# Mindfulness and the Addictive Process: Psychological Models and Neurobiological Mechanisms

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## Introduction

Mindfulness meditation aims at helping people reduce suffering that is fed and perpetuated by craving. The early Buddhist texts in which this practice is first articulated offer a therapeutic model explicating suffering, its cause, the possibility of a cure, and the methods required to achieve that cure. This approach targets the psychological roots of suffering, and in particular, craving, which is identified as the primary cause of suffering. It is through the "relinquishment, release, and letting go" of craving that suffering is cured (SN.56.11 in Thanissaro, B. (trans.), 2010a).[1] Mindfulness is a central component of the method prescribed for creating release from the cycle of craving and suffering.

In the recent psychological literature, craving has been defined as the "subjective experience of wanting …[something]" (Tiffany & Wray, 2012, p. 2). There are many components that contribute to the experience of craving; here we emphasize craving as a non-elaborative, somatic, and affective experience of grasping after a particular desired object (i.e., the "gut feeling" of wanting). The term for craving used in the early Pali Buddhist texts, *taṇhā*, more literally means thirst. This apt turn of phrase indeed suggests the insatiable desire reported by people dealing with addictions, and the enormous suffering that can result. Addictive behaviors cause stress and anguish on personal, family, and societal levels, and people with addictions use language reminiscent of the ancient texts we cite below. In a book entitled *Ninety Days: A Memoir of Recovery*, Billy Clegg wrote "… I can feel that old burn, that hibernating want, come awake. I imagine the relief that first hit will deliver and I'm suddenly up off the couch and pacing. No no no, I chant. No f-king way. That craving, once it begins, is almost impossible to reverse. What my addict mind imagines, my addict body chases." As he points out, we are literally slaves to our bodily sensations when we do not have mental training tools in place to work skillfully with our sensations. Not surprisingly, craving is rooted in our most basic neural processes: positive and negative reinforcement. And of course, this is where mindfulness training can help. Paradoxical to many

[1] Following convention, sutta references are to collection (e.g., Majjhima Nikāya (MN), Suttanipāta (Sn)), and then either to sutta number (in the case of DN, MN, and Iti), saṃyutta and sutta number (SN), nipāta and sutta number (AN), verse number (Dhp), vagga and sutta number (Ud, Sn).

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modern cognitive-behavioral and/or control-based treatments, which focus on building "mental muscle" to avoid, think through, and substitute behaviors, mindfulness training teaches us to see more clearly what we get from our addictions, rather than avoiding or trying to change them. In doing so, we naturally begin to become disenchanted with the cycle of craving, which begins the process of letting go.

Addictions are one of the costliest human conditions, having significant effects on mental, physical, and economic health. Drug abuse, as a whole in the USA, grows in economic cost by an estimated $7 billion per year, costing approximately $180.8 billion in 2002, primarily in lost productivity (Office of National Drug Control Policy, 2004). Given the impact of these disorders, much convergent work has been done to identify the mechanistic underpinnings of addictions, and to develop effective treatments (Goldstein et al., 2009; Kalivas & Volkow, 2005). In this chapter, we outline contemporary psychological models of addiction and highlight how current understanding of the addictive process relates to Buddhist psychological models of human suffering. Also, we review studies of mindfulness training for addictions and discuss insights they might provide with regard to targeting core components of the addictive process. Finally, we relate models of addiction and mindfulness to emerging neuroimaging studies and explain how these may provide critical links between psychological models of addiction, the key components of the addictive process that mindfulness training targets, and the neurobiological mechanisms thereunder.

## Early Models of Addiction

Buddhist psychological models distinguish five aspects of emotional reaction to triggers (i.e., anything that elicits a reaction): bodily, affective, cognitive, volitional, and conscious components. The dynamic, causal relationships between these differentiated processes are delineated by the notion of "dependent [co-]origination." In this process, craving is said to result from a process

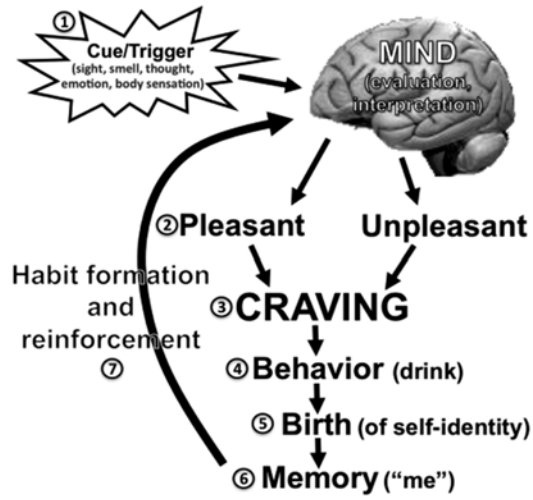


**Fig. 14.1** Early models of addiction: dependent origination. Copyright 2011 Judson Brewer. Reprinted with permission of author

