Chapter 9
The Emerging Science of Mindfulness as a Treatment for Addiction

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Introduction

There are few conditions that cause as much suffering on a personal and societal level as addictions. Extensive strides have been made in understanding the neurobiological circuitry that drives various substance addictions in both animal models and humans, but these insights have yet to produce comparable advances in treatment methods. Mindfulness trainings, which are based on ancient Buddhist psychological models, have recently been tested as addiction treatments and have yielded promising results. Fascinatingly, these Buddhist models revolve around the elimination of suffering, which is thought to be the inevitable product of craving. Further, there are considerable overlaps between these ancient ideas and modern models of behavioral reinforcement. The early Buddhist models may even offer a more sophisticated understanding of the psychological mechanisms of addiction and ways to improve current treatment strategies. Since mindfulness itself has recently become the subject of psychological and neurobiology study, this chapter will consider the overlaps between the early Buddhist and contemporary models of the addictive process, review studies of mindfulness-based addiction treatments, and discuss recent neuroimaging studies to further inform our understanding of the neurological mechanisms and potential effects of mindfulness-based addiction treatments.

When people think of addiction, it is often the debilitating drug addictions that first spring to mind such as heroin and alcohol dependence. Indeed, drug addictions are one of the costliest human conditions, having significant effects on mental, physical, and economic health. As a whole, substance abuse in the United States

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cost approximately $193 billion in 2007, primarily as a result of lost productivity (Office of National Drug Control Policy, 2007). While many salient examples of addictive behavior are associated with drug use, addictive tendencies take many (often subtler) forms, and an exogenous chemical dependency is not requisite for an addiction to exist. Compulsive gamblers can be helplessly ensnared by a slot-machine in much the same way as someone else is by cocaine. If a drug dependency does manifest, however, the physical effects of withdrawal reinforce the addiction and add momentum to an already powerful feedback loop (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004).

Acquisition of an addictive behavior is a complex process with a basis in operant conditioning: the pairing of actions with "effects," which alters future behaviors. Behavioral modification occurs via induction of positive (pleasant) and negative (unpleasant) affective states linked to action patterns. This sets up positive and negative loops by reinforcing the associative memories between these affective states and behaviors. The consequence is the formation of associative memories that pair actions with "affects." Subsequently, stimuli cue associative memories and are interpreted as positive or negative in light of prior experiences, which induces positive or negative affective states. The affective states in turn trigger cravings to either maintain the state if it is positive or alleviate the state if it is negative. The cravings incite behaviors that are rewarded or punished by the subsequent affective state, thus encoding more associative memories and fueling a feedback loop. In this way, craving drives the repetition of behavior patterns (Baker et al., 2004).

In some cases, the associative loops are strengthened, modified, and eventually molded into an addiction that takes on a life of its own. This automatization of the loop leads to a habitual cue-induced behavior that is largely outside of consciousness, let alone conscious control (Bargh & Chartrand, 1999; Curtin, McCarthy, Piper, & Baker, 2006). Additionally, neutral cues that have been classically conditioned may directly trigger craving (Lazev et al., 1999). These associative learning processes may then lead to increased motivational salience of future cues, fortifying the addictive loop (Robinson & Berridge, 2008).

There are limitless variations of the circumstances that initiate addictive tendencies, and addictions can seem quite dissimilar—addictive loops might similarly develop around the euphoria and dysphoria cycle of cocaine use, the passion and comfort of a romantic relationship, or the excitement of receiving facebook likes for a witty post about an ill-suited presidential candidate. Seemingly innocuous behaviors such as eating or checking one's cell phone can also become objects of addiction. The expanding understanding of brain function has partially illuminated what common neurological features underlie seemingly disparate behaviors such as cocaine use, romantic infatuation, rich food, and posting selfies to Facebook, when they turn addictive (Aron et al., 2005; Bartels & Zeki, 2004; Tang, Fellows, Small, & Dagher, 2012; Meshi, Morawetz, & Heekeren, 2013). The range of behaviors that can be incorporated into addictive loops suggests that the effects of associative learning are widespread, underlie many of our cognitive functions, and are probably, from an evolutionary perspective, quite ancient.

The neural circuitry permitting this type of associative learning has extensively influenced the evolution of our species, shaping behaviors critical to our survival by enabling learned associations between actions and the consequences of those actions (e.g., learning where a food source is or where danger is lurking). The mechanisms underlying associative learning can be observed not only in our species and our close relatives but even in the most primitive nervous systems, for instance, those of sea slugs (Aplysia). The near ubiquity of associative learning among animals suggests that the process is evolutionarily conserved. This is relevant for our consideration of addiction because like other primitive nervous system functions, associative learning is likely resistant to cognitive manipulation (Nargeot & Simmers, 2011; Treat, Viken, Kruschke, & McFall, 2011). This may provide some explanatory power for the relative strengths and weaknesses of current treatment paradigms.

