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# *DELAY DISCOUNTING AND THE USE OF MINDFUL ATTENTION VERSUS DISTRACTION IN THE TREATMENT OF DRUG ADDICTION: A CONCEPTUAL REVIEW*

MELINDA L. ASHE, MICHELLE G. NEWMAN, AND STEPHEN J. WILSON

THE PENNSYLVANIA STATE UNIVERSITY

In recent decades, researchers have integrated measurements of delay discounting, how the subjective valuation of a reward changes as a function of time, into their study of addiction. Research has begun to explore the idea that delay discounting may serve as both a marker for the effectiveness of existing treatments for addiction and a potential target for novel intervention strategies. As this work is in its infancy, many potentially significant connections between the construct of delay discounting and the treatment of addiction have yet to be explored. Here, we present a conceptual review highlighting novel points of intersection between delay discounting and two approaches to treating addiction that have become increasingly popular in recent years: those that focus on the development of mindfulness skills and those that emphasize the use of distraction techniques. Viewing these two techniques through the lens of delay discounting is particularly intriguing because of the very different way that they address the experience of drug cravings in the present moment (nonjudgmentally attending to vs. shifting attention away from subjective cravings, respectively). We propose that these opposing strategies for dealing with cravings may interact with delay discounting in ways that have important implications for treatment effectiveness.

*Key words:* delay discounting, drug addiction, mindfulness, distraction, craving

Over the past several decades, behavioral economics has been integrated in diverse ways into the field of psychology (Angner & Loewenstein, 2012). In particular, several researchers have used measurements of delay discounting, which assess how the subjective value of some commodity changes as a function of time, in their examination of drug addiction, gambling, weight loss, and other conditions marked by impaired self-control (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012). It is widely understood that as the time at which one collects a reward moves further away (or, as temporal distance increases), the value of that reward to an individual decreases to a given degree, known as the discounting factor (Rachlin, Raineri, & Cross, 1991). As the literature concerning the interaction between delay discounting and addiction has been reviewed extensively elsewhere (e.g., Bickel et al., 2012; MacKillop et al., 2011; May, Andrade, Willoughby, & Brown, 2012), the current article will provide a smaller, targeted background for readers.

Using this selective summary as a foundation, the goal of this paper will be to build upon recent work conceptualizing delay discounting as a sensitive behavioral marker with the potential to guide the selection and goals of treatment for addiction and related disorders in valuable ways (e.g., Bickel, Johnson, Koffarnus, MacKillop, & Murphy, 2014; Chivers & Higgins, 2012; MacKillop et al., 2010). Specifically, we present a conceptual review that draws novel connections between the construct of delay discounting and two increasingly prevalent components in the treatment of addiction: mindfulness and distraction. Following Bishop et al. (2004, p. 232), we define *mindfulness* as "the self-regulation of attention so that it is maintained on immediate experience" using "an orientation that is characterized by curiosity, openness, and acceptance." We define *distraction* as diverting attention away from a particular aspect (or aspects) of immediate experience by engaging in alternative thoughts or behaviors (Gross, 1998; Skinner, Edge,

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Correspondence concerning this article should be addressed to Stephen J. Wilson, 311 Moore Building, Department of Psychology, The Pennsylvania State University, University Park, Pennsylvania 16802.
e-mail: sjw42@psu.edu

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Altman, & Sherwood, 2003). We have selected these techniques because they differ fundamentally regarding how they address moments of temptation during which the pull of a short term reward (e.g., the lure of using drugs) is juxtaposed against a competing long-term behavioral goal (e.g., the intention to remain abstinent), making them particularly useful "cases in point" to contrast with respect to the role(s) that delay discounting may play in treatment effectiveness. We focus on drug addiction because it is one of the domains in which delay discounting has been examined most extensively (Bickel et al., 2012; MacKillop et al., 2011). Importantly, although we emphasize addiction, the issues discussed herein are likely to have broad conceptual and clinical relevance, as excessive delay discounting appears to be a salient feature of several psychiatric disorders (Bickel et al., 2012).

Below, we provide an overview of delay discounting and evidence that excessive delay discounting contributes to the maintenance of addiction, followed by a brief review of recent research examining the bidirectional influences between the treatment of addiction and delay discounting processes. Building upon this foundation, we review the different ways in which mindfulness versus distraction techniques are used to manage and/or reduce *drug craving* (defined as an intense desire to use drugs; Wilson & Sayette, in press) in the treatment of addiction and how, when viewed through the lens of delay discounting, these differences have several potentially significant implications for treatment outcome. We also offer suggestions regarding fruitful directions for future research and applications of the ideas presented herein.

## Delay Discounting and Drug Addiction

Delay discounting has been succinctly defined as, "the decline in the present value of a reward with delay to its receipt" (Odum, 2011a, p.427). Researchers determine the degree to which individuals discount future rewards by asking a series of incremental questions, such as, "Would you rather have $75 today or $100 in one month?" varying both the amount of reward and length of delay (Bickel et al., 2014). Delay discounting behavior has been observed using monetary and nonmonetary rewards, as well as in choices between two amounts of one commodity or between two different commodities (Bickel, Landes et al., 2011; Green, Myerson, Oliveira, & Chang, 2013; Jiga-Boy, Storey, & Buehner, 2013).

The hyperbolic model of delay discounting is a time-inconsistent model that weights rewards and costs according to how distant in the future they are; by doing so, it allows for preference reversal, a phenomenon in which when making a choice, individuals initially prefer to wait for a larger, distant reward rather than wait a shorter amount of time for a smaller reward but, as time goes on and the small reward draws near, they subsequently change their minds (Frederick, Loewenstein, & O'Donoghue, 2002). Such preference reversals help to explain a pattern frequently observed in those who struggle with impulse control—they honestly pledge to stop using in the near future but, when that future arrives and they are confronted with their vice, they are unable to follow through with their pledges (Bickel & Marsch, 2001). Recognizing the theoretical connection between hyperbolic discounting and a commonly experienced behavioral struggle in addiction, researchers began studying how delay discounting predicts and maintains self-control lapses, such as compulsive gambling, failed weight loss attempts and substance use disorders (see Bickel et al., 2012).

Initially, researchers conducted cross-sectional studies and found that addicted populations discounted money more steeply than did healthy controls, as well as demonstrated steeper discounting of drugs than for money in general, for substances including alcohol (e.g., Claus, Kiehl, & Hutchison, 2011; Mitchell, Fields, D'Esposito, & Boettiger, 2005; Vuchinich & Simpson, 1998), tobacco (e.g., Baker, Johnson, & Bickel, 2003; Bickel, Odum, & Madden, 1999; Heyman & Gibb, 2006; Johnson, Bickel, & Baker, 2007; Mitchell, 1999), cocaine (e.g., Coffey, Gudleski, Saladin, & Brady, 2003; Heil, Johnson, Higgins, & Bickel, 2006; Johnson, 2012), opioids (e.g., Kirby, Petry, & Bickel, 1999), and methamphetamine (e.g., Hoffman et al., 2006; Monterosso et al., 2007). More recently, MacKillop and colleagues (2011) performed a comprehensive meta-analysis of these and other studies and found an average effect size (Cohen's *d*) of 0.58, which rose to 0.61 when only including studies that used clinical populations. This moderate effect size provides strong support for the existence of a

reliably higher degree of discounting among addicted populations. Moreover, as reviewed by Bickel and colleagues (2012), excessive delay discounting appears to be a transdisease process that is associated with multiple disorders characterized by poor impulse control (e.g., compulsive gambling or excessive overeating).

There is some evidence that elevated delay discounting prior to drug use is a risk factor for addiction. In rodent populations, for example, performance on a task modeling delay discounting predicted both the initiation and severity of subsequent substance use (Perry, Nelson, & Carroll, 2008; Perry, Larson, German, Madden, & Carroll, 2005). Similarly, in humans, longitudinal studies of adolescents have found that the degree of delay discounting predicted the development and/or worsening of behaviors such as smoking, alcohol abuse, and substance use in general (Audrain-McGovern et al., 2009; Khurana et al., 2013). Studies have also examined the possibility that drug exposure leads to steeper discounting, with mixed results (for recent reviews of this literature, see Stein & Madden, 2013; Weafer, Mitchell, & de Wit, 2014). For instance, whereas some nonhuman animal studies have observed that drug administration is associated with increases in delay discounting (e.g., Mendez et al., 2010), others have failed to find such an effect (e.g., Harty, Whaley, Halperin, & Ranaldi, 2011). In sum, it is clear that delay discounting is intimately related to the processes underlying addiction, although more and better-controlled longitudinal studies are needed to determine whether there is a causal relationship between delay discounting and substance dependence (and, if so, whether the relationship is unidirectional or bidirectional), as well as to characterize the exact nature of the mechanism(s) through which discounting affects behavior.