based in automated affective reactions to perceptual stimuli. For example, when environmental cues register through the senses (thoughts are considered categorically indistinct from the standard five senses, Fig. 14.1, #1), an "affective tone" automatically arises that is typically felt as pleasant or unpleasant (#2). The valence of this affective tone is conditioned by associative memories that were formed from previous experiences (#6 + MIND). Subsequently, a desire or craving arises as a psychological urge to act or perform a behavior (#3). The craving is for the continuation of pleasant, or the cessation of unpleasant feeling tones, respectively. This craving motivates action (#4) and fuels the "birth" of self-identity (#5), creating a link between action and outcome that is recorded in memory (#6). Importantly, when this pleasant affective tone (or absence of an unpleasant affective tone) passes, one is left with the "pain, distress, and despair" of its absence, thus completing one cycle and priming the individual for the next time he/she encounters a similar sensory stimulus (#7) (SN.12.2 in Thanissaro, 2010b).

In other words, an individual learns that drug use (action) decreases unpleasant feelings such as negative affect and craving, and he/she starts forming a behavior pattern related to these affective reactions.

The perception of an object is influenced by previous experiences, and the consolidation of related memories leads to habits or dispositions—consequently "updating" how perception will function in the future (MIND). This cycle can build on itself in another way as well: states associated with craving and aversion are themselves unpleasant; individuals often develop aversive reactions towards their own craving and aversion. Fortunately, the iterative nature of this cycle also means that it can be disrupted at each new round.

The central point of this model is that craving and aversion arise in response to an affective tone that is associated with perceptual representations of a sensory object, rather than directly in response to the object (Grabovac, Lau, & Willett, 2011). This provides a critical entry point for therapeutic interventions: through paying careful attention to one's own experience, the Buddhist accounts claim that one can see that perceptions and associated affective reactions (affective tone) are separate from—and indeed separable from—craving and aversion, as well as the elaborative thought processes these can initiate. As one Buddhist scholar puts it, through paying mindful attention to affective reactions, "one distinctly realizes that a pleasant feeling is not identical with lust and need not be followed by it … By doing so, he makes a definite start in cutting through the chain of dependent origination at that decisive point where feeling becomes the condition for craving … It will thus become the meditator's indubitable experience that the causal sequence of feeling and craving is not a necessary one …" (Nyanaponika, 2000). It should also be noted that even when craving has already arisen, mindful awareness can prevent further cycles of aversive reaction to the unpleasant feelings associated with this craving, and thus reduce habitual reactions that arise in an attempt to escape this unpleasantness.

Importantly, craving is the link that is targeted here in cutting through the cycle of dependent origination. Some traditional accounts take meditation practice to be aimed at the realization that there is no self. However, this interpretation has been controversial in contemporary Buddhist scholarship (Hamilton, 2000). Indeed, nowhere in the early Buddhist dialogues is the Buddha reported as claiming that there is no self; on the contrary, both the view that there is no self and the view that there is a self are said to lead to suffering (MN.2 in Ñāṇamoli & Bodhi, 1995). The sense of self that is born in the process of dependent co-arising, sketched above, is constituted by habituated reactions of clinging to pleasant aspects of experience and to the absence of the unpleasant. In a moment of desperate craving for something, it seems as if appeasing this particular sense desire will bring all that one needs, even if one knows better. But this is a distorted perception; sense pleasures are fleeting, and incapable of resolving the core distress that fuels the cycle of searching for gratification. As one discourse puts it, "Indeed, I have long been tricked, cheated, and defrauded by this mind. For when clinging, I have been clinging just to material form … feeling … perception … formations, consciousness … With my clinging as condition, being … birth … ageing and death, sorrow, lamentation, pain, grief, and despair come to be. Such is the origin of this whole mass of suffering" (MN.75 in Ñāṇamoli & Bodhi, 1995). The idea here is that *by clinging to any kind of experience, a sense of self is born*. This sense of self is very basic, being dependent only on grasping after the objects of experience. It does not depend on clinging to an explicit self-identity. Thus, even if one does not ruminate about one's self-identity, as long as there is craving for any aspect of experience, this affectively constructed sense of self continues. When the sense of self is threatened, by the inability to prevent the loss of what is grasped after or to prevent the presence of what is pushed away, then one suffers.

We postulate that mindfulness does not prevent the cognitive construction of self-identity necessary for functioning in the world, but instead targets previously developed affective biases (Elliott, Zahn, Deakin, & Anderson, 2011). Such affective biases prevent individuals from accurately assessing what is happening in the present moment, and acting accordingly. Mindfulness functions to decouple pleasant and unpleasant experience from habitual reactions of

craving and aversion. By overcoming affective biases of attention and memory, mindfulness allows individuals to feel and know more clearly the pain of perpetuating emotional craving and aversion. As we suggest below in more detail, being fully present with the pain of this emotional reactivity may be sufficient to motivate individuals not to perpetuate it. In other words, mindfulness does not stop one from being a person, but rather from taking things personally.

