Psychobiology of Mindfulness

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ABSTRACT

There is controversy about whether mindfulness-based approaches to psychotherapy represent a new wave of cognitive-behavioral therapy or a core process in all psychotherapies. One way of conceptualizing mindfulness is in terms of emotion regulation; mindfulness is a strategy aimed at opposing suppression and avoidance. Dispositional mindfulness has been associated with greater activation in prefrontal cortex and greater deactivation of amygdala during affect labeling. A number of rigorous studies of mindfulness-based cognitive therapy for depression have been positive. However, much remains to be discovered about the underlying mechanisms of and clinical indications for mindfulness-based approaches.

CASE REPORT

Steve is a 24-year-old student who had experienced episodes of recurrent depression. He had various options for graduate school and was concerned about whether his choice would be a meaningful one. All too often, he was pessimistic about the future, and concerned that graduate school was the first step toward a life of unhappiness. Initially, Steve's therapist used mindfulness-based stress reduction techniques, which provided some short-term alleviation of his emotional distress. These techniques were consistent with previous readings he had done on the importance of self-acceptance and self-discovery. Over time, his therapist began challenging his worldviews more aggressively, and he gradually began to see graduate school as an exciting step into the next phase of his life.

COGNITIVE-AFFECTIVE NEUROSCIENCE

Mindfulness is a construct with a long and rich history; it is not a unitary phenomenon, and there is ongoing work on optimal operational definition.[1-3] As an initial step, mindfulness has been described in terms of sustained and non-evaluative moment-to-moment awareness and attention to perceptible mental states and processes, including sensations, feelings, and thoughts.[4] Mindfulness is thought to play a key role in meditation practices.[5]

One way of understanding mindfulness is in terms of emotional regulation. Gross[6,7] has divided emotional regulation into antecedent-focused and response-focused strategies. Antecedent-focused emotional-regulation strategies include situation modification and cognitive reframing. Response-focused emotional-regulation strategies include suppression and experiential avoidance strategies.

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Mindfulness is one such strategy as it opposes suppression and avoidance.[8]

A key mechanism for increasing mindfulness is the labeling of aspects of experience. Labeling emotions, for example, may allow recognition of, distancing from, and regulation of affective experience.[5] Thus, a cognitive-behavioral mindfulness-meditation intervention (mindfulness-based cognitive therapy) encourages the use of words or phrases to label emotional states.[9] However, meditative practices may use a range of different approaches,[10] and the mechanisms underlying mindfulness require further investigation.[11]

Neuroanatomy/Neurochemistry

Emotional regulation appears to be accompanied by increased activation in prefrontal cortex (PFC) and/or decreased activation in regions such as the amygdala and insula.[12] Failure of emotional regulation may play a key role in anxiety[13] and in depression.[14] On the other hand, dorsolateral PFC may be important in conscious reframing and control of external behavioral processes, while ventromedial PFC and orbitofrontal cortex may be particularly important in emotion evaluation and control of internal states.[15-17]

Verbal labeling of affective stimuli has been studied during imaging. Affect labeling activates right ventrolateral PFC (RVLPFC) and attenuates responses in amygdala (Figure 1).[18-20] This process may disrupt automatic affective responses and lead to a decrease in their intensity or duration; indeed, imaging correlates of emotional regulation have been associated with more adaptive diurnal cortisol patterns.[21] Importantly, dispositional mindfulness is associated with greater activation in PFC and greater deactivation of amygdala during affect labeling (Figure 2).[5] Conversely, mindfulness training leads to a stronger coupling of medial PFC and insula connectivity.[22]