### Addiction Treatment and Delay Discounting

With mounting evidence that excessive delay discounting may contribute to the development and maintenance of addiction, studies began to examine whether degree of delay discounting might predict treatment success. This work has demonstrated that steep delay discounting predicts poorer outcomes for the treatment of substance dependence across a variety of drugs and clinical settings (e.g., Sheffer et al., 2012; Stanger et al., 2012). More recently, researchers have considered decreasing the degree of discounting as a means to facilitate addiction treatment. For example, Bickel et al. (e.g., 2014) proposed that it would be possible to alter delay discounting by using procedures in which individuals are conditioned to choose a larger–later instead of a smaller–sooner reward consistently over a series of incrementally different choices. Neurological, behavioral, and genetic evidence indicating that one's discount factor is relatively stable over time (Odum, 2011b) highlight a potential obstacle to this approach—trait variables can be difficult to change. There is, however, still considerable debate as to whether delay discounting is best classified as a state or trait variable; state factors, such as the type of reward being evaluated, as well as trait factors such as age or socioeconomic status have both been shown to alter the discount factor, suggesting that excessive delay discounting may be amenable to intervention (see Odum & Baumann, 2010).

Indeed, there is growing interest in developing treatments that effectively target and reduce delay discounting (e.g., Black & Rosen, 2011; Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013). One recently-developed strategy that has shown great promise builds upon the relationship between executive functioning (e.g., working memory, reasoning) and impulse-control (Day, Metrik, Spillane, & Kahler, 2013; Ochoa et al., 2013) and seeks to decrease delay discounting via working memory training. Specifically, Bickel, Yi, and colleagues (2011) found that working memory training reduced delay discounting in individuals in treatment for stimulant use, whereas there was no change in delay discounting among those who received control training (see Renda, Stein, & Madden, 2015 for a failure to replicate this effect in rats). This innovative study suggests that the degree of delay discounting can be manipulated to aid treatment for substance abuse and other impulse-control disorders, although additional long-term work is needed to determine the extent to which such changes persist. There is, however, emerging evidence from nonhuman animal research that long-lasting changes in delay discounting are possible—rats display robust and protracted reductions in impulsive choice after being provided with prolonged exposure to delayed rewards

(Stein et al., 2013; Stein, Renda, Hinnenkamp, & Madden, 2015). In addition to supporting the idea that interventions can lead to enduring changes in delay discounting, these findings highlight that such changes can be achieved using strategies other than working memory training.

Several treatments have incorporated techniques that involve behavioral economics by altering how people structure choices. One long-standing approach uses contracts in therapy to avoid preference reversals. Contracts are formal agreements that stipulate the consequences of (un)desirable choices surrounding a target behavior; for instance, a contract may indicate that monetary fines must be paid if drug use occurs. Peysakhovich (2014) used a series of proofs to argue that contracts that offer rewards for good behavior ("carrots") are more effective than those that punish bad behavior ("sticks" or "binding") because of the increased temptation to cancel or avoid a punishing contract. Additional methods include choice bundling or bracketing, in which individuals are asked to make a series of decisions rather than just one at any given moment (Ainslie & Monterosso, 2003; Read, Loewenstein, & Rabin, 1999). Read et al. proposed that bracketing is superior to a series of individual decisions because it allows individuals to consider aggregate effects (for instance, the rewards of abstaining from smoking are larger after one month than a single instance of refraining from cigarettes) and helps to combat preference reversal by extending the decision-maker's temporal perspective to highlight these delayed benefits. Ainslie and Monterosso (2003) tested these ideas in rats and found that they chose larger–later rewards more consistently (i.e. acted less impulsively) when decisions were bundled compared to when they made a series of individual choices. The results are promising but, as Read et al. point out, it is not always feasible for people to bundle choices, and more research is needed to evaluate the effectiveness of these approaches with clinical populations (e.g., see Hofmeyr, Ainslie, Charlton, & Ross, 2011).

Techniques informed by behavioral economics have also attempted to enhance brief motivational interventions by asking clients to identify and highlight the value of delayed goals (Murphy, Correia, Colby, & Vuchinich, 2005). The objective of this strategy was to increase the salience of delayed rewards and/or punishments in order to reduce impulsive behavior. In fact, a brief randomized controlled trial using this approach led to greater reduction in alcohol consumption problems in undergraduate drinkers compared to a motivational treatment supplemented with relaxation exercises (Murphy et al., 2012). Clearly, there is some evidence supporting the inclusion of behavioral economic tools and perspectives in the treatment of substance use and impulse-control disorders.

A neurological perspective, competing neurobehavioral systems (CNDS) theory, offers a useful framework for conceptualizing how interventions may be used to target and alter the degree of discounting. As reviewed by Koffarnus et al. (2013) there is compelling evidence that choosing smaller–sooner rewards is associated with increased activation in the "impulsive system" of the brain (which includes the amygdala, ventral striatum, and related structures), whereas the "executive system" (which includes distinct regions of the prefrontal cortex) is more likely to exhibit increased activation when a larger–later reinforcer is chosen (for related discussions, see Bechara, 2005; Peters & Büchel, 2011; Bickel et al., 2012). Koffarnus and colleagues used the CNDS model to describe how an imbalance between the impulsive and executive neural systems can lead to risky behavior, as well as the various mechanisms through which interventions can strengthen the ability to resist acting upon immediate temptations. Theoretically, a treatment could alter delay discounting by influencing either or both of these systems, so long as it improves the relative strength of the executive system over the impulsive system.

In addition to providing useful information for developing new techniques to address delay discounting, it is possible that individual differences in delay discounting moderate outcomes from existing treatments. As discussed further below, it may be particularly pertinent to use a person's propensity to discount delayed rewards when selecting between treatment components that differ substantially in how they address craving. Loewenstein (1996) proposed that craving represents a "visceral factor" that heightens the value of drug consumption relative to alternative goods and actions. Similarly, Marlatt (2000, p. xviii)

argued that "[c]raving for drug reinforcers locks the addict into a fixation on the immediate future, and long-term costs are often discounted." Thus, from a behavioral economic perspective, one reason why craving may contribute to relapse is because it reflects an increase in the incentive value of proximal drug consumption that threatens an individual's ability to work for the delayed rewards that come with drug abstinence and/or avoid the delayed costs associated with continued drug use. There is in fact some empirical evidence for an association between drug craving and the valuation of immediate versus delayed drug and nondrug rewards (e.g., Badger et al., 2007; MacKillop et al., 2010; Sayette, Martin, Wertz, Shiffman, & Perrott, 2001; but see Joos et al., 2013). Although more research examining relations among these variables is needed, it is reasonable to hypothesize that some people may be more swayed than others by craving episodes as a function of the degree to which they discount delayed rewards in general (e.g., those who are prone to steeply discount delayed rewards may be particularly susceptible to relapse as a function of the motivational shifts that accompany craving states). Broadly consistent with this idea, it is known that impulsivity, for which the discounting factor is a proxy, is cross-sectionally associated with craving levels (Joos et al., 2013) and poorer outcomes (e.g., inability to abstain; Stevens et al., 2014) in treatment for addiction.

If delay discounting moderates treatment effectiveness, it follows that information about an individual's propensity to discount delayed rewards may be quite useful when it comes to choosing intervention components. Related to this idea, Bickel et al. (2012) suggested that knowledge about executive functioning, considered to impact delay-discounting, could help guide treatment selection. For instance, a person with a particularly weak executive system may benefit more from working memory training versus learning how to suppress a compulsion (Bickel et al., 2012). Assessment of discounting behavior could be incorporated into an initial therapeutic session given the large number of relatively brief, well-validated measures of delay discounting (MacKillop et al., 2011). Below, we further explore the notion that delay discounting offers valuable information with respect to the treatment of addiction. Specifically, we will consider delay discounting in relation to mindfulness- and distraction-based techniques.

## Mindfulness-Based Strategies

Mindfulness is a practice that originated from Vipassana meditation and has been described as moment-to-moment, nonjudgmental awareness of peoples' experiences as they unfold (Kabat-Zinn, 2005). Mindfulness techniques presume that lack of mindfulness is something that can be remediated with practice, and studies have provided evidence that mindfulness training is associated with changes in both behavior and underlying neurobiology (e.g., Carmody & Baer, 2008; Hölzel et al., 2011; Witkiewitz, Lustyk, & Bowen, 2013). For instance, in one study mindfulness training was associated with increases in grey matter in brain areas involved in learning, memory, and emotion regulation, such as the hippocampus, posterior cingulate cortex, temporo-parietal junction and cerebellum (Hölzel et al., 2011).

A component of mindfulness is self-monitoring so that people can objectively assess their thoughts and behaviors and respond to tempting experiences purposefully rather than impulsively (Marlatt, 2002). Mindfulness techniques have been incorporated into many cognitive-behavioral therapies for the treatment of mood and anxiety disorders, chronic pain, sleep problems, and, most relevant to the current paper, substance use disorders (Lau & Yu, 2009). In fact, employing mindfulness- and acceptance-based practices in substance use treatment has become extremely popular in the past decade (for an extensive review see Ussher, Cropley, Playle, Mohidin, & West, 2009; Zgierska et al., 2009).