To recapitulate: the addictive loop model is noteworthy for several reasons. First, its general and ubiquitous nature blurs the line between addictions and habitual reactivity, indicating that addictive process might be more of a norm and less an exception. Second, each link in the chain is supported by convergent findings from both nonhuman animal and human studies, suggesting an evolutionarily conserved process. Third, its self-propagating nature aligns surprisingly well with Buddhist psychological models of human suffering, which the next section of this chapter will explore.

Early Buddhist Models of Addiction

Mindfulness endeavors to help reduce the experience of suffering, which is understood to be ultimately derived from attachment to particular experiences and fear of other experiences. The early Buddhist texts present a therapeutic model that explicates the pervasiveness of suffering, its cause, the possibility for a cure, and the methods for achieving that cure. The method prescribed revolves around understanding the cause of suffering and the way to interrupt the positive feedback loops that perpetuate it. External objects are not considered the origin of these loops nor are our spontaneously arising internal experiences. Rather, it is our reactions to our own sensoria that drive the process. In Pali, the language of these early texts, the critical juncture between sensory perception and the cycle of suffering is called *taṇhā* (N.B. there are six senses in Buddhist psychology: the five that we are accustomed to, plus the experience of mental thought activity). *Taṇhā* is commonly translated as "craving,"' though it more literally means "thirst," and can be understood in some contexts as habitual reactivity. Mindfulness aims to teach the "relinquishment, release, and letting go" of this reactive craving, such that suffering is cured (SN.56.11 in Thanissaro, 2010).

The early Buddhist texts that articulate the model are understood to be the teachings of a North Indian prince named Siddhartha Gautama who, as an adolescent, abdicated his royal title to single-mindedly investigate the nature of suffering.

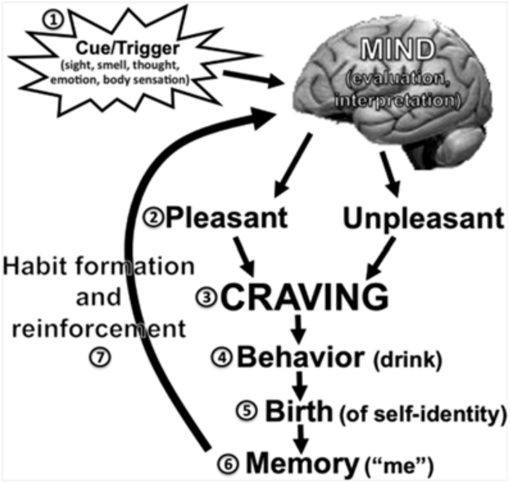

Fig. 9.1 Early models of addiction: dependent origination (Copyright 2011 Judson Brewer. Reprinted with permission of author)

Gautama's campaign led him to study with the premiere teachers of his time, but he found their methods to be unsatisfactory. Their approaches largely dealt with the objects of temptation (sex, drugs, physical comfort, etc.) by avoiding them and the objects of aversion (pain, fear, not getting what we want, etc.) by building extreme tolerances to them (SN.56.11 in Thanissaro, 2010). Finding that these methods did not fully accomplish what they intended to, Gautama isolated himself and set about investigating his own mental processes. By way of his intensive introspection, it is said that Gautama brought about the ultimate fruition of his mind: Buddhahood, which is marked by the cessation of suffering caused by craving (movement toward objects of desire) and aversion (movement away from objects of dislike).

Gautama Buddha's central discovery was how the human mind processes information, i.e., the sequence of causal links by which our minds construct experience. Interestingly, this shows major overlaps with modern-day models of operant conditioning (Brewer, Elwafi, & Davis, 2013). This model, called "dependent [co-]origination," posits that at any given moment, our minds exist in a state preconditioned by our prior experiences (For this brief illustration of dependent origination, consider the example of Sally in the adjoining text box.). When Sally encounters sensory input (cf. #1 in Fig. 9.1), her mind interprets the input based on her mind's prior experiences (conditioning; #2). Registration of the incoming information rapidly and automatically generates somatic information, an "affective tone," which can be felt as pleasant or unpleasant. That is, the valence of the affective tone arises from the interaction of the current state of the mind with the sensory input. Subsequently, an impulse arises as a psychological urge (craving; #3) to perform some behavior that will continue the pleasant or discontinue the unpleasant feeling. The craving motivates action (#4) and fuels the birth of what is referred to in Buddhist psychology as "self-identity" (#5; Brewer et al., 2013). The outcomes of that action are recorded in memory (#6), resulting in the formation of a new associative link, which updates the conditioning of Sally's mind, leading to subsequent rounds of this process (#7).

