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# Self-Regulation Without Force: Can Awareness Leverage Reward to Drive Behavior Change?

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**Abstract**

To reach longer-term goals and live aligned with their values, people typically must regulate their behavior. Effortful self-control is one way to achieve this and is usually framed as a forceful struggle between lower-level impulses and higher-level cognitive control processes. For example, people may restrain themselves from eating cake in order to lose weight. An alternative avenue of self-regulation draws on autonomous motivation: Individuals eat healthfully because it is values-congruent or intrinsically satisfying. Recent advances in the understanding of reward valuation on a neural level (e.g., ventromedial prefrontal cortex/orbitofrontal cortex) and emerging treatments on a clinical level (e.g., mindfulness training) suggest a possible mechanistic convergence between brain and behavior that is consistent with a shift from forced to unforced behavior change. Here we propose how an overlooked aspect of reinforcement learning can be leveraged using a simple yet critical feature of experience that is not reliant on willpower: Bringing awareness to one's subjective experience and behavior can produce a change in valuation of learned but unhealthy behaviors, leading to self-regulatory shifts that result in sustainable behavior change without force.

**Keywords**

self-regulation, self-control, operant conditioning, behavior change, self-determination theory, mindfulness

The ability to regulate behavior in line with one's long-term goals and values is crucial to mental and physical health (Casey et al., 2011; Duckworth & Gross, 2014; Eskreis-Winkler, Duckworth, Shulman, & Beal, 2014; Hofmann, Kotabe, & Luhmann, 2013; Robertson-Kraft & Duckworth, 2014; Tangney, Baumeister, & Boone, 2004), yet many people struggle with it (American Psychological Association, or APA, 2012). Common targets of behavior regulation, such as diet and exercise, can alter diabetes risk and longevity (Chen et al., 2015; Dempsey, Owen, Yates, Kingwell, & Dunstan, 2016; Ekelund et al., 2016), and reducing smoking and excessive drinking can benefit multiple psychosocial and physical outcomes (Jha et al., 2013; Rehm et al., 2017). However, many people have difficulties with and often fail at behavior change despite using well-known self-control strategies (Aamodt, 2016; APA, 2012). In addition, willpower—or effortful self-control—has recently been challenged as a driver behind behavior change (Hofmann, Baumeister, Förster, & Vohs, 2012; Milyavskaya & Inzlicht, 2017). In this article, we suggest that an alternate approach, one that conjoins theory and research on autonomous motivation, mindfulness, and reinforcement learning, may lead to more sustainable behavior change. This approach can be applied to all possible domains of self-regulation (e.g., productivity at work, emotion regulation during social interactions, regulation of sexual behaviors), although we use health behaviors as the main examples throughout the article.

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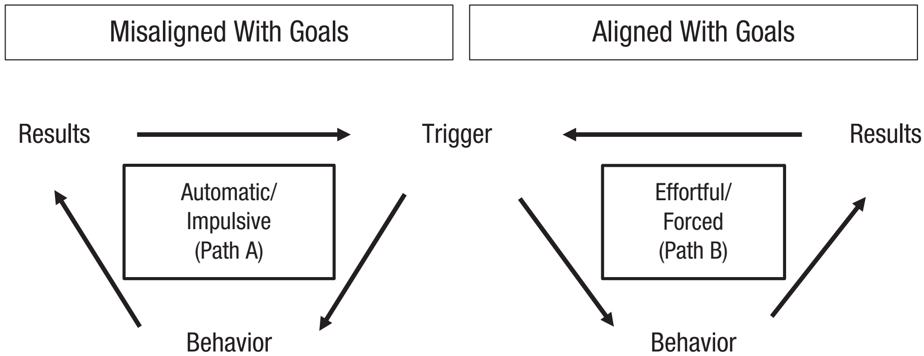


**Fig.1.** Reinforcement learning model of habit formation and change. A trigger (e.g., stress) cues a habitual behavior (e.g., eat cake) that results in hedonic reward (pleasure and stress relief) or hedonic punishment (dissatisfaction with longer-term goal progress; Path A). To carry out a goal-congruent behavior instead, the same trigger cues an effortful behavior (e.g., eat fruit) that results in hedonic reward (satisfaction with goal alignment) and concomitant punishment (unpleasant feeling of effort; Path B).