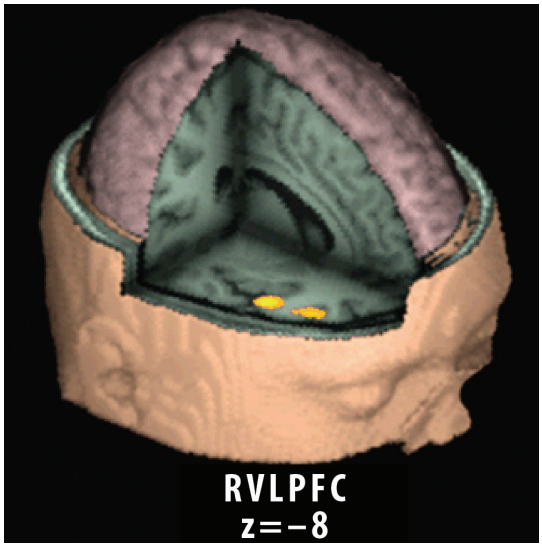
A related set of research[23,24] has focused on electrophysiological and imaging correlates of meditative and hypnotic states. Such studies have highlighted the role of limbic regions involved in control of autonomic responses and in interoceptive awareness.[25-28] In addition, skilled meditators have (inconsistently) differential activation of anterior cingulate and adjacent medial frontal cortex,[29,30] and increased gray matter concentration in the insula.[31] Furthermore, meditation appears to be associated with increased striatal dopamine release (Figure 3).[32]

It has been suggested that mindfulness-based stress reduction may lead to a range of health benefits.[4] Consistent with this are findings that mindfulness may have positive effects on the hypothalamic-pituitary-adrenal axis, and on various hormonal and immunological systems.[33,34] Mindfulness-based interventions have led to changes in brain electrical activity[35] (increased left-sided anterior activation), affective and cognitive changes,[36-38] and increases in antibody titres to influenza vaccine.[35] It is also notable that the neuronal correlates of dispositional and trained mindfulness are reminiscent of those seen during pain control, placebo response, and empathy.[5,39-41]

Gene/Environment

Interpersonal differences in mindfulness may well be influenced by genes and environments.[42] Catechol-O-methyltransferase, the major enzyme determining cortical dopamine flux, has a com-

FIGURE 1.
On fMRI, activation of RVLPC was increased during affect labeling compared with gender labeling[18]



fMRI=functional magnetic resoance imaging; RVLPFC=right ventrolateral prefrontal cortex.

Lieberman MD, Eisenberger NI, Crockett MJ, Tom SM, Pfeifer JH, Way BM. Putting feelings into words: affect labeling disrupts amygdala activity in response to affective stimuli. *Psychol Sci.* 2007;18:421-428. Reprinted with permission. Copyright 2007.

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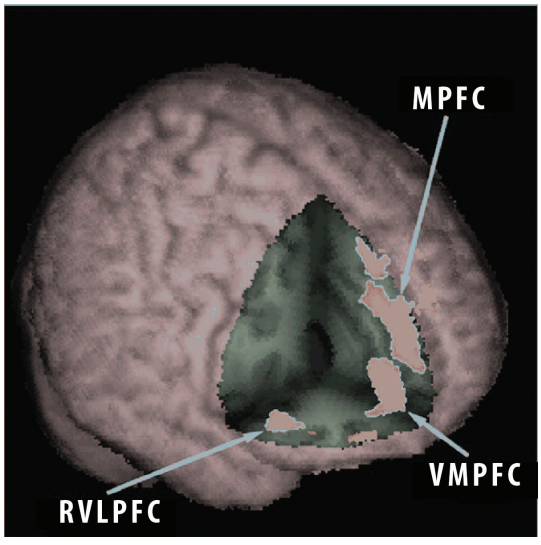
mon functional polymorphism, val[158]met. In one study,[43] the met allele was associated with heightened reactivity and increased connectivity in corticolimbic circuits in response to negative emotion. In another study, controls had the expected activation of RVLPFC and deactivation of amygdala when labeling emotions, while those exposed to early adversity (in the form of harsh parenting) had a positive correlation between RVLPFC and amygdala activation.[44]

Evolutionary Approaches

Clearly emotional regulation including mindfulness can be adaptive. Nevertheless, particular setpoints for mindfulness may be useful in particular contexts. In most circumstances, a judicious use of emotion, with careful integration of reason and passion, is a successful strategy. However, in certain situations, for example, when there are fewer resources, it may be hypothesized that a "live hard–die young" strategy, perhaps characterized by less empathy,[45] is more successful.[46] Speculatively, it is possible that emotional suppression or alexithymia can also be useful in certain contexts.