Consider Sally, a junior at Hypothetical High School, who is invited to drink with a group of older students that she looks up to (see #1, "positive cue" in Fig. 9.1). She learns to associate drinking with social disinhibition, peer-group bonding, and excitement. When she is drinking at a party with her friends, she feels good (#2). In fact, even when she is not so happy, she finds that she can still go and have fun at a party, and the tribulations of her life at Hypothetical High fade into the background (#2–6). As Sally grows up and the thrill of underage drinking dissipates, the adrenaline rush gives way to a subtle sense of relief that she can come home from work and relax with a bottle of wine. When her boss yells at her or she feels stressed out (#2), she finds herself thinking, "I could use a drink" (#3). The more Sally drinks in these situations, the more she reinforces her behavioral pattern and the deeper she engrains the sense of release and escape from unpleasantness with the act of drinking (#5–7). At times, she may even find herself "waking up" en route to a bar she occasionally stops at on the way home, before knowing that she decided to go there. At other times, she may find that she notices the urge to drink before noticing that something is actually bothering her, stimulating the craving.

In this way, an individual learns that some action (mental or physical) decreases unpleasant feelings and begins to form a behavior pattern around these affective reactions. The perception of any object is influenced by a person's prior experiences. One's mind interprets and filters incoming sensory stimuli according to its current state of conditioning. The present encounter, which is now a composite of present and past, is then consolidated with related memories, leading to the formation of a habit pattern. These patterns do not need to be complicated and drawn out but can be nearly instantaneous reactions. Thus, the current experience modifies the perception of future experiences. The recursive nature of these loops means that they can fortify and fuel themselves via positive feedback. Further, since the states of craving and aversion are themselves unpleasant, individuals often develop aversive reactions toward their own reactions. Fortunately, the iterative nature of this cyclic process also means that it can be disrupted at each new round.

From this Buddhist perspective, clinically defined addictions can be thought of as dependent origination loops that have developed in such a way that they no longer fit with societal norms to the point of causing concern. However, the associative loops that fall within a given culture's criteria for addiction are themselves not categorically different than the many other associative loops that we have all developed over the course of our lives. If Buddhist methods are effective at uprooting craving from a person's mind, we might reasonably expect that the same methods could also have clinical utility as treatments for addiction. The pervasiveness of associative learning and its capacity to form addictive feedback loops set up an important caveat for traditional addiction treatment strategies. Without understanding the fundamental structure of the addictive process, it is all too easy to unwittingly perpetuate it. Many treatment regimes utilize the transferability of addictive tendencies through behavioral substitution. For example, someone might "will" themselves to exercise when the urge to smoke a cigarette arises, thereby diminishing smoking behavior by building a new link between the urge to smoke and an exercise. This approach can meet with moderate success in treating the targeted addictive behavior, but it does not address the person's underlying addictive tendencies, which can lead to relapses (and other problems) down the road. The difficulty with treating people's addictions is that many treatments attempt to treat a specific addictive behavior instead of treating the fundamental cause of addiction: craving itself.

Since the English word "craving" only partially maps onto the Pali term, it is important to understand that *taṇhā* encompasses both wanting to gain and maintain desirable things (craving), as well as wanting to avoid undesirable things (aversion). Furthermore, the psychological process in question occurs rapidly and automatically in most cases, such that people are frequently only conscious of its downstream effects. It is through the practice of closely observing one's experiences that the sequence of these events becomes readily apparent. Further, the rapidity with which *taṇhā* forms then subsequently generates the next step in the process, which may pose a problem for cognitive interventions. Cognition is a comparatively slow process. This inherently forces cognitive interventions to contend not with the ephemeral reactivity at the core of the process but rather with the cascade of self-reinforcing loops that the initial craving begat. Thus, cognitive-behavioral and/or control-based treatments focus on building willpower—"mental muscle" to avoid, think through, and substitute behaviors—essentially putting individuals at odds with their unruly minds. Further, this willpower may be "depleted" precisely at times when individuals are most susceptible to relapse, such as when they are mentally and physically tired (Muraven & Baumeister, 2000). Mindfulness training teaches us to see more clearly the nature of our addictions, rather than avoiding or trying to change them. When we can perceive the mental processes, we feel and know more clearly the pain of perpetuating emotional craving and aversion, and we naturally begin to become disenchanted with the cycle, which begins the process of letting go. Conversely, blindness to this process leads to proliferation of craving through the iterative reinforcement of these cycles (This process is referred to as *avijjā* in Pali. It is commonly translated as *ignorance* and literally means "to not see."). Buddhist texts call this repetitive proliferation *saṇsāra*, or endless wandering, as there is no obvious way out of it when propagated.

The central point of the early Buddhist model is that craving and aversion arise in response to an affective tone that is associated with perceptual representations of a sensory object (Grabovac, Lau, & Willett, 2011). This provides a critical entry point for therapeutic interventions. By paying careful attention to present-moment experience, the Buddhist model claims that one can see that perceptions and the associated affective reactions (affective tone) are separate from—and indeed separable from—craving and aversion, as well as the elaborative thought processes that these can initiate. In theory, the potential of mindfulness practice is to prevent the associative loop from beginning. However, since it can require substantial practice to develop the mental acuity required to clearly perceive and modify dependent origination, it is important to note that even when craving has already arisen, mindful awareness can prevent further cycles of aversive reaction by helping an individual disengage from the loop. In this way, mindfulness practice can immediately begin deconstructing these links. By overcoming the habitual reactions of craving and aversion that biases attention and memory, mindfulness allows individuals to feel and know more clearly the pain of perpetuating emotional craving and aversion. Being fully present with the pain of this emotional reactivity may be sufficient to motivate individuals not to perpetuate it (Brewer, Davis, & Goldstein, 2012).