In one influential intervention labeled mindfulness-based relapse prevention (MBRP), groups participate in a manualized, 8-week posttreatment course that combines cognitive and meditative techniques to aid the maintenance of drug abstinence (Bowen & Marlatt, 2009; Ussher et al., 2009). In each session, participants are guided in a formal meditation exercise, discuss their insights, and practice skills. The hope is that this exercise helps increase awareness and acceptance of negative mood and craving in reaction to tempting situations, and that such acceptance and "riding out" of urges will replace substance use in response to triggers. In support of this

hypothesized mechanism of change, Witkiewitz and Bowen (2010) found that craving mediated the relationship between negative affect and posttreatment drug use in individuals with substance use disorder who received treatment-as-usual, but craving did not mediate the link between negative affect and posttreatment drug use in those receiving MBRP. This was interpreted as evidence that MBRP augmented the ability to experience aversive emotional states without using drugs. In a similar vein, subsequent work by Witkiewitz and colleagues demonstrated that mindfulness training weakened the relationship between craving and smoking behavior (Elwafi, Witkiewitz, Mallik, Iv, & Brewer, 2013). More generally, MBRP has shown promise vis-à-vis substance use outcomes—in a pilot study, Bowen and Marlatt (2009) found that undergraduate smokers who received mindfulness-based instructions (e.g., that they should picture urges to smoke as waves, and imagine riding them as they naturally move up and down, without attempting to change or eliminate the urges) in conjunction with one session of cue exposure treatment reported smoking fewer cigarettes across a 7-day follow-up period compared to those who received cue-exposure without instruction in mindfulness. Although more studies are needed to confirm the effectiveness of MBRP and fully characterize the associated mechanisms of change, these initial explorations indicate that it may be a very effective treatment approach.

A related form of treatment is Acceptance and Commitment Therapy (ACT), which tries to increase self-control by teaching clients to accept their internal states and to make behavioral decisions based on goals and *not* because they are trying to alter a thought or feeling (Gifford et al., 2004). Recently, a series of randomized clinical trials has shown that ACT can be effective in treating a wide variety of substance abuse difficulties (Bricker, Bush, Zbikowski, Mercer, & Heffner, 2014; Bricker, Mull et al., 2014; Bricker, Wyszynski, Comstock, & Heffner, 2013; Gifford et al., 2004; Gifford et al., 2011; Gonzalez-Menendez, Fernandez, Rodriguez, & Villagra, 2014; Hayes et al., 2004; Luoma, Kohlenberg, Hayes, & Fletcher, 2012; Petersen & Zettle, 2009; Smout et al., 2010; Stotts et al., 2012). For instance, in a randomized pilot study, there were no differences between ACT and nicotine replacement therapy immediately following treatment, but a larger percentage of those in the ACT group were still abstaining from smoking 1-year posttreatment (Gifford et al., 2004). Another randomized pilot study found that ACT was feasible to administer via telephone and that it (combined with nicotine replacement therapy) was more effective than telephone-administered CBT (also combined with nicotine replacement therapy) for smoking cessation, as indicated by higher rates of abstinence at 6 months post-randomization (Bricker, Bush et al., 2014). Thus, like MBRP, there is growing support for the efficacy of ACT for the treatment of addiction.

### Connecting Mindfulness to Delay Discounting

Given the conceptual overlap between delay discounting and mindfulness, researchers have begun to explore how these constructs relate to one another and potentially jointly influence impulsive behavior (Hendrickson & Rasmussen, 2013; Morrison, Madden, Odum, Friedel, & Twohig, 2014; Murphy & MacKillop, 2012). Using validated questionnaires, Murphy and MacKillop (2012) found that facets of impulsivity and mindfulness were positively and negatively related to alcohol misuse, respectively, and that certain aspects of impulsivity and mindfulness were negatively correlated with one another. In addition, mindfulness-based interventions do appear to have the capacity to alter delay discounting, at least in those who exhibit subclinical levels of impulsivity (Hendrickson & Rasmussen, 2013; Morrison et al., 2014). For example, relative to a wait-list control condition, a brief (60–90 min) acceptance-based training focusing on components of ACT reduced the extent to which undergraduates discounted delayed monetary rewards (Morrison et al., 2014). Although additional research is needed to characterize the nuanced associations among mindfulness and delay discounting, they appear to be connected in clinically meaningful ways.

To the extent that the effects observed in nonclinical populations (Hendrickson & Rasmussen, 2013; Morrison et al., 2014) extend to those with substance-related problems, one hypothesis is that mindfulness-based techniques may provide a way to address the excessive delay discounting associated with drug

addiction by increasing the capacity to attend to and tolerate bouts of craving (the pull of an immediate reward) without using drugs (Elwafi et al., 2013; Witkiewitz et al., 2014), thereby allowing long-term goals (maintaining abstinence) to have a stronger influence on their behavior.

It is important to note, however, that not all studies have provided unequivocal support for the efficacy of mindfulness-based interventions for treating substance use disorders. For example, a randomized pilot trial of recovery house patients found no significant difference between treatment as usual and mindfulness-supplemented treatment in either self-reported addiction severity or urine toxicology at 8 weeks and 5 months posttreatment (Alterman, Koppenhaver, Mulholland, Ladden, & Baime, 2004). A potential unexplored, albeit arguably unlikely, challenge to the efficacy of mindfulness is that, when attending carefully during a period of craving, some individuals may become overwhelmed by the urge to use drugs and experience greater difficulty remaining abstinent as a result. That is, some cravings may simply be too strong to resist without some more active intervention (Kalivas, Volkow, & Seamans, 2005; Sayette & Griffin, 2011). If this were the case, those who discounted the future most steeply might be especially vulnerable to experiencing instances of seemingly irresistible desire. Compelling evidence suggests that even brief lapses in abstinence attempts significantly increase the risk of a full relapse (e.g., Juliano, Donny, Houtsmuller, & Stitzer, 2006; Shadel et al., 2011). Given the high potential costs of succumbing to temptation for even a moment, it will be important to explore the possibility that mindfulness may be more likely to fail for steep-discounters.

### Distraction-Based Strategies

Diametrically opposed to mindfulness, distraction approaches are, broadly, behavioral and/or cognitive coping strategies that instruct participants to exercise, change their physical location, or take part in some physical or mental activity to reduce the degree to which tempting situations or substance-related cues occupy the focus of their attention. Distraction is thought to work in large part by providing time for acute urges to naturally dissipate, or by directly reducing urge intensity (Kavanagh, Andrade, & May, 2005), decreasing the likelihood that someone will be driven by craving to use drugs. In support of this view, a study examining the relationship between different forms of coping and clinical outcomes among individuals seeking residential treatment found that the use of distraction longitudinally predicted reduced risk of full-blown relapse following treatment (Gossop, Stewart, Browne, & Marsden, 2002). In addition to being effective when used spontaneously (i.e., outside of the context of formal intervention), distraction techniques, when combined with cognitive skill building, have been shown to be efficacious for treating substance use disorders in a variety of populations (Back, Gentilin, & Brady, 2007; Brown, Stetson, & Beatty, 1989; Curry & Marlatt, 1985; McHugh, Hearon, & Otto, 2010; Shiffman, 1982, 1984). Whereas these analyses demonstrate the potential utility of distraction in abstaining from drugs, distraction is not the central focus of these approaches, so they cannot speak to the effectiveness of distraction as a stand-alone technique. However, an experimental study did find that in heavy drinkers distraction was better at reducing acute urges in response to alcohol-related stimuli compared to mindfulness (Murphy & MacKillop, 2014).

One recent theory that has placed more emphasis on distraction as a key technique for directly managing cravings and facilitating addiction treatment is the elaborated intrusion theory of desire developed by Kavanagh and colleagues (2005). According to their theory, desire states including drug craving involve initial intrusive thoughts that are triggered automatically (e.g., thoughts prompted by exposure to drug-related cues in the environment), followed by cognitive elaboration—"mentally embellishing" or "going beyond" the initial intrusive thoughts by seeking relevant information, which is then retained and manipulated in working memory. The cognitive elaboration of intrusive desire-related thoughts using nonautomatic (effortful or controlled) cognitive processes—particularly through the use of visual imagery and working memory—is thought to be the key process that underlies the maintenance of cravings/desires. For example, a smoker might imagine the taste and smell of a cigarette and wonder whether they have enough time to take a smoke break after having an intrusive thought triggered by finding a

lighter in their pocket. One clinical implication of this framework is that interfering with the process of cognitive elaboration (especially by way of a competing task that occupies the cognitive resources required for visual imagery and working memory) should disrupt ongoing cravings. The theory therefore articulates one potential mechanism through which distraction can be used to reduce the intensity and duration of craving, and provides a straightforward framework for the development of novel interventions.