From this perspective, mindfulness allows practitioners to clearly ascertain what is driving their behavior, and whether or not it is moving them towards or away from their goals. To illustrate this point, we will use a fictional character, Ethel Knoll-Kraver throughout this chapter (see Text Box). For example, mindfulness might enable Ethel Knoll-Kraver to see clearly that each time she drinks in reaction to being stressed, she only briefly avoids the stress. By seeing that drug use only provides a minimal amount of relief, and does not address whatever led to her stress in the first place, she can work to fix its root cause. By better understanding her context and the factors that have previously contributed to her drug use, Ethel may also become more disenchanted with drinking by simply seeing more clearly its effects. Ethel may know the health risks and financial costs of drinking but fail to give sufficient weight to these facts in her decisions about her behavior. By attenuating emotional distortions in the decision-making process, mindfulness may function to enable Ethel to weigh these factors more accurately.

Young Ethel Knoll-Kraver is invited to have a drink by a group of older kids who are popular at school (see #1 "positive cue" in Fig. 14.1a). She learns to associate drinking with "being cool"—when she's at a party drinking with friends, she feels good (#2). Over time, she also learns that having a drink after work calms her nerves (#2–6). When Ethel gets yelled at by her boss, or gets a bad grade in school (#1 "negative cue"), she feels stressed out (#2), gets a craving (#3), and stops by a bar on the way home for a drink (#4). The more Ethel drinks in these situations, the more she reinforces her behavior (#5–7), and the more she finds herself licking her lips when she gets stressed out. At times, she may even find herself at a bar before "waking up" to the fact that something triggered her to habitually drive there and order a drink.

Given that one's self-identity is largely based on memory, the Buddhist description of dependent origination is remarkably similar to the contemporary model of the addictive loop. When Ethel, who has learned to associate drinking with the reduction of stress and/or the temporary abatement of withdrawal (#6), encounters a stressful situation or alcohol withdrawal symptoms such as irritability, restlessness, and agitation (#1), her brain interprets these as unpleasant (#2). She wants the unpleasant feeling to go away, and consequently gets a craving to drink (#3). When she drinks, she reinforces the habituated reaction to affective experience (e.g., "if I drink, I will feel better"; #4–6).

While Ethel might take this personally, having thoughts such as "I am drinker," it is not these particular self-related thoughts but rather the affective bias underlying the reaction of taking things personally that fuels the birth of self-identity (i.e., habituated reactions to affective experience). As the state of satisfaction from feeding the craving is short-lived, the passing away of this mind state inevitably ensues, leading to dissatisfaction, stress, or suffering once again. Importantly, each time Ethel drinks, she re-engages and reinforces this loop, resulting in subsequent rounds of this process (#7). Buddhist texts call this repetitive process *samsara*, or endless wandering, as there is no obvious way out of it when propagated. Ethel may even begin to ruminate about drinking and start planning her day around access to alcohol, which, as we will see later, likely engages brain circuits involved in self-referential processing, thus further fueling this process. Our modern-day equivalent of the endless wandering characterized by Buddhism appears remarkably similar: the addictive loop. However, the psychological terms and links employed in dependent origination will need careful refinement and empirical validation to determine their relative explanatory and predictive power in contemporary models of addiction.

## The Birth of an Addiction

Acquisition of an addictive behavior is a complex process based on operant conditioning: pairing action with reward, which leads to modified behavior. This process has been observed for over a century in animals ranging from the simple sea slug (Aplysia) to humans. Addictions are developed in part from the formation of associative memories between behavior and both positive and negative affective states (see Text Box). Subsequently, cues that are judged to be positive or negative can induce positive or negative affective states, which can then trigger craving to repeat this behavior (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004). Additionally, neutral cues that have been classically conditioned may directly trigger craving (Lazev, Herzog, & Brandon, 1999). Craving then leads to repeated behavior, whether drinking alcohol, smoking cigarettes, or eating food and results in the maintenance of positive or reduction of negative affective states (Baker et al., 2004).

This process sets up positive or negative reinforcement loops, respectively, by reinforcing the associative memories between these affective states and behavior. This associative learning process may then lead to increased motivational salience of future cues (in which both positive and negative cues become more motivationally relevant) (Robinson & Berridge, 2008), resulting in what, building on the work of Baker, Curtin, and others (Baker et al., 2004; Curtin, McCarthy, Piper, & Baker, 2006), for convenience we term the "addictive loop." Through repeated substance use, this loop may become habitual, leading to cue-induced behavior that is largely outside of consciousness, let alone conscious control (Bargh & Chartrand, 1999; Curtin et al., 2006). So strong is this cue-induced habitual behavior, that the longer an individual remains abstinent from a drug of abuse, the stronger his or her craving for the drug becomes, making relapse more likely, and termination of the cycle less likely (Bedi et al., 2011).