## From Effortful Self-Control to Autonomous Behavior Change

As far back as the early 1900s, it was suggested that actions that lead to reward are more likely to be repeated (Thorndike's "law of effect"; Thorndike, 1911). Self-regulation is difficult because habits that contradict our long-term goals are often strongly formed through this type of reinforcement learning. A reinforcement learning "habit loop" consists of three basic elements: trigger, behavior, and result (Fig. 1, left, Path A; Brewer, 2019; Brewer et al., 2018; Skinner, 1963). When an action is reinforced by a pleasant result or avoidance of an unpleasant result, the brain encodes a memory of the action and the circumstances under which it occurred; the behavior is learned (Brewer, 2018). In the future, these circumstances become a trigger to repeat the same, previously rewarded action even though the behavior may be misaligned with long-term goals or values. For example, if a person eats cake (behavior) while stressed (trigger), resulting in hedonic reward (pleasure and stress relief), eating cake when stressed is reinforced (Brewer, 2019; Brewer et al., 2018). The next time stress is experienced, the person more likely to repeat the same behavior, forming a habit over time.

### *Willpower-based and strategic approaches to self-regulation*

Attempting to overcome unwanted habit loops by effortful self-control can feel aversive and often fails. Effortful self-control or "willpower" is often framed as a forceful inner struggle between higher-level cognitive control processes and lower-level automatic or habitual tendencies that results in a new behavior if successful (Fig. 1, right, Path B; Hofmann, Friese, & Wiers, 2008; McClure, York, & Montague, 2004). For example, to avoid dietary sugar, people may forcefully restrain themselves from eating tempting but high-calorie "comfort food." This has the benefit of being goal-congruent and therefore rewarding. However, restraint and effortful self-control can feel aversive and are cognitively costly (see Kool & Botvinick, 2013; Kool, McGuire, Wang, & Botvinick, 2013). Furthermore, the use or overuse of such strategies has been associated with poor psychological health (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Appleton & McGowan, 2006; McFarlane, Polivy, & McCabe, 1999), breakdown under stress or strong emotions (Schotte, Cools, & McNally, 1990), and disruption of the natural regulation of body functions such as appetite (Schlinkert & Koole, 2018).

Other self-regulation strategies exist (Duckworth, Milkman, & Laibson, 2018; Gross, 2015; Ochsner & Gross, 2005; Oettingen & Gollwitzer, 2010) but have limitations as well. For example, avoiding triggers for habitual behavior can be effective (Duckworth, Gendler, & Gross, 2016; Wansink, 1996) but can still feel effortful, may feel limiting, and constrain behavior in undesired ways (e.g., avoiding certain social gatherings one would have liked to attend). Moreover, with these self-regulation strategies in play, the habit loop still exists; latent habits (e.g., emotional eating) are poised to reemerge later, under the influence of stress, for example. Other self-control approaches include rewarding oneself for "good" behavior (e.g., going out only after studying hard) and imposing punishments for "bad" behavior (Trope & Fishbach, 2000). Although this may seem motivating, the behavior itself may still feel like a struggle given that it merely serves as a means to an end and may possibly lead to effective regulation only as long as the extrinsic reinforcement contingencies are in place.

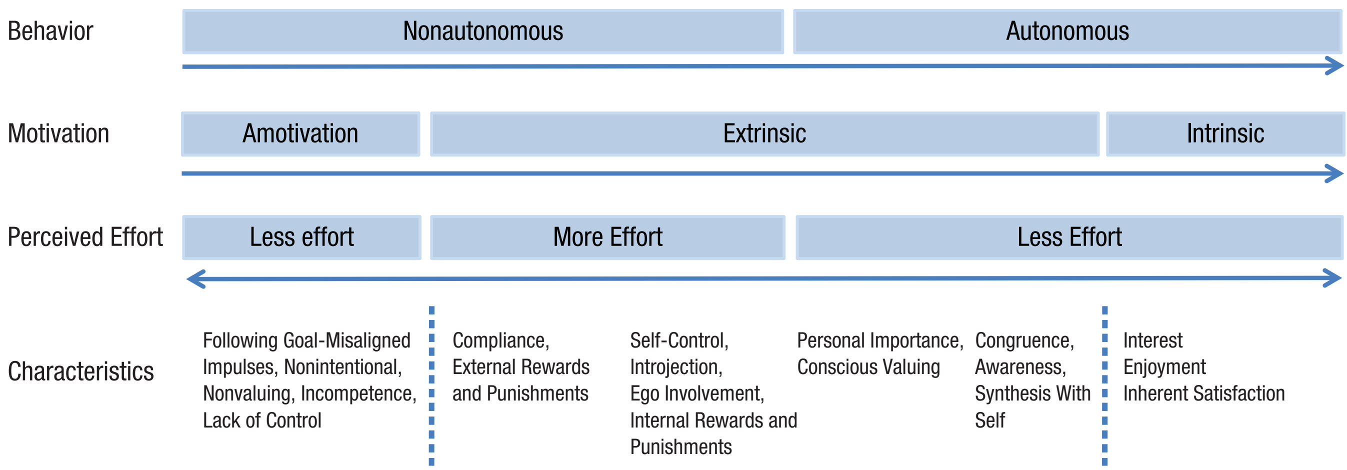


**Fig. 2.** Characteristics of different modes of self-regulation. Autonomy increases from left to right. Derived and adapted from self-determination theory (SDT; Ryan & Deci, 2000).