Another concept that bears consideration is the birth of "self-identity" (#5). The sense of self that is generated in the process of dependent origination is composed of one's habitual reactions of clinging to pleasant aspects of experience and to the absence of unpleasant aspects. Imagine how, in a moment of desperate craving for something, the mind can collapse into a singular want. It seems as if appeasing this particular desire will bring all that one needs, even if one knows better. This is a distorted perception (i.e., ignorance); sense pleasures are fleeting and incapable of resolving the core distress that fuels the cycle of searching for gratification. As one discourse relates 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… aging 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). In this model, a sense of self is born by craving and clinging to any kind of experience. This sense of self is very basic, being dependent only on grasping after experiences, and it does not depend on an explicit narrative of self-identity to exist. As long as there is craving for any aspect of experience, this affectively constructed sense of self continues. Even a person with complete retrograde amnesia (a common cliché in soap operas) who does not remember anything about his past still has a felt sense of self, although he cannot say who that is. When the sense of self is threatened by the inability to prevent the loss of what is grasped after, or to prevent the occurrence 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 that bring about internal conflict and limit perspective (Elliott, Zahn, Deakin, & Anderson, 2011). The reactive impulses produced when the sense of self is threatened prevent one from accurately assessing what is happening in the present moment and acting accordingly. Through deconstructing the habitual process by which we generate a reactive nonconceptual self-identity, the self does not go away, it simply loses the ability to obscure (i.e., ignorance is no longer at play). That is to say, mindfulness does not stop one from being a person but rather from taking things personally.

Given that one's self-identity stems largely from memory, the Buddhist description of dependent origination is remarkably similar to the contemporary model of the addictive loop (Brewer et al., 2013). When Sally, 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, or agitation (#1), her neural conditioning interprets these as unpleasant (#2). She wants the unpleasant feeling to go away and consequently experiences 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 Sally might take this personally, having thoughts such as "I am a 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). Sally 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. An addictive loop appears remarkably similar to the endless wandering characterized by Buddhist psychology. 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.

Conventional and Mindfulness-Based Treatments for Addiction

Mainstay addiction treatments have focussed on manipulating addiction behavior by teaching afflicted individuals to avoid cues, divert attention from cravings, substitute healthy activities for deleterious ones, foster positive affective states (e.g., practicing relaxation), and develop social support structures (Fiore et al., 2008). Such cognitively based treatments typically yield abstinence rates between 20 and 30 % (Law & Tang, 1995). From the view of Buddhist psychology, these methods of treatment are unlikely to have more than a limited effect on addictive loops because they do not sufficiently address the critical links of dependent origination but rather upstream and downstream elements (Niaura & Abrams, 2002). Avoiding cues that lead to temptation limits input to the addictive loop but does not dismantle it, and substitutive behaviors (e.g., eating carrot sticks in lieu of candy or doing pushups when the urge to smoke arises) only reorients the craving impulse to a different object. Acute treatments can work as short-term fixes but leave the individual to contend with the same addictive tendencies as before. It is even possible that cue-induced cravings increase with the duration of abstinence, suggesting that avoiding cues or substituting behaviors might do little to target the core processes driving addictive behaviors (Bedi et al., 2011). These methods also require recruitment of substantial mental effort (willpower) to enact, which undermines their efficacy since self-control is impaired by stress and strong affective states (Muraven & Baumeister, 2000). The experimental evidence for common addictive circuitry and the modest long-term success rates of existing treatment options suggests that treating addictive behavior may be insufficient. Innovative treatments that directly target the core networks underlying addiction may be able to produce substantially improved results. The early Buddhist model of suffering claims to do precisely this, and the clinical therapeutic interventions it has inspired have gained support from recent studies.

The meditation practices taught by Siddhartha Gautama emerged out of a vastly different cultural milieu than Western modernity. Many aspects of his basic teachings were practiced in ways best suited to his historical context and should be reexamined in light of a different culture's psychological background, the aims of a specific application, and the availability of new teaching tools. Mindfulness and the associated concepts are adaptations of Buddhist practice and philosophy (Shonin, Van Gordon, & Griffiths, 2014), which have taken 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). The framing of Buddhist practices by MBSR and the related mindfulness adaptations reflects the values of the adoptive culture, namely scientific empiricism. Mindfulness-based treatments incorporate multiple elements, most with origins in techniques taught by Gautama, but from its inception, MBSR was designed to interface with the scientific tools employed by Western medicine to assess the efficacy of medical treatments. Common features of these mindfulness-based treatments include, for instance, the training of equanimous attention in order to detect and modify automatic patterns of thought and reactivity (Desbordes, Gard, Hoge, Holzel, & Kerr, 2014). Mindfulness trainings have been evaluated in the treatment of a number of ailments including pain, anxiety, and depression (see Goyal et al., 2014 for meta-analysis). These data are promising, but additional work is needed as many of the studies to date have used small sample sizes, wait-lists, and other suboptimal control conditions.