FIGURE 2.
On fMRI, activation of prefrontal cortex was associated with mindfulness[5]



fMRI=functional magnetic resoance imaging; MPFC=medial prefrontal cortex; VMPFC=ventromedial prefrontal cortex; RVLPFC=right ventrolateral prefrontal cortex.

Creswell JD, Way BM, Eisenberger NI, Lieberman MD. Neural correlates of dispositional mindfulness during affect labeling. *Psychosom Med.* 2007;69:560-565. Reprinted with permission. Copyright 2007.

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CLINICAL IMPLICATIONS

DSM-IV-TR *Diagnosis*

Emotional regulation is disrupted in a range of conditions, including the impulse-control disorders and certain personality disorders (eg, borderline personality disorder), and anxiety and mood disorders. Nevertheless, there is less work on the association of dispositional mindfulness with different categories of psychopathology. Similarly, while neural correlates of emotional regulation have been explored in a broad range of psychopathology,[47] there is little work focusing specifically on correlates of mindfulness. Ultimately, a more detailed understanding of emotional dysregulation, including variations in mindfulness, may influence nosology.

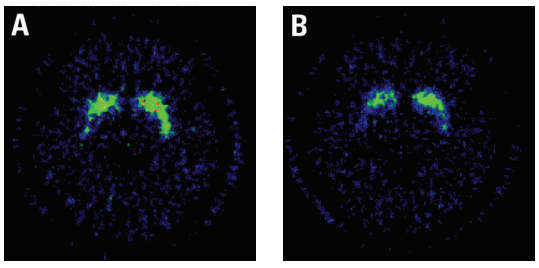
Assessment/Evaluation

Mindfulness covers a range of different phenomena.[1-3,48,49] Not surprisingly, therefore, a number of different measures are available.[50-54] The labeling subscale of one mindfulness measure was associated with higher life satisfaction and better emotion regulation.[53]

Pharmacotherapy/Psychotherapy

While some believe that acceptance and commitment therapy (ACT) represents a third wave of cognitive-behavioral therapy (CBT),[55] others emphasize that mindfulness is a core process across psychotherapies.[56] Hofmann and Asmundson[8] have argued that CBT pro-

FIGURE 3.
[11]C-raclopride binding potential images in a participant during (A) attention and (B) meditation[32*]



Reduced [11]C-raclopride binding potential in ventral striatum is evidence of increased endogenous dopamine release during meditation.[32]

Kjaer TW, Bertelsen C, Piccini P, Brooks D, Alving J, Lou HC. Increased dopamine tone during meditation-induced change of consciousness. Brain *Res Cogn Brain Res.* 2002;13:255-259. Reprinted with permission. Copyright 2002.

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motes adaptive antecedent-focused emotional regulation strategies by focusing on reappraisal, while ACT primarily targets maladaptive response-focused strategies. The goal of ACT is to discourage suppression and experiential avoidance, which is the unwillingness to experience negatively evaluated sensations, feelings, and thoughts.[57]

Arguably, acceptance and mindfulness-based strategies counter suppression and thereby alleviate short-term distress, while the cognitive-restructuring techniques used in CBT may provide skills for enduring change.[8] Mindfulness-based stress reduction employs mindfulness meditation and has been studied in a range of conditions, including borderline personality disorder, depression, anxiety disorders, insomnia, and pain.[4,58,59] Although not all outcomes are persuasive,[60] studies of mindfulness-based cognitive therapy for depression have been positive.[61,62] Mindfulness interventions are possibly helpful for psychotherapists in treating their patients.[63] Mindfulness traits may also be a predictor of treatment outcome.[64]

CONCLUSION

Mindfulness is a construct that is rooted in the body; it involves attention to sensations and feelings, and its brain basis is gradually being delineated. There is ongoing debate, however, about whether mindfulness-based interventions represents a new wave of CBT or a core process in all psychotherapies. It has been argued[8] that different CBT techniques act on different aspects of emotional regulation, with ACT helping to address strategies such as suppression and avoidance. Ongoing research on how mindfulness-based interventions alter psychobiology is contributing to the understanding of the neurobiology of CBT. ***CNS***

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