This addictive loop model is noteworthy for several reasons. First, each link in the chain is supported by convergent findings from both non-human animal and human studies, suggesting an evolutionarily conserved process. Second, it provides some explanatory power for the relative strengths and weaknesses of current treatment paradigms. Third, its self-propagating nature aligns surprisingly well with Buddhist psychological models as described above regarding the causes of human suffering: craving and attachment.

## The Promise of Mindfulness-Based Cessation Treatments

The multitude of cues that can be associated with positive and negative affective states, along with drug use, creates tremendous challenges for successful treatment and long-term abstinence. Mainstay behavioral treatments have focused on teaching individuals to avoid cues, foster positive affective states (e.g., practice relaxation or physical exercise), divert attention from cravings, substitute other activities, and develop social support mechanisms (Fiore et al., 2008). Unfortunately, these have shown only modest success, with abstinence rates for cognitively based treatments hovering between 20 and 30 % (Law & Tang, 1995). This may be because triggers are omnipresent. The omnipresence of cues makes avoidance difficult; diversion of attention requires cognitive reserves, which are often depleted after strong affective states (Muraven & Baumeister, 2000), and effective substitutions are not always available. Further, these strategies may not actually target the core addictive loop (e.g., avoidance of cues decreases input to the loop), while substitute behaviors (e.g., eating carrot sticks or candy) circumvent the loop. Importantly, these strategies, at least in theory, may not diminish the loop itself, instead leaving it dormant to reactivate at a later time. One recent finding even suggests that cue-induced craving may increase with length of abstinence, suggesting that avoiding cues or substituting behaviors may do little to target core processes fueling addictive behaviors (Bedi et al., 2011). Even cue exposure that aims to decrease the conditioned responses may not adequately disrupt the addictive loop, instead leading to different

associations that are also situation specific (Bouton, Westbrook, Corcoran, & Maren, 2006). The experimental evidence for the core links of the addictive loop and the modest long-term efficacy of current treatments provide compelling evidence for the need for innovative treatments that directly dismantle this loop instead of treating "around" it (Niaura & Abrams, 2002). Remarkably, the early Buddhist model of suffering does both, and the clinical therapeutic interventions it has inspired have gained increasing support from recent studies.

Derived from Buddhist practices, mindfulness training has been adapted for use in Western cultures, taking forms such as Mindfulness-based Stress Reduction (MBSR), Mindfulness-based Cognitive Therapy (MBCT; combined with Cognitive Therapy for depression relapse prevention), and Mindfulness-based Relapse Prevention (MBRP; combined with Relapse Prevention for addiction treatment). Typical treatments are 8 weeks in duration, though alternate lengths have been employed for targeted uses (Brewer, Mallik et al., 2011). Common features of these treatments include the training of attention to detect and modify an individual's relationship to automatic thought patterns, among others. For a review see Hölzel et al. (2011).

Mindfulness training's effectiveness has been investigated for the treatment of a number of disorders including pain, anxiety, and depression among others (reviewed in Baer, 2003; Grossman, Niemann, Schmidt, & Walach, 2004; Hofmann, Sawyer, Witt, & Oh, 2010). These data are promising, although more confirmatory studies are needed, as many of the studies were small and/or employed wait-list or other suboptimal control conditions.

Mindfulness training has only recently been evaluated in the treatment of addictions (Bowen et al., 2009; Brewer et al., 2009; Zgierska et al., 2008). It has been operationalized to include two distinct components: (1) maintaining attention on the immediate experience and (2) maintaining an attitude of acceptance towards this experience (Bishop et al., 2004). Here, for example, Ethel Knoll-Kraver might bring mindful awareness to the body sensations that constitute a craving, and just observe them from moment to moment. Even judgment of the craving becomes an object itself, instead of a driving force for subsequent behavior. As such, mindfulness training may specifically target the associative learning *process* with an emphasis on the critical link between affect and craving in the addictive loop (Nyanaponika, 2000). Through changing one's relationship to craving, via nonjudgmental awareness, one begins to remove the fuel from its fire, such that over time, craving and its resultant identity formations eventually burn out or die off.