The use of mindfulness in addiction treatments has been a more recent adaptation (Bowen et al., 2009; Brewer et al., 2009; Zgierska et al., 2008). The training has been operationalized to deploy two distinct components: (1) maintaining attention on immediate experience and (2) maintaining an attitude of acceptance toward this experience (Bishop et al., 2004). For example, when the desire for a cigarette comes on, a smoker might choose to bring mindful awareness to the sensations that constitute the craving. A key point of this practice is to begin to dissect the composite sensations that make up an experience. By heading straight into an aversive feeling like an intense craving, the surprising discovery that practitioners can make is that the overwhelming intensity breaks up into a manageable flow of simple sensory input (heat, tingling, tightness, etc.). By training the ability to directly and closely examine the somatic manifestation of an experience such as craving, one discovers that the horrific, ghastly figure lumbering through one's mind is actually only the shadow of a mouse. Paradoxically, the intensity is much greater when an experience is viewed at a distance, or out of the corner of one's eye, so to speak. Skillful application of this technique turns even judgment of the craving into an object for nonreactive examination rather than 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 (Nyanaponika, 2000). According to the early Buddhist model, this process of close, nonreactive observation has the potential to dismantle not only the associative links of the targeted addiction but the reactive tendencies of the mind in general.

Mindfulness has been packaged into several addiction treatments, such as Acceptance and Commitment Therapy (ACT) and MBRP (Bowen et al., 2009; Brewer et al., 2009). Assessment of these treatment regimes has yielded preliminary success. For example, Gifford et al. (2004) randomized 76 participants to receive either nicotine replacement treatment or ACT. The regimes performed comparably by the end of the treatment period, with 33 % of the nicotine replacement group and 35 % of the ACT group showing 24-h abstinence. At a 1-year follow-up, however, the abstinence within the nicotine replacement group had diminished to 15 % while the ACT group maintained 35 %. Other studies have not found evidence that mindfulness treatments are more effective than comparison conditions (Zgierska et al., 2009). A study by Bowen and colleagues comparing MBRP to Relapse Prevention (RP) or Treatment as Usual (TAU) as aftercare to standard treatment and found that both MBRP and RP showed significantly lower risks of relapse to substance use and heavy drinking compared to TAU at 6-month follow-up. Where RP showed an advantage in increasing the time to first drug use, MBRP showed fewer days of use and less heavy drinking at a 12-month follow-up (Bowen et al., 2014). There are several major confounds in assessing the efficacy of mindfulness treatments for addictions. Until 2009, of the 22 published studies that included mindfulness training, none tested mindfulness training as a stand-alone treatment and only one was randomized. There is also a lack of standardization between treatment regimes, and fidelity in the delivery of those regimes can be an issue. Further, since mindfulness-based trainings are often an amalgamation of multiple elements (some Buddhist, some not), there is currently little mechanistic understanding of what components at what dosages produce what effects.

With regard to smoking, mindfulness training has shown preliminary utility for reducing cigarette cravings and withdrawal symptoms (Cropley, Ussher, & Charitou, 2007), as well as for 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. Brewer, Mallik et al. (2011)) studied the effects of stand-alone mindfulness training for smoking cessation. This study randomized 88 subjects to receive a tailored mindfulness training or the American Lung Association's Freedom from Smoking (FFS) program—a gold standard smoking cessation treatment. The mindfulness groups smoked significantly fewer cigarettes during the program and upon completion showed twofold greater abstinence rates (36 % compared with 15 % in the Freedom from Smoking Program). At a 4-month follow-up, the abstinence rate of the mindfulness group had largely maintained (31 %), whereas over half of the FFS group had relapsed, bringing the 4-month success rate for the FFS group to 6 % ($p=0.01$). Similar to previous studies of psychological health and mindfulness training

(Carmody & Baer, 2008), this study observed that the more individuals in the mindfulness training group practiced, the more favorable their outcomes: increased home practice was correlated with decreased cigarette use for both formal ($r = -0.44$, $p < 0.02$) and informal practice ($r = -0.48$, $p < 0.01$). The FFS group performed home practices such as relaxation, but these did not show any correlations with smoking cessation outcomes.