A growing body of research has provided support for the central tenets of the elaborated intrusion theory. Of particular relevance, several studies have demonstrated that craving states become less intense when individuals engage in competing tasks that involve visuospatial processing and/or working memory (for review, see May, Kavanagh, & Andrade, 2014). This includes work showing that engaging in a competing cognitive task reduces the strength of cravings for cigarettes (May et al., 2012; May, Andrade, Panabokke, & Kavanagh, 2010; Shorey, Brasfield, Anderson, & Stuart, 2013), food/drinks (e.g., Andrade, Pears, May, & Kavanagh, 2012; Kemps, Tiggemann, Woods, & Soekov, 2004; Kemps & Tiggemann, 2007; 2009), and naturally-occurring urges of an unspecified nature (Skorka-Brown, Andrade, & May, 2014). For example, May and colleagues (2010) found that a laboratory-based visual working memory task led to rapid and persistent reductions in cigarette craving among nicotine-deprived smokers. Therefore, as with mindfulness strategies, distraction-based techniques appear to have great promise, although more research is needed to test the application of cognitive distraction strategies under clinically relevant conditions.

### Connecting Distraction to Delay Discounting

Evidence for a link between distraction and delay discounting can be traced back to the seminal work on self-control conducted by Mischel and colleagues (Mischel & Ebbesen, 1970; Mischel, Ebbesen, & Zeiss, 1972). In these studies, preschool children between the ages of 3 and 5 were presented with a choice between two food rewards: one that was less preferred but available immediately and one that was highly preferred but available only after a delay. Mischel and Ebbesen (1970) noted that some children spontaneously exhibited behaviors that diverted their attention from the immediately available food (e.g., covered their eyes, talked to themselves). It was speculated that these activities were a form of self-distraction that facilitated the ability to wait for the highly preferred but delayed food.

Mischel and colleagues obtained support for their hypothesis in a series of follow up experiments in which they examined the effects of directly manipulating distraction on choice behavior. They found that children waited significantly longer for a more preferred but delayed reward when they were provided with a toy to play with or were encouraged to think about something enjoyable, relative to when they were not provided with such distractions (Mischel et al., 1972). In subsequent work, similarly beneficial effects of distraction were observed in a sample of slightly older children (aged 6 to 12) with "social adjustment and self-regulatory problems" (Rodriguez, Mischel, & Shoda, 1989). Specifically, there was a strong positive correlation between the amount of time that the children spent looking away from reward cues (as coded by observers) and how long they elected to wait for the more preferred but delayed reward. There is even some indication that attentional redirection influences intertemporal choice in nonhuman animals, as research indicates that both pigeons (Grosch & Neuringer, 1981) and chimpanzees (Evans & Beran, 2007) are more likely to wait for a more preferred (or larger) but delayed reward in lieu of a less preferred (or smaller) but immediately available reward when "distracted" using manipulations modeled after those used by Mischel and colleagues. Taken together, these studies demonstrate that distraction strategies can increase the capacity to resist the temptation of a short-term reward in favor of a better outcome in the future, as well as suggest that distraction can be used effectively by those lacking complex cognitive abilities.

According to Metcalfe and Mischel (1999) distraction facilitates the ability to delay gratification by shifting the balance of information processing away from the "hot" appetitive or consummatory features of a tempting stimulus or situation. Thus, distraction may be a useful way to (temporarily) reduce excessive delay discounting in addicted individuals because it decreases the strength of representations that provoke impulsive drug-seeking behavior. One

important feature of distraction is that it alters affective responses at an early stage of processing (Sheppes & Gross, 2011). Stated differently, distraction serves as a "strong early selection filter" that reduces the extent to which incoming information is processed. This can be contrasted with strategies that operate at later processing stages, such as reappraisal. Because it targets early stage processing, distraction can change the response to provocative stimuli very quickly (e.g., see Paul, Simon, Kniesche, Kathmann, & Endrass, 2013; Schonfelder, Kanske, Heissler, & Wessa, 2013; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011). In addition, by blocking the processing of emotional information at an early stage, distraction has the advantage of being cognitively efficient (Sheppes & Gross, 2011; Sheppes, Catran, & Meiran, 2009).

Presumably in large part because they provide rapid relief without being cognitively demanding, distraction techniques are preferred by participants over alternative approaches to emotion regulation when the intensity of negative affect is high (Sheppes, Scheibe, Suri, & Gross, 2011). Thus, distraction may be most effective for those with the steepest delay discounting—that is, those who have the strongest pull toward immediate rewards—particularly during moments of intense temptation. Results from a recent study examining the effects of cognitive load on self-regulation provide some support for this notion. In one of a series of experiments, Van Dillen, Papies, & Hofmann (2013) identified individuals who were particularly sensitive to being tempted by food cues in the environment, as indicated by elevated scores on a questionnaire. These highly sensitive participants exhibited less attentional bias for appealing food stimuli and were more likely to choose a healthy over an unhealthy snack when under high cognitive load than when under low cognitive load.

Nonetheless, one potential drawback of distraction strategies is that their effects are likely to be short-lived (Mullen & Suls, 1982; Sheppes & Gross, 2011). This could present as either a situation- or person-level problem. For instance, distraction may not be ideal if an episode of temptation persists for an extended period of time, or if the individual using it does not concurrently develop skills suitable for sustaining long-term behavioral change. Support for these predictions can be found in pain management research. Participants experiencing recent-onset pain adapted better when coping by diverting their attention away from versus focusing their attention on their discomfort, whereas the reverse was true for chronic pain participants (Holmes & Stevenson, 1990). Similarly, emotion-processing research suggests that, although both distraction and the adoption of a "distanced" but attentive perspective (an approach conceptually similar to mindfulness-based strategies) temporarily attenuate the response to negative emotional material, only the latter produces lasting changes in the way that the material is processed (Kross & Ayduk, 2008). The short-term nature of distraction could pose an issue for those who are in most need of skill development—again, those with the steepest delay discounting. For such individuals, distraction alone is not likely to produce enduring changes in the neurocognitive processes that underpin their tendency to excessively devalue delayed rewards. In sum, distraction may be effective as a temporary solution for particular individuals in particular moments (e.g., those with particularly steep delay discounting in the midst of acute craving), but it may not be sufficient in the long term as a sole or primary approach for the treatment of addiction.

### Synthesis and Future Directions

Those seeking treatment for substance use often display both excessive delay discounting (e.g., Bickel & Marsch, 2001) and low levels of mindfulness (e.g., Shorey et al., 2013). Mindfulness-based techniques may offer a way to remediate both of these issues and may be especially beneficial for those who discount delayed outcomes most steeply. However, there is a possibility, as yet untested, that mindfully attending to the present may be risky for particularly steep discounters when faced with acute cravings. Distraction-based techniques are a potential solution to this quandary. Also having shown promise in substance use treatment (e.g., Back et al., 2007; Walker & Stephens, 2014), distraction therapies help to mitigate cravings by diverting cognitive resources away from tempting stimuli. Therefore, distraction-based strategies may be more effective (at least temporarily) than mindfulness-based ones for those with the most pronounced delay discounting because

distraction techniques rapidly and efficiently defuse the bias toward smaller–sooner rewards that plagues steep discounters.

A third—and perhaps most likely—possibility is that the implications of delay discounting for the relative effectiveness of mindfulness- and distraction-based techniques are more nuanced. It may be best to think of delay discounting as a critical variable to take into account *along with* situational factors (e.g., the strength of urges and client experiences) and phase of treatment when considering how best to employ mindfulness- and distraction-based techniques. For instance, mindfulness as a general strategy may offer the most benefit for individuals who are prone to excessive discounting but who are not currently experiencing unbearable cravings—such individuals may gain the most benefit in the long term from engaging in mindfulness practices during moments in which their cravings are manageable. Distraction may not be needed to meet their long-term goals under these conditions. In contrast, distraction-based techniques may be particularly useful as an acute ancillary strategy for preventing lapse (and eventual relapse) in clients prone to excessive delay discounting in a circumscribed set of conditions—e.g., early on in treatment, when the urge to use drugs is too intense to combat, and/or when the costs associated with a potential failure of self-control are too high.

Accordingly, an integrative approach, in which mindfulness training is implemented to foster long-term changes and distraction is used selectively to deal with short-term crises, may have the broadest utility. We believe that the assessment of between- and within-individual variability in delay discounting would offer valuable data for optimizing this kind of dual-pronged strategy. That is, in addition to facilitating the selection of individuals for whom such an approach may be most useful, the measurement of changes in delay discounting over time would potentially allow for tailoring which strategies are used by given individuals as their level of impulsivity and/or the demands of the situation change. Recent advancements in both the assessment of delay discounting (Koffarnus & Bickel, 2014) and the ability to dynamically adjust and deliver interventions to individuals under naturalistic conditions (Heron & Smyth, 2010; Newman, Szkodny, Llera, & Przeworski, 2011) have opened the door for such innovative possibilities. The ideas offered above are particularly ripe for future research, as, to the authors' knowledge, no one has explored using a combined distraction–mindfulness approach for substance abuse disorders.