Mindfulness training has been incorporated into several approaches for addiction treatment, such as Acceptance and Commitment Therapy (ACT) and MBRP (Bowen et al., 2009; Brewer et al., 2009), and has shown preliminary success therein. For example, Gifford et al. (2004) randomized 76 participants to nicotine replacement or ACT (seven individual + seven group sessions) and found 24-h abstinence of 33 % and 35 %, respectively, after treatment and 15 and 35 % at 1-year follow-up. Because mindfulness training has the advantages of teaching just a few basic techniques (awareness) that target the addictive loop *process*, aiming both at reducing automaticity and interrupting the loop, it requires fewer and less specialized sessions than other treatments. Theoretically, this simpler, more focused approach may facilitate both conceptual and behavioral skills mastery and durability of effects in a relatively brief treatment. Studies on the efficacy of mindfulness training for addictions remain preliminary: a recent review of trials that included mindfulness training reported that only 1 of 22 included a randomized experimental design (Zgierska et al., 2009). Importantly, a number of these studies showed no significant differences between the mindfulness and comparison conditions. However, subsequent randomized trials have shown some promise. For example, in a small pilot study of cocaine and alcohol dependence, Brewer et al. (2009) found equivalent efficacy of mindfulness training to that of cognitive behavioral therapy (CBT, which is considered a "gold standard" treatment for addictions) during an 8-week treatment period. Importantly, in this study, participants that

received mindfulness training also showed adaptive psychological and autonomic changes during a laboratory-based stress challenge that weren't observed in the CBT group at the end of treatment. This suggests that mindfulness may help to target core addictive loop features, such as negative affective states. Further, in a larger trial, Bowen et al. (2009) found significantly lower rates of substance use up to 4 months post-intervention in individuals receiving MBRP compared to those receiving treatment as usual. However, these studies should be interpreted cautiously, as MT has not yet been rigorously compared to empirically based treatments in large-scale head-to-head trials, and indeed may not be more efficacious for these conditions than standard treatment (Zgierska et al., 2009).

With regard to smoking, mindfulness training has shown preliminary utility in reducing cigarette cravings and withdrawal symptoms (Cropley, Ussher, & Charitou, 2007), as well as in smoking cessation (Davis, Fleming, Bonus, & Baker, 2007). Bowen et al. (2009) provided college students with brief mindfulness-based instructions and found that they smoked significantly fewer cigarettes 1 week after the intervention compared to those that did not receive instructions. Also, in an uncontrolled trial, Davis et al. (2007) found that 10 of 18 patients showed abstinence 6 weeks post-quit after receiving MBSR. More recently, Brewer et al. (2011a) randomized 88 subjects to receive mindfulness training or the American Lung Association's Freedom From Smoking treatment. They found significant differences in number of cigarettes smoked as well as abstinence rates 4 months after treatment completion (31 vs. 6 % at 4 months, $p=0.01$).

## Mindfulness Training May Directly Target the Addictive Loop

Effective implementation of mindfulness training may, over time, lead to the dampening and eventual dismantling of the addictive loop that perpetuates smoking or drug use rather than just removing stimuli that might propagate it. For example, through its attentional focus, individuals learn to become more aware of habit-linked, minimally conscious affective states and bodily sensations (e.g., low-level craving), thus "de-automating" this largely habitual process (Brewer, Bowen, Smith, Marlatt, & Potenza, 2010). One recent study showed that MT alters the way that the brain processes interoceptive cues, showing greater activity in regions (anterior insula) associated with integration of internal bodily sensations with external conditions or cues (Farb, Segal, & Anderson, 2013). Another study showed that MT, relative to a relaxation control group, not only decreased emotional interference on a cognitive processing task, but also led to significant changes in a psychophysiological measure of arousal while viewing pleasant and unpleasant images (Ortner, Kilner, & Zelazo, 2007). Together these findings may suggest that MT leads not only to greater emotional stability at a physiological level, but also that this emotional stability is paired with better neural monitoring of the body and association of its states with the external environment, in essence, helping individuals to "see things as they are."

By decoupling pleasant and unpleasant experience from the habitual reactions of craving and aversion, careful attention to present moment experience can function to bring a broadening or spaciousness of awareness that allows new appraisals of life situations. A possible result of this is the ability of mindfulness to specifically facilitate positive reappraisal. For instance, Garland, Gaylord, and Fredrickson (2011) have given the example of mindfulness allowing individuals' reappraisal of a serious heart condition as "an opportunity to change their lifestyle and health behaviors rather than as a catastrophe portending imminent doom." Other empirical findings do not support this idea. Ortner et al. (2007) found that decreases in arousal to negative images were *common* to both MT and relaxation training groups, but decreases in arousal to positive images were *unique* to MT. Interestingly, traditional presentations also do not support a conception of mindfulness as biasing subjects especially towards positive appraisal of life situations. Rather, as Garland, Gaylord, and Park (2009) acknowledge, mindfulness may function by

"attenuating emotional distortions of stimuli perception by encouraging non-evaluative contact with phenomenological experience," leading to more clearly "seeing things as they are." This point deserves emphasis. Explicit techniques for positive reappraisal are taught both in contemporary clinical settings and also in holistic traditional approaches to ending suffering. For example, Theravada Buddhist teachings include cultivation of loving-kindness (*metta*) as well as other positive or wholesome mind states such as appreciation/sympathetic joy at the joy of others (*mudita*). In traditional presentations, however, these practices are clearly delineated from the practice of mindfulness (*satipatthana*), which involves attenuating both desire and discontent in regard to external objects (MN.10 in Ñāṇamoli & Bodhi, 1995). On this construal, the application of mindfulness in Ethel Knoll-Kraver's case (see Text Box) may not result in positive appraisal, but will allow her to be more aware of the various features of craving as they actually are.