Through 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). Effective implementation of mindfulness training may, over time, lead to the attenuation and eventual dismantling of addictive loops that perpetuate smoking, drug use, and other deleterious behaviors. In the absence of an intact associative loop, subsequent addiction-related cues will fail to elicit cravings. If the underlying craving is uprooted, it would be consistent with Buddhist theory that even recalcitrant addictions, which can lay dormant only to reemerge years later, can be eradicated through the sustained application of nonreactive attention to subjective somatic experience. Of course, it will take many years of longitudinal addiction studies to assess if this claim is borne out. There is, however, evidence that mindfulness practice alters the way the brain processes interoceptive cues. Bornemann, Herbert, and Mehling (2015) found that following a 3-month mindfulness training, participants reported significantly greater awareness of bodily sensations, including increased awareness of emotions and mind–body interactions and a higher propensity to listen to their bodies for insight about their emotional state, particularly under stress. Another study showed that relative to a relaxation control group, mindfulness training decreased emotional interference on a cognitive processing task and lead to significant changes in a psychophysiological measure of arousal while viewing pleasant and unpleasant images (Ortner, Kilner, & Zelazo, 2007). These findings may suggest that mindfulness practice 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." For example, women who are distracted by emotionally driven self-evaluative thoughts were 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).

Simply by teaching individuals to 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., enhancing self-control; Curtin et al., 2006). Additionally, mindfulness training may help individuals change their relationships to negative affective or physically unpleasant states and thoughts (i.e., "not taking 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. Since it is the habitual affective bias underlying emotional reactivity that fuels further rounds of craving and habituation, attenuation of this affective bias diminishes momentum of the feedback loop and ultimately leads to smoking cessation (Bowen et al., 2009; Bowen & Marlatt, 2009; Brewer et al., 2010). However, studies that directly test these hypotheses are needed.

Craving at the Core

Mindfulness training teaches that rather than running away from unpleasantness, one can learn to accept what is happening right now and, paradoxically, move "into" the experience and explore what it actually feels like in the body, no matter how unpleasant it might be at the moment. In this way, mindfulness training may help individuals sit with or "ride out" their cravings. In drugs that produce physical dependencies, sitting with a craving can be overwhelming; the longer a craving goes unsatisfied, the more it may intensify as it becomes fueled by further reactions to the symptoms of withdrawal and the unpleasantness of the wanting itself. 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). Mindful dissection of these intense experiences can lead people to see two aspects clearly. First, that cravings are physical sensations in their bodies, not moral imperatives that must be acted on. Second, that each time they successfully ride out a craving—experiencing its physicality without acting on it—cravings naturally subside on their own, even if not satiated. Through repeated and sustained application of this introspective observation, individuals learn "from experience" that cravings are inherently impermanent and that the intense experiences are not as overwhelming as they first seemed.

Through the practice of "befriending" all of one's experiences as they arise and pass, one strengthens one's cognitive capacity for equanimity (nonjudgmental awareness), attenuates one's habitual emotional reactivity, and begins to build insight into the mechanisms of dependent origination. Cravings may continue to arise (often with a vengeance, especially at the beginning), but literally sitting with these urges and becoming curious about their nature (rather than immediately reacting to them) disrupt both the automaticity and the strength of the associative loop. If mindfulness is a causative agent in the success of these addiction treatments, one might predict that it would decouple the traditional observation that smoking and craving are positively correlated.

In a follow-up to their smoking cessation trial of mindfulness training, Brewer and colleagues examined the relationship between craving and smoking behavior during treatment (Elwafi, Witkiewitz, Mallik, Thornhill, & Brewer, 2013). At the beginning of treatment, subjects showed strong positive correlations 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, the relationship between self-reported cigarette cravings and smoking had decoupled to the point of statistical nonsignificance ($r = 0.13$, $p = 0.49$).

In fact, the individuals who quit smoking showed no difference in craving scores compared to those who continued to smoke and instead demonstrated a delayed reduction in reported craving, while those who did not quit reported an increase in craving concomitant with increases in smoking. Further, the observed decoupling was itself moderated by mindfulness practice—the more that individuals practiced during treatment, the less their craving correlated with the number of cigarettes they smoked at the end of treatment. These results suggest that after just 4 weeks of outpatient mindfulness training, individuals were no longer reacting to their cravings by smoking. This finding is consistent with the hypothesis that mindfulness decouples the relationship between craving and smoking. In other words, mindfulness practice may help individuals stop adding fuel to the fire (craving) so that while the fire still continues to burn off of the fuel already present, the heat is no longer intolerable. Over time, without continued sustenance (smoking), the fire burns out by itself.

The capacity 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 craving, substance use, and depression following a randomized clinical trial of Mindfulness-Based Relapse Prevention. They found that craving mediated the relationship between depressive symptoms and substance use in the group that received a conventional treatment but not in the group that received MBRP. These results further support the Buddhist claim that mindfulness training targets craving itself. The Buddhist model goes on to claim that when the craving is attenuated, over time the addictive loop will become dismantled through a dis-identification with the object (or dismantling of self-identity; Brewer et al., 2013). The next logical steps will be to determine how these map onto current psychological models of 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 processes unto themselves?

