward stimuli and externally-directed cognitions, the Ventral Attention Network (VAN, inferior frontal gyrus (IFG)/ventrolateral PFC (vlPFC) and middle temporal gyrus (MTG)), is involved in relatively automatic orientation to unexpected events. The Salience Network (SN, dorsal anterior cingulate (dACC), insula, and amygdala) [41], is associated with detection of salience and threat in the environment [42, 43] and error detection between flows of information. SN activation can move attention away from spontaneous internal thoughts and toward "salient" external stimuli, integrating sensory, emotional, and cognitive information to facilitate optimal communication, social behavior, and self-awareness [41]. The Frontoparietal Control Network (FPCN, bilateral dlPFC and posterior parietal cortex (PPC)), is involved in executive functions and "top-down control", as well as monitoring moment-to-moment coordination between attention, sensory, and internal networks, regulating and directing distributed systems according to current task goals [44].

Increasing evidence indicates distress disorders exhibit aberrant patterns of within- and between-network connectivity [45-49] including decreased activity and within-network connectivity in the FPCN, and FPCN-DAN connectivity, that may underlie cognitive and concentration deficits. GAD and PTSD show hyperactivity and hyperconnectivity with the SN, likely underlying increased somatic anxiety and hyperarousal. MDD and GAD show increased DMN activity and connectivity, which may underlie negative rumination and worry, whereas PTSD shows decreased DMN and increased SN-DMN hyperconnectivity, which may underlie intrusion of hypervigilance into resting awareness [45, 46, 50, 51].

Effects of mindfulness on proposed metacognitive processes in decentering

Establishing a mindfulness practice leads to increased capacity for decentering [17-20] as well as reliable and enduring alterations in the basal neural activity and connectivity, which may account for clinical improvement associated with MBIs [46, 52, 53]. Accumulating evidence offers indications for functional patterns of brain network configurations reflected in the proposed decentering components [16] that may contribute to the resolution of distress disorders [54, 55].

Meta-Awareness.

Meta-awareness reflects awareness of one's subjective experience and the processes of sensing, feeling, and thinking [16] and requires both volitional control of attention, as well

the ability to identify and inhibit spontaneous evaluative processes. Mindfulness practices often facilitate *meta-awareness* through sustained, volitional attention to bodily sensations. Initially, considerable effort is required both to retain focus on the body sensations, and to "monitor" and become aware of when one is not attending to sensation and/or when attention is drifting into spontaneously generated internal thoughts (mediated by DMN) [56]. Volitional attention to external stimuli is mediated by DAN, often in coordination with FPCN, whereas attending to bodily sensations (and interoception in particular) is also expected to engage activity in the insula, an important node of the SN [26, 29, 56]. Detecting moments of not attending to one's object during meditation, and spontaneous internal thoughts and mind-wandering generated by DMN (i.e. a form of error detection) is expected to engage SN, in particular dACC and insula [29, 31]. The subsequent moving of attention away from internal thoughts (and back to the body sensations) likely involves SN-mediated shifting of connectivity of FPCN away from DMN and toward DAN [29, 31].

Similarly, repeated practice of mindfulness meditation leads to enduring increases in baseline activity and connectivity (i.e. when not meditating) of SN and attention networks in formerly meditation-naïve people [57], which may underlie increased capacity for *meta-awareness* in daily life. Numerous MBI-linked fMRI findings report increased basal activity in SN including the dACC and insula [56, 58], increased white matter structural connectivity in dACC [59, 60], increased network efficiency of dACC [61], increased functional connectivity in SN [62], structural connectomic reorganization of right anterior insula [63], and enhanced EEG fronto-central theta synchrony following MBCT [64], suggesting increased dACC activity

MBIs also lead to enduring changes in FPCN and DAN, including increased activity in FPCN (dlPFC and posterior parietal cortex [PPC]) during executive processing [65] and emotion regulation tasks [66] following MBSR. Three-days of intensive meditation produced increased connectivity between FPCN, DAN, and VAN [67]. Taken together, these findings suggest MBIs may lead to enduring increases in activity and/or coordination of SN, FPCN, and DAN that possibly underlie increased capacity for *meta-awareness* of and disengagement with spontaneous internal thoughts and shifting attention toward present-moment physical sensations [31].