As mentioned above, mindfulness may help in dispelling emotional distortions based on positive as well as negative affective biases (Brewer, Davis, & Goldstein, 2012), which keep us from paying careful attention to the painful aspects of grasping and distorting our memory of them even after we act in unskillful ways. For example, women who are distracted by emotionally driven, self-evaluative thoughts have been shown to be much slower in registering bodily reactions to emotionally charged images, an effect that is reversed by meditation training (Silverstein, Brown, Roth, & Britton, 2011). The textual account of the Buddha's spiritual journey highlights these types of cognitive distortions in comparing his pre-awakening times of mistaking stress for happiness: "In the past sensual pleasures were painful to touch, hot, and scorching; in the future sensual pleasures will be painful to touch, hot, and scorching; and now at present sensual pleasures are painful to the touch, hot, and scorching. But these beings who are not free from lust for sensual pleasures, who are devoured by craving for sensual pleasures, who burn with fever for sensual pleasures, have faculties that are impaired; thus, though sensual pleasures are actually painful to touch, they acquire a mistaken perception of them as pleasant" (MN.75 in Ñāṇ amoli & Bodhi, 1995).

Mindfulness counteracts both not knowing (lack of awareness) and knowing wrongly (misperception), indicating an important role in developing what the texts call "knowledge and vision of things as they are." The role of mindfulness in increasing individuals' ability to register and report on their emotional reactions in conceptual terms may derive from a more fundamental function of cultivating and broadening a kind of rich, experiential feeling of emotional states within ourselves (Davis & Thompson, 2012). Knowing cognitively that continued substance use only perpetuates one's and others' suffering is often not sufficient. In their seminal article examining behavioral change, Prochaska, DiClemente, and Norcross (1992) stated, "The progression from contemplation to action is… essential to beneficial outcome …." Instead of merely developing awareness or contemplating the problem, individuals need to feel the pain of this cycle directly, in a rich, experiential, preverbal way. In the words of Bob Marley, "who feels it knows it." When one is fully and accurately aware of the pain involved in the search for gratification, one does not have to positively reappraise the situation or suppress emotional reactions in other ways. Rather, by feeling and knowing what brings pain, individuals can counteract motivated reasoning and other unconscious strategies to appease their craving. There is already some evidence that training in meditation increases this type of subtle awareness of bodily states and their integration with thoughts, beliefs, feelings, etc. (Farb et al., 2013). In this way, Ethel Knoll-Kraver may come to see directly for herself what she actually gets from feeding her cravings—a relief that is temporary, and is motivated by a pain and destructive type of emotional reactivity.

By teaching individuals to simply observe aversive body and mind states (e.g., negative affect) rather than reacting to them, mindfulness training may foster the replacement of stress- and affect-induced, habitual reactions with more adaptive responses (e.g., enhanced self-control and regulation; Curtin et al., 2006).

Additionally, mindfulness training may help individuals change their relationships to negative affective or physically unpleasant states and thoughts (i.e., to "not take them personally"). To be clear, we postulate that the mechanism of action here is the attenuation of affective bias underlying the reaction of "taking things personally," rather than a change in self-related thoughts or cognitive attributions. As noted above, it is the habitual affective bias underlying emotional reactivity that fuels further rounds of craving and habituation. Thus, with attenuation of this affective bias, oxygen is slowly removed from the fire, ultimately leading to smoking cessation (Bowen et al., 2009; Bowen & Marlatt, 2009; Brewer et al., 2010). However, studies that directly test these hypotheses are needed.