Due to extremely high rates of relapse in substance use disorders, it is important to consider other novel ideas, such as the one presented here, that might improve treatment success. To address the theoretical concepts in this paper, studies could explore the association between clients' degree of delay discounting and treatment outcomes in existing programs that utilize either mindfulness or distraction-based approaches. For instance, randomized, controlled trials could be conducted explicitly comparing each treatment, with discounting as a potential moderating variable of treatment success. In addition, well-controlled trials might examine delay discounting as a moderator of the impact of distraction versus mindfulness techniques used alone and in stages to determine what might work best for particular individuals. It is important to note that many of the predictions made in this review could be substantially refined by basic research on the precise nature of the relationship between delay discounting and craving; thus, studies seeking to explore such associations would be valuable for future expansion of this work. It also should be mentioned that we chose to conceptualize both mindfulness and distraction under a broad umbrella, with the former encompassing attention to and tolerance/acceptance of present experiences and the latter referring to the diversion of attention through either cognitive or behavioral means. It is conceivable (perhaps even likely) that delay discounting would have different implications across more narrowly-defined variants of these constructs (e.g., in relation to cognitive vs. behavioral distraction or for nonjudgmental attention to vs. acceptance of present experience). Research directly exploring these possibilities is needed. Notably, as delay discounting has been shown to be a transdisease process (Bickel et al., 2012), it is likely that knowledge gained through such research would have implications for applying similar strategies in other behavioral domains (e.g., weight loss programs, compulsive gambling treatments). Contemplating future research becomes particularly exciting when one considers that both

clinical and healthy populations could benefit from using delay discounting to choose the best self-control strategy the *first* time.

## References


Ainslie, G., & Monterosso, J. R. (2003). Building blocks of self-control: Increased tolerance for delay with bundled rewards. *Journal of the Experimental Analysis of Behavior, 79*, 37–48. doi:10.1901/jeab.2003.79–37.

Alterman, A. I., Koppenhaver, J. M., Mulholland, E., Ladden, L. J., & Baime, M. J. (2004). Pilot trial of effectiveness of mindfulness meditation for substance abuse patients. *Journal of Substance Use, 9*, 259–268. doi:10.1080/14659890410001711698.

Andrade, J., Pears, S., May, J., & Kavanagh, D. J. (2012). Use of a clay modeling task to reduce chocolate craving. *Appetite, 58*, 955–963. doi:10.1016/j.appet.2012.02.044.

Angner, E., & Loewenstein, G. (2012). Behavioral economics. In U. Maki (Ed.), *Handbook of the philosophy of science: philosophy of economics* (pp. 641–690). Amsterdam: Elsevier. doi:10.1016/B978–0-444–51676-3.50022–1.

Audrain-McGovern, J., Rodriguez, D., Epstein, L. H., Cuevas, J., Rodgers, K., & Wileyto, E. P. (2009). Does delay discounting play an etiological role in smoking or is it a consequence of smoking. *Drug and Alcohol Dependence, 103*, 99–106. doi:10.1016/j.drugalcdep.2008.12.019.

Back, S. E., Gentilin, S., & Brady, K. T. (2007). Cognitive-behavioral stress management for individuals with substance use disorders: A pilot study. *Journal of Nervous and Mental Disease, 195*, 662–668. doi:10.1097/NMD.0b013e31811f3ffd.

Badger, G. J., Bickel, W. K., Giordano, L. A., Jacobs, E. A., Loewenstein, G., & Marsch, L. (2007). Altered states: The impact of immediate craving on the valuation of current and future opioids. *Journal of Health Economics, 26*, 865–876. doi:10.1016/j.jhealeco.2007.01.002.

Baker, F., Johnson, M. W., & Bickel, W. K. (2003). Delay discounting in current and never-before cigarette smokers: Similarities and differences across commodity, sign, and magnitude. *Journal of Abnormal Psychology, 112*, 382–392. doi:10.1037/0021–843x.112.3.382.

Bechara, A. (2005). Decision making, impulse control and loss of willpower to resist drugs: A neurocognitive perspective. *Nature Neuroscience, 8*, 1458–1463. doi:10.1038/nn1584.

Bickel, W. K., Jarmolowicz, D. P., Mueller, E. T., Koffarnus, M. N., & Gatchalian, K. M. (2012). Excessive discounting of delayed reinforcers as a trans-disease process contributing to addiction and other disease-related vulnerabilities: Emerging evidence. *Pharmacology and Therapeutics, 134*, 287–297. doi:10.1016/j.pharmthera.2012.02.004.

Bickel, W. K., Johnson, M. W., Koffarnus, M. N., MacKillop, J., & Murphy, J. G. (2014). The behavioral economics of substance use disorders: Reinforcement pathologies and their repair. *Annual Review of Clinical Psychology, 10*, 641–677. doi:10.1146/annurev-clinpsy-032813–153724.

Bickel, W. K., Landes, R. D., Christensen, D. R., Jackson, L., Jones, B. A., Kurth-Nelson, Z., & Redish, A. D. (2011). Single- and cross-commodity discounting among cocaine addicts: The commodity and its temporal location determine discounting rate. *Psychopharmacology, 217*, 177–187. doi:10.1007/s00213–011-2272-x.

Bickel, W. K., Yi, R., Landes, R. D., Hill, P. F., & Baxter, C. (2011). Remember the future: Working memory training decreases delay discounting among stimulant addicts. *Biological Psychiatry, 69*, 260–265. doi:10.1016/j.biopsych.2010.08.017.

Bickel, W. K., Odum, A. L., & Madden, G. J. (1999). Impulsivity and cigarette smoking: Delay discounting in current, never, and ex-smokers. *Psychopharmacology, 146*, 447–454. doi:10.1007/PL00005490.

Bickel, W. K., & Marsch, L. A. (2001). Toward a behavioral economic understanding of drug dependence: Delay discounting processes. *Addiction, 96*, 73–86. doi:10.1046/j.1360–0443.2001.961736.x.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice, 11*, 230–241. doi:10.1093/clipsy.bph077.

Black, A. C., & Rosen, M. I. (2011). A money management-based substance use treatment increases valuation of future rewards. *Addictive Behaviors, 36*, 125–128. doi:10.1016/j.addbeh.2010.08.014.

Bowen, S., & Marlatt, A. (2009). Surfing the urge: Brief mindfulness-based intervention for college student smokers. *Psychology of Addictive Behaviors, 23*, 666–671. doi:10.1037/a0017127.

Bricker, J., Bush, T., Zbikowski, S. M., Mercer, L. D., & Heffner, J. L. (2014). Randomized trial of telephone-delivered acceptance and commitment therapy versus cognitive behavioral therapy for smoking cessation: a pilot study. *Nicotine & Tobacco Research, 16*, 1446–1454.

Bricker, J., Mull, K. E., Vilardaga, R., Mercer, L. D., Akioka, K. J., & Heffner, J. L. (2014). Randomized, controlled pilot trial of a smartphone app for smoking cessation using acceptance and commitment therapy. *Drug and Alcohol Dependence, 143*, 87–94.

Bricker, J., Wyszynski, C., Comstock, B., & Heffner, J. L. (2013). Pilot randomized controlled trial of web-based acceptance and commitment therapy for smoking cessation. *Nicotine & Tobacco Research, 15*, 1756–1764.

Brown, S. A., Stetson, B. A., & Beatty, P. A. (1989). Cognitive and behavioral features of adolescent coping in high-risk drinking situations. *Addictive Behaviors, 14*, 43–52. doi:10.1016/0306–4603(89)90015–4.

Carmody, J., & Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of Behavioral Medicine, 31*, 23–33. doi:10.1007/s10865–007-9130–7.

Chivers, L. L., & Higgins, S. T. (2012). Some observations from behavioral economics for consideration in promoting money management among those with substance use disorders. *American Journal of Drug and Alcohol Abuse, 38*, 8–19. doi:10.3109/00952990.2011.643979.

Claus, E. D., Kiehl, K. A., & Hutchison, K. E. (2011). Neural and behavioral mechanisms of impulsive choice in alcohol use disorder. *Alcoholism: Clinical and Experimental Research, 35*, 1209–1219. doi:10.1111/j.1530–0277.2011.01455.x.

Coffey, S. F., Gudleski, G. D., Saladin, M. E., & Brady, K. T. (2003). Impulsivity and rapid discounting of delayed hypothetical rewards in cocaine-dependent individuals. *Experimental and Clinical Psychopharmacology, 11*, 18–25. doi:10.1037/1064–1297.11.1.18.

Curry, S., & Marlatt, G. A. (1985). *Strategies for coping with temptations to smoke* (pp. 243–265). New York: Academic Press.

Day, A. M., Metrik, J., Spillane, N. S., & Kahler, C. W. (2013). Working memory and impulsivity predict marijuana-related problems among frequent users. *Drug and Alcohol Dependence, 131*, 171–174. doi:10.1016/j.drugalcdep.2012.12.016.

Elwafi, H. M., Witkiewitz, K., Mallik, S., Thornhill, T. A., 4th, & Brewer, J. A. (2013). Mindfulness training for smoking cessation: Moderation of the relationship between craving and cigarette use. *Drug and Alcohol Dependence, 130*, 222–229. doi:10.1016/j.drugalcdep.2012.11.015.

Evans, T. A., & Beran, M. J. (2007). Chimpanzees use self-distraction to cope with impulsivity. *Biology Letters, 3*, 599–602. doi:10.1098/rsbl.2007.0399.

Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature, 40*, 351–401. doi:10.1257/002205102320160020161311.

Gifford, E. V., Kohlenberg, B. S., Hayes, S. C., Antonuccio, D. O., Piasecki, M. M., Rasmussen-Hall, M. L., & Palm, K. M. (2004). Acceptance-based treatment for smoking cessation. *Behavior Therapy, 35*, 689–705. doi:10.1016/s0005–7894(04)80015–7.

Gifford, E. V., Kohlenberg, B. S., Hayes, S. C., Pierson, H. M., Piasecki, M. M., Antonuccio, D. O., & Palm, K. M. (2011). Does acceptance and relationship focused behavior therapy contribute to bupropin outcomes? A randomized controlled trial of functional analytic psychotherapy and acceptance and commitment therapy for smoking cessation. *Behavior Therapy, 42*, 700–715.

Gonzalez-Menendez, A., Fernandez, P., Rodriguez, F., & Villagra, P. (2014). Long-term outcomes of Acceptance and Commitment Therapy in drug-dependent female inmates: A randomized controlled trial. *International Journal of Clinical Health & Psychology, 14*, 18–27.

Gossop, M., Stewart, D., Browne, N., & Marsden, J. (2002). Factors associated with abstinence, lapse or relapse to heroin use after residential treatment: protective effect of coping responses. *Addiction, 97*, 1259–1267. doi:10.1046/j.1360–0443.2002.00227.x.

Green, L., Myerson, J., Oliveira, L., & Chang, S. E. (2013). Delay discounting of monetary rewards over a wide range of amounts. *Journal of the Experimental Analysis of Behavior, 100*, 269–281. doi:10.1002/jeab.45.

Grosch, J., & Neuringer, A. (1981). Self-control in pigeons under the Mischel paradigm. *Journal of the Experimental Analysis of Behavior, 35*, 3–21. doi:10.1901/jeab.1981.35–3.

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology, 2*, 271. doi:10.1037/1089–2680.2.3.271.

Harty, S. C., Whaley, J. E., Halperin, J. M., & Ranaldi, R. (2011). Impulsive choice, as measured in a delay discounting paradigm, remains stable after chronic heroin administration. *Pharmacology Biochemistry and Behavior, 98*, 337–340.

Hayes, S. C., Wilson, K., Gifford, E. V., Bissett, R., Piasecki, M. M., Batten, S. V., & Byrd, M. (2004). A Preliminary trial of twelve-step facilitation and acceptance and commitment therapy with polysubstance-abusing methadone-maintained opiate addicts. *Behavior Therapy, 35*, 667–688.

Heil, S. H., Johnson, M. W., Higgins, S. T., & Bickel, W. K. (2006). Delay discounting in currently using and currently abstinent cocaine-dependent outpatients and non-drug-using matched controls. *Addictive Behaviors, 31*, 1290–1294. doi:10.1016/j.addbeh.2005.09.005.

Hendrickson, K. L., & Rasmussen, E. B. (2013). Effects of mindful eating training on delay and probability discounting for food and money in obese and healthy-weight individuals. *Behaviour Research and Therapy, 51*, 399–409. doi:10.1016/j.brat.2013.04.002.

Heron, K. E., & Smyth, J. M. (2010). Ecological momentary interventions: Incorporating mobile technology into psychosocial and health behaviour treatments. *British Journal of Health Psychology, 15*, 1–39. doi:10.1348/135910709×466063.

Heyman, G. M., & Gibb, S. P. (2006). Delay discounting in college cigarette chippers. *Behavioural Pharmacology, 17*, 669–679. doi:10.1097/FBP.0b013e3280116cfe.

Hoffman, W. F., Moore, M., Templin, R., McFarland, B., Hitzemann, R. J., & Mitchell, S. H. (2006). Neuropsychological function and delay discounting in methamphetamine-dependent individuals. *Psychopharmacology, 188*, 162–170. doi:10.1007/s00213–006-0494–0.

Hofmeyr, A., Ainslie, G., Charlton, R., & Ross, D. (2011). The relationship between addiction and reward bundling: An experiment comparing smokers and non-smokers. *Addiction, 106*, 402–409. doi:10.1111/j.1360–0443.2010.03166.x.

Holmes, J. A., & Stevenson, C. A. (1990). Differential effects of avoidant and attentional coping strategies on adaptation to chronic and recent-onset pain. *Health Psychology, 9*, 577–584. doi:10.1037/0278–6133.9.5.577.

Hölzel, B. K., Carmody, J., Vangel, M., Congleton, C., Yerramsetti, S. M., Gard, T., & Lazar, S. W. (2011). Mindfulness practice leads to increases in regional brain gray matter density. *Psychiatry Research, 191*, 36–43. doi:10.1016/j.pscychresns.2010.08.006.

Jiga-Boy, G. M., Storey, K., & Buehner, M. J. (2013). Smokers discount their drug of abuse in the same way as other consumable rewards. *Quarterly Journal of Experimental Psychology, 66*, 1992–2007. doi:10.1080/17470218.2013.772646.

Johnson, M. W. (2012). An efficient operant choice procedure for assessing delay discounting in humans: Initial validation in cocaine-dependent and control individuals. *Experimental and Clinical Psychopharmacology, 20*, 191–204. doi:10.1037/a0027088.

Johnson, M. W., Bickel, W. K., & Baker, F. (2007). Moderate drug use and delay discounting: A comparison of heavy, light, and never smokers. *Experimental and Clinical Psychopharmacology, 15*, 187–194. doi:10.1037/1064–1297.15.2.187.

Joos, L., Goudriaan, A. E., Schmaal, L., De Witte, N. A., Van den Brink, W., Sabbe, B. G., & Dom, G. (2013). The relationship between impulsivity and craving in alcohol dependent patients. *Psychopharmacology, 226*, 273–283. doi:10.1007/s00213–012-2905–8.

Juliano, L. M., Donny, E. C., Houtsmuller, E. J., & Stitzer, M. L. (2006). Experimental evidence for a causal relationship between smoking lapse and relapse. *Journal of Abnormal Psychology, 115*, 166–173. doi:10.1037/0021–843X.115.1.166.

Kabat-Zinn, J. (2005). *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness (15th*

*anniversary ed.)*. New York: Delta Trade Paperback/ Bantam Dell.

Kalivas, P. W., Volkow, N., & Seamans, J. (2005). Unmanageable motivation in addiction: A pathology in prefrontal-accumbens glutamate transmission. *Neuron*, *45*, 647–650. doi:10.1016/j.neuron.2005.02.005.

Kavanagh, D. J., Andrade, J., & May, J. (2005). Imaginary relish and exquisite torture: The elaborated intrusion theory of desire. *Psychological Review*, *112*, 446–467. doi: 10.1037/0033–295X.112.2.446.

Kemps, E., & Tiggemann, M. (2007). Modality-specific imagery reduces cravings for food: An application of the elaborated intrusion theory of desire to food craving. *Journal of Experimental Psychology: Applied*, *13*, 95–104. doi: 10.1037/1076–898X.13.2.95.

Kemps, E., & Tiggemann, M. (2009). Competing visual and olfactory imagery tasks suppress craving for coffee. *Experimental and Clinical Psychopharmacology*, *17*, 43–50. doi:10.1037/a0014962.

Kemps, E., Tiggemann, M., Woods, D., & Soekov, B. (2004). Reduction of food cravings through concurrent visuospatial processing. *International Journal of Eating Disorders*, *36*, 31–40. doi:10.1002/eat.20005.

Khurana, A., Romer, D., Betancourt, L. M., Brodsky, N. L., Giannetta, J. M., & Hurt, H. (2013). Working memory ability predicts trajectories of early alcohol use in adolescents: The mediational role of impulsivity. *Addiction*, *108*, 506–515. doi:10.1111/add.12001.

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *Journal of Experimental Psychology: General*, *128*, 78–87. doi:10.1037/0096–3445.128.1.78.

Koffarnus, M. N., & Bickel, W. K. (2014). A 5-trial adjusting delay discounting task: Accurate discount rates in less than one minute. *Experimental and Clinical Psychopharmacology*, *22*, 222–228. doi:10.1037/a0035973.

Koffarnus, M. N., Jarmolowicz, D. P., Mueller, E. T., & Bickel, W. K. (2013). Changing delay discounting in the light of the competing neurobehavioral decision systems theory: A review. *Journal of the Experimental Analysis of Behavior*, *99*, 32–57. doi:10.1002/jeab.2.

Kross, E., & Ayduk, O. (2008). Facilitating adaptive emotional analysis: Distinguishing distanced-analysis of depressive experiences from immersed-analysis and distraction. *Personality and Social Psychology Bulletin*, *34*, 924–938. doi:10.1177/0146167208315938.

Lau, M. A., & Yu, A. R. (2009). New developments in research on mindfulness-based treatments: Introduction to the special issue. *Journal of Cognitive Psychotherapy*, *23*, 179–184. doi:10.1891/0889–8391.23.3.179.