Disidentification.

Disidentification refers to the capacity for creating psychological distance from internal states, thereby helping individuals regard thoughts, emotions, and sensations as passing mental phenomena as not necessarily true and not necessarily identical to one's self [16]. Disidentification is perhaps epitomized by the slogan "Don't believe everything you think". All humans spend considerable time mind-wandering in a self-immersed state experiencing spontaneous internal thoughts such as self-appraisals of the static self, when not addressing other neural and physical demands [68]. Self-immersed mentation is especially associated with the "core" DMN (PCC and vmPFC) and other mPFC regions [39, 69, 70]. Aberrant DMN activity has been linked to depressive rumination [71] and although not universally maladaptive, many forms of psychiatric disorder are marked by hyperactivity in DMN [72], which can delay or interfere with purposeful activation of neural regions associated with

executive control [72], undermining cognitive load and emotion regulation capacities [72, 73], further impairing emotional control in the face of negative self-referentiality. MDD, GAD, and PTSD are all associated with deficits in executive control, and weakened FPCN and FPCN connectivity with attention networks [46, 47, 74, 75].

The attentional focus on internal thoughts practiced in mindfulness suggest *disidentification* may involve dynamic modulation or regulation of spontaneous DMN activity by executive control and attentional processes. Several studies of acute practice of mindfulness meditation and laboratory analogues report decreased connectivity in "core" DMN (PCC-vmPFC) activity and connectivity in meditation-naïve people [39, 76, 77] and more pronounced decreases in DMN occur when instructed to meditate following a course of MBSR [39] and among long-term meditators [73, 77]. Decreased basal levels (when not meditating) of core DMN connectivity are also reported in long-term meditators [76, 78], which may reflect the enduring neurobehavioral effects of mindfulness. Recent reports of mindfulness-linked increases in enduring cross-network connectivity between DMN and FPCN might be related to changes in executive control in mindfulness. Several independent groups report increased connectivity between PCC and dlPFC, in healthy people [76, 79] and in psychiatric patients with anxious depression [27] and PTSD [80], suggesting MBIs may lead to increased access to executive attention networks during mind-wandering. Greater DMN-FPCN (PCC-dlPFC) connectivity following MBI was associated with greater clinical improvement in PTSD symptoms [80], suggesting it could be linked to a therapeutic mechanism; decreased connectivity between anterior DMN and FPCN (dlPFC) has been related to greater severity of PTSD symptoms [81]. MBIs and long-term meditation are also associated with increased connectivity between the dlPFC (FPCN) and insula (SN) during self-referential processing [39], and increased PCC (DMN) and dACC (SN) during rest / mind-wandering [76, 80].

Although speculative, taken together, these early findings are suggestive of a mindfulness-entrained brain network configuration characterized by coordinated increased within-network connectivity in FPCN (73) and SN [67] increased cross-network connectivity in FPCN-DMN [27, 76, 79, 80] and FPCN-DAN [67], and altered patterns of cross-network connectivity between DMN and SN [39, 76, 80]. Such altered coordination between attention and executive control networks and DMN by MBIs might underlie increased capacity for *meta-awareness* and *disidentification,* and thereby improved top-down control of spontaneous negative internal self-related thoughts, greater capacity for disengagement with negatively-biased internal thoughts, and greater flexibility of shifting attention [31, 82, 83], thereby decreasing susceptibility to perceptual decoupling and less "stickiness" of negative rumination.