## Is Craving an Important Target of Mindfulness Training?

As stated above, mindfulness training may help individuals sit with or "ride out" their cravings. What is meant by this, and how does it fit with the theoretical underpinnings of mindfulness training? First, craving is inherently unpleasant (consider the feeling of wanting a drink of water on an extremely hot day), and naturally drives individuals to act, whether to smoke, drink, or use other drugs. The longer this craving goes unsatisfied, the more it may intensify as it becomes fueled by further reactions to the unpleasantness of the wanting itself. For example, in a study of treatment-seeking smokers, for each standard deviation increase in craving scores on the target quit date, the risk of lapsing rose by 43 % on that day, and 65 % on the following day (Ferguson, Shiffman, & Gwaltney, 2006). Mindfulness training teaches individuals to instead step back and take a moment to explore what cravings actually *feel* like in their bodies, however uncomfortable or unpleasant they may be. Two important insights can be learned from this process. First, individuals learn that cravings are physical sensations in their bodies rather than moral imperatives that must be acted upon. Second, they gain first-hand experience of the impermanent nature of these physical sensations. Each time they ride out a craving—experiencing its physicality without acting on it—this reinforces their insight that cravings will subside on their own, even if not satisfied. In theory, this allows individuals to learn how to tolerate the physical sensations without acting on them. Cravings may continue to arise, but learning to sit with urges, to pause and not immediately react, may disrupt the associative learning process and the automaticity of the action ordinarily taken. In other words, the birth of an identity around an object ("This is uncomfortable for me, I'd better go smoke a cigarette") is not fostered or fed. Or put another way, the fuel has not been added to the fire, such that the fire burns out more quickly. If this is true, MT should affect the traditional observation that smoking and craving are positively correlated. In fact one might predict that it would decouple this relationship.

A recent study suggests that this decoupling may be true. In a follow-up to their MT for smoking cessation trial, Brewer and colleagues examined the relationship between craving and smoking behavior during treatment (Elwafi, Witkiewitz, Mallik, Iv, & Brewer, 2012). At the start of MT, individuals showed a strong positive correlation between average daily cigarette use and their self-reported craving for cigarettes, as measured by the Questionnaire on Smoking Urges ($r = 0.58$, $p < 0.001$). At the end of the 4-week treatment period, this correlation was reduced to the point of statistical nonsignificance ($r = 0.13$, $p = 0.49$). Importantly, individuals who quit smoking showed *no difference* in craving scores compared to those who continued to smoke at the end of treatment, but instead demonstrated a delayed reduction in reported craving, while those who did not quit reported an increase in craving concomitant with increases in smoking. These results suggest that after just 4 weeks of mindfulness training, individuals were no longer reacting to their cravings by smoking. One interpretation of this is that mindfulness training may have decoupled the relationship between craving and smoking during treatment. In other words, mindfulness practice may help individuals stop adding fuel to the fire (craving), but the

fire still continues to burn based on the fuel that is already present (e.g., individuals still crave when they first quit). Importantly, over time, without continued sustenance (smoking), the fire burns out by itself.

The possibility of craving and smoking being decoupled by MT is further supported by the amount of home practice that subjects reported. Similar to previous studies of psychological health and mindfulness training (Carmody & Baer, 2008), Brewer et al. (2011a) initially found that increased home practice was correlated with decreased cigarette use for both formal ($r=-0.44$, $p<0.02$) and informal practice ($r=-0.48$, $p<0.01$). In fact, the amount of mindfulness practice during treatment not only predicted smoking behavior at the end of treatment but moderated the relationship between craving and smoking as well: the more that individuals practiced during treatment, the less craving correlated with the number of cigarettes individuals smoked at the end of treatment (Elwafi et al., 2012).

The ability of mindfulness training to attenuate the relationship between craving and substance use has been observed in other studies as well. Witkiewitz and Bowen (2010) examined the relationship between depression, craving, and substance use following a randomized clinical trial of MBRP. They found that craving mediated the relationship between depressive symptoms and substance use in the group that received conventional treatment, but not in the group that received MBRP. Taken together, these results suggest that mindfulness training may indeed help individuals develop a tolerance to craving itself, thus over time acting to dismantle the addictive loop through a dis-identification with the object (or dismantling of self-identity). The next logical steps will be to determine how these map onto current psychological models of change behavior. For example, do tolerance of craving and dismantling of self-identity equate to reappraisal and extinction, respectively, or to other skills, or constitute unique entities unto themselves?

## Neurobiological Mechanisms of Mindfulness Training

Brain regions that show commonality between a number of different maladies and importantly have also been theoretically and functionally linked to mindfulness training may provide a logical starting point in assaying its neurobiological mechanisms (for a more detailed review of possible mechanisms, see Hölzel et al., 2011). The default mode network (DMN; a network of highly correlated brain regions that show coherent activity during rest and relate to aspects of self-referential processing—see Andrews-Hanna, Reidler, Sepulcre, Poulin, & Buckner, 2010; Buckner, Andrews-Hanna, & Schacter, 2008; Fox & Raichle, 2007) may be one of these targets, given its primacy in a number of psychiatric disorders ranging from anxiety to addiction (Buckner et al., 2008). There are two primary nodes of the DMN, the medial prefrontal cortex and the posterior cingulate cortex (PCC). These have been shown to be temporally correlated with a number of peripheral nodes, and anticorrelated with brain regions involved in self-monitoring, and cognitive control (anterior insula; AI; dorsal anterior cingulate cortex, dACC; dorsolateral prefrontal cortex, dlPFC) (Andrews-Hanna et al., 2010). Though self-referential processing is a complex area of investigation in itself, on a first approximation, this may be where models of self-identity formation at least partially overlap; memory retrieval and the "self across time" are linked by PCC activity (Andrews-Hanna et al., 2010; Buckner et al., 2008). As the DMN has been shown to be altered by mindfulness training (Brewer et al., 2011b), and given its documented contributions to mind-wandering and self-referential processing, the DMN is a biologically plausible target for mindfulness training as MT teaches the inverse of mind-wandering and self-referential processing. Of course, the exact patterns and functions of the brain's resting state networks (of which the DMN is one) should be interpreted with some caution as there are

limitations to our current analytic methods and we are only just beginning to understand the various causal factors that lead to the observed patterns (see, e.g., Fan et al., 2012).