Neurobiological Underpinnings of Addiction as Related to Mindfulness

Mindfulness meditation integrates multiple neurological systems, including networks that regulate attention, working memory, somatic perception, and emotion (for a more detailed review see Hölzel et al., 2011). Brain systems that show commonality between a number of different maladies and have also been theoretically and functionally linked to mindfulness training may provide a logical starting point for assaying the neurobiological mechanisms by which mindfulness impacts disease progression and for identifying promising targets for clinical interventions. The default mode network (DMN; a collection of brain regions that show robust functional correlation when one's mind is otherwise unoccupied) may be one such point of convergence (see Andrews-Hanna, Reidler, Sepulcre, Poulin, & Buckner, 2010; Buckner, Andrews-Hanna, & Schacter, 2008; Fox & Raichle, 2007).

The DMN was originally identified as a conserved pattern of regional activations that the participants in fMRI studies “defaulted” to while laying in a neuroimaging scanner and waiting for experiments to begin (Raichle et al., 2001). The DMN is strongly associated with off-task ideation (mind-wandering), self-referential processing, and with a number of psychiatric disorders ranging from anxiety to addiction (Buckner et al., 2008; Whitfield-Gabrieli et al., 2011; Whitfield-Gabrieli & Ford, 2012). Two primary nodes of the DMN, the medial prefrontal cortex (MPFC)and the posterior cingulate cortex (PCC), show temporally correlated activity with multiple peripheral nodes and anticorrelated activity with brain regions involved in self-monitoring and cognitive control (including the anterior insula, AI; dorsal anterior cingulate cortex, dACC; and dorsolateral prefrontal cortex, DLPFC; Andrews-Hanna et al., 2010). Though self-referential processing is a complex area of investigation in itself, on first approximation, this may be where models of self-identity formation at least partially overlap with cognitive disorders; memory retrieval and the “self across time” are linked by PCC activity (Andrews-Hanna et al., 2010; Buckner et al., 2008). Mindfulness practices generate marked deactivation of the DMN and have also been shown to increase functional connectivity between the DMN and regions associated with cognitive control (the DLPFC and dACC). Long-term meditators show these differences both during meditation and at rest compared to controls, suggesting that the functional connectivity alterations associated with active meditation practice may become stably integrated as trait changes in these individuals. Given the primacy of the DMN in numerous psychiatric disorders and contribution to self-referential processing and mind-wandering, the DMN appears a biologically plausible target for mindfulness training, which retrains the mind’s tendency for discursive thought activity and for developing pathological self-constructs. Of course, the exact patterns and functions of these networks should be interpreted with some caution as there are limitations to our current analytic methods; we are only just beginning to understand the various causal factors that lead to the observed patterns (e.g., see Fan et al., 2012).

The DMN, and in particular the PCC, are also implicated specifically in addiction. PCC activity has been positively correlated with the severity of alcohol addiction (Claus, Ewing, Filbey, Sabbineni, & Hutchison, 2011; Tapert et al., 2003) and with the likelihood of relapse following treatment for cocaine and nicotine addiction (Kosten et al., 2006; Janes et al., 2010). In cocaine users, a relatively higher PCC response to cocaine-related cues during a 2-week treatment program distinguished patients who used again from those that did not in the 10-week following treatment (Kosten et al., 2006). Similarly, Janes et al. (2010) found that smokers who slipped after attaining abstinence had shown greater activations in response to smoking cues in brain regions including the PCC during the treatment. The PCC is only one of many brain regions implicated in the progression of addiction, yet it may be a central player. A meta-analysis of the neural substrates of reactivity to smoking-related cues found that the most reliably activated regions were the PCC and adjacent areas (Engelmann, Versace, Robinson, & Minnix, 2012). Other meta-analyses have similarly found that cue reactivity in nicotine addiction positively correlated with PCC activation (Tang et al., 2012). Importantly, in a direct comparison of cigarette smokers currently undergoing treatment who were shown smoking cues and instructed to either allow themselves to crave smoking or resist their cravings, Brody et al. (2007) found that resisting craving was associated with increased activity in the MPFC and PCC. It may seem counterintuitive that increased PCC activity correlates with addiction severity and relapse, but also with resisting cravings during treatment. After all, it could be reasonably presumed that patients who are committed to quitting smoking "should" be resisting their cravings. From the dependent origination model, however, it is clear that resistance reengages the addictive cycle, rather than dismantling it, ultimately undermining the intention of the effort.