Disidentification might also reflect altered patterns of function in DMN subsystems. Spontaneous self-related thought processes particularly relevant to distress disorders such as autobiographical memories and negative future self-prospections (e.g., distressing or catastrophic) involve the MTL-DMN and dmPFC-DMN subsystems. Whereas autobiographical memory retrieval is associated with the hippocampal MTL-DMN subsystem, metacognition or "mentalizing" of autobiographical memories leads to greater involvement of the dmPFC-DMN subsystem [37, 84], suggesting the dmPFC-DMN subsystem might contribute to *disidentification.* Consistent with this speculation, MBI-

induced alterations reported in the dmPFC-DMN subsystem include increased connectivity of dmPFC with posterior DMN [62, 85], increased dmPFC-IPL connectivity [78], and increased dmPFC-insula anti-correlation [86]. Long-term meditation and MBIs also appear to lead to enduring alterations in the MTL-DMN, including greater hippocampal grey matter density [52, 87-89] and increased resting connectivity between hippocampus and PCC [85]. These findings suggest the possibility that MBI-induced changes in these DMN subsystems could be involved in increased capacity for *disidentification* to spontaneously generated painful autobiographic memories or catastrophic self-projections.

Reduced reactivity.

The psychological distancing in *disidentification* is proposed to facilitate reduced reactivity to negative thoughts so that they are less likely to trigger stronger negative emotional reactions and negative self-conscious or depressive rumination. Improved *meta-awareness* of spontaneous negative thoughts that could trigger a cycle of rumination or worry, used in conjunction with increased capacity for *disidentification,* might underlie the ability of MBIs to decrease negative rumination in people with distress disorder [64, 83, 90, 91]. Increased capacity to more flexibly refocus attention away from negative internal thoughts and toward a broader awareness of present-moment external and interoceptive stimuli may also lead to greater opportunities to connect with contemporaneous pleasure/reward and increased positive reappraisals [92]. We hypothesize coordinated network connectivity between FPCN, DAN, and DMN might facilitate *disidentification* from negative self-related thoughts and improved top-down control of emotional responses.

Aberrant within-network and between network connectivity in the SN is implicated in intense negative emotionality and can amplify somatosensory and interoceptive awareness of physiological cues, potentially underlying hypervigilance. Although commonly associated with positive health outcomes [93], greater interoceptive awareness also predicts increased anxiety and panic, especially when one’s bodily sensations are catastrophized [94-98] or when engaging in negative self-referentiality [96, 97]. Negative self-referentiality appears to exaggerate arousal (i.e., positive or negative) and increases the likelihood that such cues are interpreted negatively, resulting in increased sympathetic arousal, and increased escape or avoidance behaviors [97]. Hyperactivity of insula, dACC, and amygdala is widely seen in PTSD and GAD [45, 99-101]. MDD and GAD consistently show that hyperactivity of the anterior insula is often accompanied by increased connectivity with nodes of DMN including the PCC [97, 102, 103] and mPFC [47]. PTSD is associated with hyperconnectivity within the SN, in particular heightened insula-amygdala and insula-dACC connectivity [45, 51] as well as hyperconnectivity between insula and DMN nodes [104] that is thought to underlie hyperarousal symptoms.

Mindfulness is associated with decreased subjective emotional reactions and decreased amygdala (a key node of SN) responses to negative self-related or social stimuli in laboratory paradigms with meditation-naive individuals [105, 106], in healthy people [107], in MBI patients [39, 108, 109], and in long-term meditators [110]. Similarly, mindfulness tasks [111] and MBIs increase top-down regulation of emotional amygdala responses by increased amygdala connectivity or coordination with vmPFC [110], ventrolateral PFC

(vlPFC) [109], and left fronto-parietal network [111]; suggesting increased frontal-amygdala integration as a potential neural mechanism of emotional regulation increased by MBIs. Similarly, a 3-day intensive mindfulness intervention led to decreased sgACC (DMN node) resting connectivity with amygdala suggesting another related potential mechanism underlying decreased reactivity to internal thoughts [112].