Loewenstein, G. (1996). Out of control: Visceral influences on behavior. *Organizational Behavior and Human Decision Processes*, *65*, 272–292. doi:10.1006/Obhd.1996.0028.

Luoma, J. B., Kohlenberg, B. S., Hayes, S. C., & Fletcher, L. (2012). Slow and steady wins the race: A randomized clinical trial of acceptance and commitment therapy targeting shame in substance use disorders. *Journal of Counseling and Clinical Psychology*, *80*, 43.

MacKillop, J., Amlung, M. T., Few, L. R., Ray, L. A., Sweet, L. H., & Munafo, M. R. (2011). Delayed reward discounting and addictive behavior: A meta-analysis. *Psychopharmacology*, *216*, 305–321. doi:10.1007/s00213–011-2229–0.

MacKillop, J., Miranda, R., Jr., Monti, P. M., Ray, L. A., Murphy, J. G., Rohsenow, D. J., & Gwaltney, C. J. (2010). Alcohol demand, delayed reward discounting, and craving in relation to drinking and alcohol use disorders. *Journal of Abnormal Psychology*, *119*, 106–114. doi:10.1037/a0017513.

Marlatt, G. A. (2000). Foreward. In W. K. Bickel & R. E. Vuchinich (Eds.), *Reframing health behavior change with behavioral economics (p. xviii)*. Mahwah, NJ: Lawrence Erlbaum.

Marlatt, G. A. (2002). Buddhist philosophy and the treatment of addictive behavior. *Cognitive and Behavioral Practice*, *9*, 44–49. doi:10.1016/S1077–7229(02) 80039–6.

May, J., Andrade, J., Panabokke, N., & Kavanagh, D. (2010). Visuospatial tasks suppress craving for cigarettes. *Behaviour Research and Therapy*, *48*, 476–485. doi:10.1016/j.brat.2010.02.001.

May, J., Andrade, J., Willoughby, K., & Brown, C. (2012). An attentional control task reduces intrusive thoughts about smoking. *Nicotine & Tobacco Research*, *14*, 472–478. doi:10.1093/ntr/ntr238.

May, J., Kavanagh, D. J., & Andrade, J. (2014). The Elaborated Intrusion Theory of desire: A 10-year retrospective and implications for addiction treatments. *Addictive Behaviors*. doi:10.1016/j.addbeh.2014.09.016.

McHugh, R. K., Hearon, B. A., & Otto, M. W. (2010). Cognitive behavioral therapy for substance use disorders. *Psychiatric Clinics of North America*, *33*, 511–525. doi:10.1016/j.psc.2010.04.012.

Mendez, I. A., Simon, N. W., Hart, N., Mitchell, M. R., Nation, J. R., Wellman, P. J., & Setlow, B. (2010). Self-administered cocaine causes long-lasting increases in impulsive choice in a delay discounting task. *Behavioral Neuroscience*, *124*, 470–477. doi:10.1037/a0020458.

Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: Dynamics of willpower. *Psychological Review*, *106*, 3–19. doi:10.1037/0033–295X.106.1.3.

Mischel, W., & Ebbesen, E. B. (1970). Attention in delay of gratification. *Journal of Personality and Social Psychology*, *16*, 329. doi:10.1037/H0029815.

Mischel, W., Ebbesen, E. B., & Zeiss, A. R. (1972). Cognitive and attentional mechanisms in delay of gratification. *Journal of Personality and Social Psychology*, *21*, 204–218. doi:10.1037/h0032198.

Mitchell, J. M., Fields, H. L., D'Esposito, M., & Boettiger, C. A. (2005). Impulsive responding in alcoholics. *Alcoholism: Clinical and Experimental Research*, *29*, 2158–2169. doi:10.1097/01.alc.0000191755.63639.4a.

Mitchell, S. H. (1999). Measures of impulsivity in cigarette smokers and non-smokers. *Psychopharmacology*, *146*, 455–464. doi:10.1007/PL00005491.

Monterosso, J. R., Ainslie, G., Xu, J., Cordova, X., Domier, C. P., & London, E. D. (2007). Frontoparietal cortical activity of methamphetamine-dependent and comparison subject performing a delay discounting task. *Human Brain Mapping*, *28*, 383–393. doi:10.1002/hbm.20281.

Morrison, K. L., Madden, G. J., Odum, A. L., Friedel, J. E., & Twohig, M. P. (2014). Altering impulsive decision making with an acceptance-based procedure. *Behavior Therapy*, *45*, 630–639. doi:10.1016/j.beth.2014.01.001.

Mullen, B., & Suls, J. (1982). The effectiveness of attention and rejection as coping styles: A meta-analysis of temporal differences. *Journal of Psychosomatic Research*, *26*, 43–49. doi:10.1016/0022–3999(82)90061–7.

Murphy, C., & MacKillop, J. (2012). Living in the here and now: Interrelationships between impulsivity, mindfulness, and alcohol misuse. *Psychopharmacology, 219*, 527–536. doi:10.1007/s00213–011-2573–0.

Murphy, C. M., & MacKillop, J. (2014). Mindfulness as a strategy for coping with cue-elicited cravings for alcohol: An experimental examination. *Alcoholism: Clinical and Experimental Research, 38*, 1134–1142. doi:10.1111/acer.12322.

Murphy, J. G., Correia, C. J., Colby, S. M., & Vuchinich, R. E. (2005). Using behavioral theories of choice to predict drinking outcomes following a brief intervention. *Experimental and Clinical Psychopharmacology, 13*, 93–101. doi:10.1037/1064–1297.13.2.93.

Murphy, J. G., Dennhardt, A. A., Skidmore, J. R., Borsari, B., Barnett, N. P., Colby, S. M., & Martens, M. P. (2012). A randomized controlled trial of a behavioral economic supplement to brief motivational interventions for college drinking. *Journal of Consulting and Clinical Psychology, 80*, 876–886. doi:10.1037/a0028763.

Newman, M. G., Szkodny, L. E., Llera, S. J., & Przeworski, A. (2011). A review of technology-assisted self-help and minimal contact therapies for drug and alcohol abuse and smoking addiction: Is human contact necessary for therapeutic efficacy. *Clinical Psychology Review, 31*, 178–186. doi:10.1016/j.cpr.2010.10.002.

Ochoa, C., Álvarez-Moya, E. M., Penelo, E., Aymami, M. N., Gómez-Peña, M., Fernández-Aranda, F.,...Jiménez-Murcia, S. (2013). Decision-making deficits in pathological gambling: The role of executive functions, explicit knowledge and impulsivity in relation to decisions made under ambiguity and risk. *American Journal on Addictions, 22*, 492–499. doi:10.1111/j.1521–0391.2013.12061.x.

Odum, A. L. (2011a). Delay discounting: I'm a k, you're a k. *Journal of the Experimental Analysis of Behavior, 96*, 427–439. doi:10.1901/jeab.2011.96–423.

Odum, A. L. (2011b). Delay discounting: Trait variable. *Behavioural Processes, 87*, 1–9. doi:10.1016/j.beproc.2011.02.007.

Odum, A. L., & Baumann, A. A. L., (2010). Delay discounting: State and trait variable. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting* (pp 39–65). Washington, DC: American Psychological Association. doi:10.1037/12069–002.

Paul, S., Simon, D., Kniesche, R., Kathmann, N., & Endrass, T. (2013). Timing effects of antecedent- and response-focused emotion regulation strategies. *Biological Psychology, 94*, 136–142. doi:10.1016/j.biopsycho.2013.05.019.

Perry, J. L., Larson, E. B., German, J. P., Madden, G. J., & Carroll, M. E. (2005). Impulsivity (delay discounting) as a predictor of acquisition of IV cocaine self-administration in female rats. *Psychopharmacology, 178*, 193–201. doi:10.1007/s00213–004-1994-4.

Perry, J. L., Nelson, S. E., & Carroll, M. E. (2008). Impulsive choice as a predictor of acquisition of IV cocaine self-administration and reinstatement of cocaine-seeking behavior in male and female rats. *Experimental and Clinical Psychopharmacology, 16*, 165–177. doi:10.1037/1064–1297.16.2.165.

Peters, J., & Büchel, C. (2011). The neural mechanisms of inter-temporal decision-making: Understanding variability. *Trends in Cognitive Sciences, 15*, 227–239. doi:10.1016/j.tics.2011.03.002.

Petersen, C., & Zettle, R. D. (2009). Treating inpatients with comorbid depression and alcohol use disorders: A comparison of acceptance and commitment therapy versus treatment as usual. *The Psychological Record, 59*, 521–536.

Peysakhovich, A. (2014). How to commit (if you must): Commitment contracts and the dual-self model. *Journal of Economic Behavior & Organization, 101*, 100–112. doi:10.1016/j.jebo.2014.02.003.

Rachlin, H., Raineri, A., & Cross, D. (1991). Subjective probability and delay. *Journal of the Experimental Analysis of Behavior, 55*, 233–244. doi:10.1901/jeab.1991.55–233.

Read, D., Loewenstein, G., & Rabin, M. (1999). Choice bracketing. *Journal of Risk and Uncertainty, 19*, 171–197. doi:10.1023/A.