## *Autonomous self-regulation as an alternative strategy*

Theoretically, a more sustainable solution may involve being motivated to act in a goal-congruent way such that an inner struggle or avoidance of triggers would not be necessary (referred to as Path C in this article). This is termed *autonomous self-regulation* in self-determination theory (SDT; Deci & Ryan, 1985; Ryan & Deci, 2000, 2017). Autonomy means acting in line with "self-endorsed values, needs, and intentions rather than in response to controlling forces external to the self, whether these forces are within the individual (e.g., drives or ego involvements) or from outside (e.g., social pressure)" (Ryan, Kuhl, & Deci, 1997, p. 702). For example, people may autonomously choose to study, exercise, or eat healthy food because they find such activities valuable, inherently interesting, enjoyable, or satisfying rather than because they feel that they "have to" perform them. The same may apply to social behaviors such as donating money to people in need or being honest with others instead of deceiving them. Thus, for autonomous behavior, there is less conflict between longer-term goals and impulses or habits. Rather, one's impulses are aligned with one's goals and values and thus help drive behavior in a desired direction. For example, a desire for fresh salad motivates healthy eating, or an impulse for curious exploration motivates studying (see Di Domenico & Ryan, 2017). Although cognitive-control processes are still needed during autonomous behavior (e.g., to direct attention), there is less need for effortful control (see Ryan et al., 1997).

Autonomy can apply to the level of action implementation as well as to the level of goal selection (Deci & Ryan, 2000). That is, the same behavior (e.g., going for a run) can be carried out more or less autonomously (e.g., valuing and therefore choosing it vs. doing it because others admire it). However, increasing autonomy may also lead individuals to choose different goals altogether—those that turn out to be more authentic to them (e.g., yoga rather than running, striving for health rather than good looks; see Ryan, Sheldon, Kasser, & Deci, 1996).

Autonomous self-regulation predicts better task performance, creativity, and persistence; higher levels of vitality ("the positive feeling of having energy available to the self," Nix, Ryan, Manly, & Deci, 1999, p. 266); and both hedonic and eudaimonic well-being, among other positive outcomes (Amabile, 1996; Czikszentmihalyi, 1990; Deci & Ryan, 2000; Ryan & Deci, 2017). Autonomous action is also perceived as being less effortful (Nix et al., 1999), or at least the effort involved in such activities is experienced differently: It is enjoyed rather than experienced as an inner struggle (Waterman, 2005). Autonomously motivated behavior change has proven more successful than willpower-based efforts in realms of weight loss, exercise, and smoking cessation, among others (for a review, see Ryan & Deci, 2017), which lends support to sustainability.

SDT proposes that autonomy is not an all-or-nothing phenomenon but that actions range on a continuum from nonautonomous to autonomous (Fig. 2; Deci & Ryan, 1985; Di Domenico & Ryan, 2017; Ryan & Deci, 2000, 2017). According to SDT, acting on impulses misaligned with a person's goals is related to a low sense of autonomy (Fig. 2, left side) because in such cases, the person appears to be under the control of inner coercions (e.g., Wiers et al., 2014). Furthermore, when a person regulates impulses on the basis of extrinsic motivation (Fig. 2, middle), there is little autonomy;

even though behavior is self-controlled, it is perceived to originate from a source outside of the person's "true" self (e.g., derived from relatively rigid, internalized rules, such as "I have to eat healthily" rather than from a sense of free choice; Ryan et al., 1997). As shown in Figure 2, extrinsic motivation itself comes in degrees, ranging from completely extrinsic (e.g., avoiding external punishment) to intermediate (e.g., avoiding self-induced guilt based on what we have learned from others) to least extrinsic and autonomous (e.g., voluntarily adhering to values from society that one has accepted as valid; Ryan & Deci, 2000; Ryan et al., 1997). Finally, SDT claims that individuals experience most autonomy when they are completely intrinsically motivated—acting based on interest, enjoyment, or inherent satisfaction (Fig. 2, right side).