With regard to the effects of mindfulness training on the DMN, there is evidence of decreased DMN activity during mindful awareness of visually presented adjectives versus determination of personal meaning of adjectives, following 8 weeks of MBSR (Farb et al., 2007). Taylor et al. (2011) similarly found deactivation of DMN structures in meditators practicing a "mindful state" while viewing emotionally evocative pictures. Extending these, Brewer and colleagues found that in very experienced meditators (>10,000 h of practice on average), DMN deactivation was common to three different types of meditation (concentration, loving-kindness, and choiceless awareness) (Brewer, Worhunsky et al., 2011). These findings may suggest that the success of MT for addictions may work via a disengagement from self-identified habitual response patterns. By mindfully attending to cravings, the DMN node activity and/or connectivity may be altered, as seen above during meditation or the viewing of evocative pictures. Over time, these circuits may even change, as the habituated sense of self around smoking fades due to lack of sustenance or fuel.

Interestingly, Brewer and colleagues found an increase in functional connectivity between the PCC, and the dACC as well as the dlPFC in experienced meditators compared to controls. This is important, because these regions are anticorrelated in the vast majority of contexts, and thus named the "task-negative" (DMN) and "task-positive" (dACC, dlPFC, and others) networks, respectively (Fox & Raichle, 2007). Controls showed typical anticorrelation patterns between these structures at baseline, which decreased during meditation, suggesting a state-dependent connectivity pattern in untrained individuals. However, the observed *increased* connectivity patterns seen in experienced meditators were present *both* at baseline and during meditation, suggesting that they may have established a "new" *default mode* of intrinsic brain activity and connectivity. These findings should be interpreted with caution, as this study was cross-sectional, and could be influenced by self-selection bias.

As action-monitoring/prediction (e.g., dACC) and cognitive control regions (e.g., dlPFC) have been shown to be important in self-control, addictions, and treatment outcomes (Brewer, Worhunsky, Carroll, Rounsaville, & Potenza, 2008), these findings suggest that MT may fundamentally alter brain activity and connectivity patterns in networks important for perpetuation of addictive behaviors. In essence, mindfulness may help to bring together our capacity to monitor our internal and external environments (AI/dACC; see Farb et al., 2013), especially when craving or self-referential states arise (likely activation of DMN), and to utilize self-control (likely activation of dlPFC) when needed. Over time, as monitoring strengthens and the processes of craving weaken due to a lack of sustenance, effortful self-control may not be needed as much. In theory, the more Ethel develops her capacity to pay attention to her internal and external environment, the less she would fuel her habitual "coping" strategies of drinking to deal with stress and withdrawal states, leading to the cooling off of her habituated affective self-identity and its eventual cessation. However, prospective studies of individuals receiving MT for addictions that measure changes in brain activity and connectivity over time are needed to test such hypotheses. As we focused mainly on the DMN in this chapter, studies assessing other possible brain regions/networks that may emerge as prominent players in the neural mechanisms of mindfulness will also be important.

## Conclusions and Future Directions

Over the past century, much has been discovered about the addictive process and its underlying neurobiology (Goldstein et al., 2009; Kalivas & Volkow, 2005). From these findings, psychological models have been put forward that have been instrumental in the development of novel treatments that directly target core components of this process. These models show remarkable similarities to ancient Buddhist psychological models

aimed at describing the causes of human suffering. Modern treatments, such as MT that are based on these Buddhist models, are beginning to show preliminary efficacy in the treatment of addictions, and may be doing so through changing one's relationship to core addictive elements such as craving. Recent neuroimaging studies are converging with these concepts, suggesting that MT can fundamentally change basic brain processes, such as the brain's spontaneous activation and intrinsic connectivity patterns. These may manifest behaviorally, in that individuals may develop new habits such as monitoring unskillful thought processes and automatic behaviors, and objectively observing them rather than being "sucked in" by them and smoking, using other drugs, or engaging in other unhealthy behaviors. Perhaps people can even practice becoming interested and fascinated with the bodily sensations of craving, thereby co-opting the very process that perpetuates this addictive cycle to uproot it, leading to the later dying away or cessation of craving itself. Ultimately, with practice, this may lead to more adaptive choices with concomitant decreases in stress and suffering.

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