Mindfulness meditation has been proposed to reflect a form of exposure to feared and distressing spontaneous thoughts and internal experiences leading to decreased subjective and neural reactivity [57, 113-115]. MBI-related changes occur in the same limbic and orbitofrontal/prefrontal regions [52, 87-89, 115] underlying fear conditioning, extinction, and extinction recall [50, 100, 116]. One study reports MBSR increased fear conditioning as well as extinction learning, and also increased structural connectivity (fractional anisotropy) with the uncinate fasciculus, a fiber tract involved in emotional regulation and associative learning [113]. The MTL-DMN subsystem contains the vmPFC-hippocampal circuits involved in contextual modulation of conditioned fear and extinction recall, and processes of pattern completion and pattern separation crucial for appropriate contextual responses to learned fear [50, 117]. The present-moment, sensory focus of mindfulness practice appears to be a form of “contextualizing” oneself in time and space (now and here), and better differentiating between one’s present-moment sensory experiences vs. one’s thoughts, autobiographic memories, and future prospections.

Although increased engagement of SN during mindfulness practice and enduring increases in SN connectivity following MBIs may improve one’s capacity to disengage from internal thoughts such as rumination, worry, and distressing memories, SN is already hyperactive in anxiety disorders and PTSD [99], and aberrant cross-network connectivity between SN and DMN appears to play a role in driving distress in these disorders [97, 104]. Sustained attention to interoceptive processes during mindfulness practice in patients with anxiety or PTSD may provide important additional forms of exposure to feared interoceptive cues and negative internal thoughts and interpretations (i.e., as seen in the phenomena of “relaxation induced anxiety”[118]) potentially leading to habituation and decreased reactivity, as well as more accurate interpretations of such stimuli. These observed alterations in patterns between-network connectivities between SN, FPCN, and DMN following MBIs may underlie habituation and improved top-down regulation of these internal experiences.

Summary

In this paper, we reviewed known or hypothesized neural correlates of how the practice of mindfulness meditation may increase one’s ability for decentering, especially in relation to neural networks implicated in distress disorders. Although the state of the literature is preliminary, MBI-related alterations including increased within-network connectivity in SN and FPCN and increased coordination of FPCN with attention networks are consistent with increased capacity for *meta-awareness.* It seems plausible that *disidentification* from internal thoughts may involve modulation of spontaneous DMN activity by attentional and executive processes, possibly reflected by altered between-network DMN connectivity with FPCN and SN and/or alteration in DMN subsystems.

Despite progress in better understanding the distressed brain and the potential ameliorative effects of MBIs, questions remain yet also point to some important future directions. For instance, further work is needed to better differentially examine psychological components of the practice of mindfulness and decentering (e.g. *meta-awareness* vs. *disidentification*) [29, 119] within neuroimaging paradigms, to better understand their specific functional neurocircuitry. An important future direction will be to delineate whether MBI-linked changes in connectivity patterns may provide the neural basis for decreased identification with and emotional reactivity to spontaneously generated negative episodic memories in PTSD and depression, and negative or catastrophic future prospections that are central features of disorders of distress [46, 115]. Future work might examine the effects of MBIs on the neurocircuitry of contextual processing in disorders of distress, and in particular the deficits in contextual processing circuitry seen in PTSD [50]. Finally, we have based this account of mindfulness meditation linked gains in relation to the conceptual model of decentering posited by Bernstein and colleagues [16] which is but one of several contemporary models [26, 57, 114] and treatment packages [120-122] that offer account for how practice of mindfulness leads to greater well-being. An important future direction will be to thoughtfully compare and synthesize all these models into a more comprehensive understanding of the salutary benefits of mindfulness meditation.

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Highlights

- We discuss the issues related to distress and challenges to in resolving distress disorders
- We propose that the metacognitive capacity of decentering which is reliably increased by mindfulness-based interventions can increase decentering can resolve distress
- We describe normative neural networks that underlie emotion, cognition, and goal directed behavior
- We review known or hypothesized patterns neural activation and connectivity associated with the components of decentering and how mindfulness-based interventions have been shown or are hypothesized to increase decentering