In this chapter alone, we have seen that PCCactivity correlates with multiple attributes of addiction, self reference, internal resistance, and mind-wandering and that PCC deactivation is seen across multiple types of meditation. While still preliminary, there are some converging lines of evidence that while the function of mindfulness practice may be to disassemble pathological habit patterns, the unskillful use of self-identified effort to accomplish this may itself be a pathological loop. To better understand the contribution of PCC function to conscious experience, Garrison et al. (2013) used real-time fMRI neurofeedback for PCC activity in the context of mindfulness meditation. Activation of this structure tracked with the experience of being "caught up" in one's experience, whereas PCC deactivation corresponded with the sense of "effortless awareness" (being nonreactively aware of one's present experience). Farb et al. (2007) found that participants of an 8-week MBSR course showed less DMN (including PCC and MPFC) activation when mindfully viewing self-referential adjectives. Another group found that experienced meditators exhibited deactivation of DMN structures (including the PCC and MPFC) during mindful viewing of emotionally evocative pictures whereas novice meditators did not (Taylor et al., 2011). These findings suggest that the success of mindfulness training for addictions may be due to the disengagement from self-identified habitual response patterns and that the sense of "effort" during enacting control might actually be part of the problem.

Since DMN activity is tightly coupled with mind-wandering, the possibility that in the above studies, mindful viewing of the images and the self-referential words simply suppressed mental elaboration should be considered. Indeed some elements of mindfulness training are intended to develop the practitioner's capacity to direct attention and focus uninterruptedly on a specified object (commonly the somatic perception of breath). As the skill of the practitioner increases, this type of concentration practice progressively eliminates mind-wandering during the meditation period and elicits pronounced DMN deactivations, as one might expect (Brewer, Worhunsky et al., 2011; Hasenkamp, Wilson-Mendenhall, Duncan, & Barsalou, 2012). However, other mindfulness practices that do not aim to alter the prevalence of mind-wandering, but rather the practitioner's relationship to it, also elicit MPFC and PCC deactivation (Brewer, Worhunsky et al., 2011). In these "choiceless awareness" practices, the intent is to bring nonreactive observation to one's experience, which includes unrestricted spontaneous thought. In the same study, the very experienced meditators (having on average over 10,000 h of practice) showed greater functional connectivity than controls between the PCC and regions associated with self-monitoring and cognitive control (namely the dACC and DLPFC). In the vast majority of contexts, the PCC and these regions are anticorrelated (Fox & Raichle, 2007). In this case, the control subjects 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 diligent meditation practice may have established a “new” default mode of intrinsic brain activity and connectivity. These neurological findings are consistent with the notion that awareness and affective control are being coupled with spontaneous mental activity, not suppressing it. These findings should be interpreted with caution, however, as this study was cross-sectional and could be influenced by self-selection bias.

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). The above findings from Brewer, Worhunsky et al. (2011), showing that experienced meditators exhibited altered resting-state networks, suggest that mindfulness practice may fundamentally alter brain activity and connectivity patterns in networks important for the perpetuation of addictive behaviors. In essence, mindfulness may help to integrate the capacity to monitor internal and external environments (AI/dACC; see Farb, Segal, & Anderson, 2013), especially when craving or self-referential states arise (likely activating the DMN and its major nodes, the MPFC and PCC), and to utilize self-control (likely activating the DLPFC) when needed. Over time, as the ability to meta-cognitively monitor one’s experience 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 Sally develops her capability to pay attention to her internal and external environments while maintaining affective equipoise, the less fuel she would add to her habitual “coping” strategies of drinking to deal with stress and withdrawal states, leading to the winding-down of her habituated affective self-identity and its eventual cessation. However, prospective studies of individuals receiving mindfulness training for addictions that measure changes in brain activity and connectivity over time are needed to test such hypotheses. We focused mainly on the DMN in this chapter, but 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

The past century has seen a great leap forward in the understanding of the psychology and neurobiology of behavioral change mechanisms and addiction mechanisms (Goldstein et al., 2009; Kalivas & Volkow, 2005). This impressive body of work has shown remarkable similarities to the ancient Buddhist model, which is aimed at describing the causes and cure of human suffering. Modern treatments that have reframed Buddhist practices for use in addiction treatment have shown preliminary utility. While longitudinal studies will be needed to assess the long-term efficacy of mindfulness-based trainings compared to conventional treatments, it is possible that mindfulness-based approaches offer substantial improvements in the durability of addiction cessation rates. If the Buddhist theory holds, it may also be that mindfulness treatments are able to induce fundamental modifications to neural networks so as to act nonspecifically on the root of craving, rather than on targeted behaviors. Neuroimaging data are beginning to inform the neural mechanisms of mindfulness and how mindfulness practices specifically interface with active addictions. Insight into the functional, structural, and network changes brought about by mindfulness may open the door for improved therapies and therapeutic tools. The initial evidence indicates that meditation practice grants one deeper access to one's own cognitive functions and present-moment experience. With practice, this may lead to more adaptive choices with concomitant decreases in stress and suffering. It is particularly interesting that there are fundamental similarities between the methods of Western empiricism and the methods of Buddhist insight meditation. While the practice of meditation takes many years to master, at essence, all that is required is to simply observe one's experience without preconception and see what one discovers.

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