Renda, C. R., Stein, J. S., & Madden, G. J. (2015). Working-memory training: Effects on delay discounting in male Long Evans rats. *Journal of the Experimental Analysis of Behavior, 103*, [N.B. typesetters: insert page numbers from current issue].

Rodriguez, M. L., Mischel, W., & Shoda, Y. (1989). Cognitive person variables in the delay of gratification of older children at risk. *Journal of Personality and Social Psychology, 57*, 358–367. doi:10.1037/0022–3514.57.2.358.

Sayette, M. A., Griffin, K. M., Vohs, K. D. & Baumeister, R. F. (2011). Self-regulatory failure and addiction. In *Handbook of self-regulation: Research, theory, and applications* (2nd ed., pp. 505–521). New York: Guilford Press.

Sayette, M. A., Martin, C. S., Wertz, J. M., Shiffman, S., & Perrott, M. A. (2001). A multi-dimensional analysis of cue-elicited craving in heavy smokers and tobacco chippers. *Addiction, 96*, 1419–1432. doi:10.1080/09652140120075152.

Schonfelder, S., Kanske, P., Heissler, J., & Wessa, M. (2013). Time course of emotion-related responding during distraction and reappraisal. *Social Cognitive and Affective Neuroscience, 9*, 1310–1319. doi:10.1093/scan/nst116.

Shadel, W. G., Martino, S. C., Setodji, C., Cervone, D., Witkiewitz, K., Beckjord, E. B., & Shih, R. (2011). Lapse-induced surges in craving influence relapse in adult smokers: An experimental investigation. *Health Psychology, 30*, 588–596. doi:10.1037/a0023445.

Sheffer, C., MacKillop, J., McGeary, J., Landes, R., Carter, L., Yi, R., & Bickel, W. (2012). Delay discounting, locus of control, and cognitive impulsiveness independently predict tobacco dependence treatment outcomes in a highly dependent, lower socioeconomic group of smokers. *American Journal on Addictions, 21*, 221–232. doi:10.1111/j.1521–0391.2012.00224.x.

Sheppes, G., Catran, E., & Meiran, N. (2009). Reappraisal (but not distraction) is going to make you sweat: Physiological evidence for self-control effort. *International Journal of Psychophysiology, 71*, 91–96. doi:10.1016/j.ijpsycho.2008.06.006.

Sheppes, G., & Gross, J. J. (2011). Is timing everything? Temporal considerations in emotion regulation. *Personality and Social Psychology Review, 15*, 319–331. doi:10.1177/1088868310395778.

Sheppes, G., Scheibe, S., Suri, G., & Gross, J. J. (2011). Emotion-regulation choice. *Psychological Science, 22*, 1391–1396. doi:10.1177/0956797611418350.

Shiffman, S. (1982). Relapse following smoking cessation: A situational analysis. *Journal of Consulting and Clinical Psychology, 50*, 71–86. doi:10.1037/0022–006X.50.1.71.

Shiffman, S. (1984). Coping with temptations to smoke. *Journal of Consulting and Clinical Psychology*, *52*, 261–267. doi:10.1037/0022–006X.52.2.261.

Shorey, R. C., Brasfield, H., Anderson, S., & Stuart, G. L. (2013). Mindfulness deficits in a sample of substance abuse treatment seeking adults: A descriptive investigation. *Journal of Substance Use*, *19*, 194–198. doi:10.3109/14659891.2013.770570.

Skinner, E. A., Edge, K., Altman, J., & Sherwood, H. (2003). Searching for the structure of coping: A review and critique of category systems for classifying ways of coping. *Psychological Bulletin*, *129*, 216–269. doi:10.1037/0033–2909.129.2.216.

Skorka-Brown, J., Andrade, J., & May, J. (2014). Playing 'Tetris' reduces the strength, frequency and vividness of naturally occurring cravings. *Appetite*, *76*, 161–165. doi:10.1016/j.appet.2014.01.073.

Smout, M., Longo, M., Harrison, S., Minniti, R., Wickes, W., & White, J. (2010). Psychosocial treatment for methamphetamine substance use disorders: A preliminary randomized controlled trial for cognitive behavioral therapy and acceptance and commitment therapy. *Substance Abuse*, *31*, 98–107.

Stanger, C., Ryan, S. R., Fu, H., Landes, R. D., Jones, B. A., Bickel, W. K., & Budney, A. J. (2012). Delay discounting predicts adolescent substance abuse treatment outcome. *Experimental and Clinical Psychopharmacology*, *20*, 205–212. doi:10.1037/a0026543.

Stein, J. S., Johnson, P. S., Smits, R. R., Renda, C. R., Liston, K. J., Shahan, T. S., & Madden, G. J. (2013). Early and prolonged exposure to reward delay: Effect on impulsive choice and alcohol self-administration in male rats. *Experimental and Clinical Psychopharmacology*, *21*, 172–180.

Stein, J. S., Madden, G. J., MacKillop, J. & De Wit, H. (2013). Delay discounting and drug abuse: Empirical, conceptual, and methodological considerations. In J. MacKillop & H. De Wit (Eds.), *The Wiley-Blackwell Handbook of Addiction Psychopharmacology* (pp 165–208). Oxford, UK: Wiley-Blackwell.

Stein, J. S., Renda, C. R., Hinnenkamp, J., & Madden, G. J. (2015). Impulsive choice, alcohol consumption, and pre-exposure to delayed rewards II: Potential mechanisms. *Journal of the Experimental Analysis of Behavior*, *103*, [N.B. typesetters insert page numbers, current issue].

Stevens, L., Verdejo-García, A., Goudriaan, A. E., Roeyers, H., Dom, G., & Vanderplasschen, W. (2014). Impulsivity as a vulnerability factor for poor addiction treatment outcomes: A review of neurocognitive findings among individuals with substance use disorders. *Journal of Substance Abuse Treatment*, *47*, 58–72. doi:10.1016/j.jsat.2014.01.008.

Stotts, A. L., Green, C., Masuda, A., Grabowski, J., Wilson, K., Northrup, T. F., & Schmitz, J. M. (2012). A Stage I pilot study of acceptance and commitment therapy for methadone detoxification. *Drug and Alcohol Dependence*, *125*, 215–222.

Thiruchselvam, R., Blechert, J., Sheppes, G., Rydstrom, A., & Gross, J. J. (2011). The temporal dynamics of emotion regulation: An EEG study of distraction and reappraisal. *Biological Psychology*, *87*, 84–92. doi:10.1016/j.biopsycho.2011.02.009.

Ussher, M., Cropley, M., Playle, S., Mohidin, R., & West, R. (2009). Effect of isometric exercise and body scanning on cigarette cravings and withdrawal symptoms. *Addiction*, *104*, 1251–1257. doi:10.1111/j.1360–0443.2009.02605.x.

Van Dillen, L. F., Papies, E. K., & Hofmann, W. (2013). Turning a blind eye to temptation: How cognitive load can facilitate self-regulation. *Journal of Personality and Social Psychology*, *104*, 427–443. doi:10.1037/a0031262.

Vuchinich, R. E., & Simpson, C. A. (1998). Hyperbolic temporal discounting in social drinkers and problem drinkers. *Experimental and Clinical Psychopharmacology*, *6*, 292–305. doi:10.1037/1064–1297.6.3.292.

Walker, R., & Stephens, R. S. (2014). Protective behavioral strategies mediate problem-focused coping and alcohol use in college students. *Addictive Behaviors*, *39*, 1033–1037. doi:10.1016/j.addbeh.2014.02.006.

Weafer, J., Mitchell, S. H., & de Wit, H. (2014). Recent translational findings on impulsivity in relation to drug abuse. *Current Addiction Reports*, *1*, 289–300. doi:10.1007/s40429–014-0035–6.

Wilson, S. J., & Sayette, M. A. Neuroimaging craving: Urge intensity matters. *Addiction* (in press). doi:10.1111/add.12676.

Witkiewitz, K., & Bowen, S. (2010). Depression, craving, and substance use following a randomized trial of mindfulness-based relapse prevention. *Journal of Consulting and Clinical Psychology*, *78*, 362–374. doi:10.1037/a0019172.

Witkiewitz, K., Bowen, S., Harrop, E. N., Douglas, H., Enkema, M., & Sedgwick, C. (2014). Mindfulness-based treatment to prevent addictive behavior relapse: Theoretical models and hypothesized mechanisms of change. *Substance Use & Misuse*, *49*, 513–524. doi:10.3109/10826084.2014.891845.

Witkiewitz, K., Lustyk, M. K. B., & Bowen, S. (2013). Retraining the addicted brain: A review of hypothesized neurobiological mechanisms of mindfulness-based relapse prevention. *Psychology of Addictive Behaviors*, *27*, 351–365. doi:10.1037/a0029258.

Zgierska, A., Rabago, D., Chawla, N., Kushner, K., Koehler, R., & Marlatt, A. (2009). Mindfulness meditation for substance use disorders: A systematic review. *Substance Abuse*, *30*, 266–294. doi:10.1080/08897070903250019.

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