In SDT, effortful self-control corresponds to one category within extrinsically motivated behaviors (see Fig. 2, bold) because it is assumed that it is based on norms, rules, or ideas that originally were extrinsic to the agent and that have not yet been internalized (e.g., thinking one "has to" exercise because one learned this ideal from others/society, resulting in guilt or anxiety if one does not engage in this; for details on the different categories, see Ryan & Deci, 2000; Ryan et al., 1997).

How, then, can individuals move beyond effortful self-control and become autonomously self-regulated? Although scholars have considered various social and organizational factors that can support autonomous motivation (e.g., Deci & Ryan, 2000; Kusurkar & Croiset, 2015), much less is known about how individuals themselves can produce a shift from nonautonomous, extrinsically motivated, and effortfully controlled self-regulation to autonomous, intrinsically motivated, and less effortful self-regulation. In this article, we propose that key to this shift is present-moment awareness—being conscious or cognizant of internal and external stimuli as they occur.

Here we present a model that brings together theories of how habitual behavior is formed (i.e., reinforcement learning) with how SDT specifies that autonomous behavior can be fostered; we propose that applying present-moment awareness during automatic, habitual, or extrinsically controlled behaviors is sufficient for inducing more autonomous, less effortful self-regulation (i.e., movement to the right on the continuum in Fig. 2). Moreover, we specify the points in the behavioral pathways in which awareness can drive such behavior change. We extend traditional reinforcement-learning approaches, which focus on external rewards and punishments, to include internal, subjective processes (e.g., awareness of the affective experience of carrying out a specific activity). This addresses a criticism of traditional reinforcement-learning approaches (i.e., that they do not typically take into account the internal states, needs, and goals of agents; Juechems & Summerfield, 2019).

## A Mechanistic Model for Self-Regulation Through Awareness

### *The role of awareness in previous theories of self-regulation*

A number of influential theories of behavior regulation place central emphasis on awareness of stimuli, subjective experience, and behavior as they occur (Carver & Scheier, 1981; Deci & Ryan, 1985; Varela, Thompson, & Rosch, 1991). These perspectives agree that the power of present-centered awareness lies in bringing information into consciousness that is necessary for "healthy" self-regulation to occur—self-regulation that is aligned with health and well-being. The more fully an individual is apprised of what is occurring internally and in the environment, the more adaptive and value-consistent the individual's behavior is likely to be (Brown & Ryan, 2015).

As a monitoring function, awareness creates a mental "gap" between the perceiver, the contents of consciousness (thoughts, emotions, urges, etc.), and one's behavior that can attenuate or override habitual reactions. In other words, without awareness, thoughts, emotions, and impulses might be immediately linked with action tendencies that unfold automatically (e.g., shouting when angry). With awareness, however, an individual can detach from these processes, recognize and observe them, and then make a choice as to how to act in a given situation (e.g., choosing to react in a calm, confident manner rather than shouting). Early studies in the field of addiction showed that mindfulness training—which promotes a nonjudgmental present-centered awareness (Bishop et al., 2004; Kabat-Zinn, 2003)—can promote behavior change by capitalizing on this mental gap (Brewer et al., 2009; for reviews, see Cavicchioli, Movalli, & Maffei, 2018; Chiesa & Serretti, 2014). At its core, as mentioned above, mindfulness concerns awareness of present-moment experience and is commonly fostered in training programs by encouraging an attitude of curiosity and acceptance (or nonjudgment) of what is presently occurring (Bishop et al., 2004; Kabat-Zinn, 2003), and such interventions have been shown to successfully induce behavior change in different domains (Bowen et al., 2006; Bowen et al., 2014; Brewer, Elwafi, & Davis, 2013; Brewer et al., 2011; Brewer et al., 2018; Katterman, Kleinman, Hood, Nackers, & Corsica, 2014; Loucks et al., 2015). For example, Elwafi, Witkiewitz, Mallik, Thornhill, and Brewer (2013) found that mindfulness training fostered a decoupling of the link between craving and smoking, leading to a five-fold greater quit rate than cognitive therapy. Mason, Jhaveri, Cohn, and Brewer (2018) found a similar decoupling of craving and eating in overweight and obese women; they demonstrated a 40% reduction in craving-related eating after undergoing smartphone-app-based mindfulness training.

Critically, we propose that in addition to the mechanism of a "mental gap," behavior change through awareness may be mediated by a more accurate assessment of the reward value of specific actions—because reward value is what drives future behavior (described in detail in the next section). Anecdotally, we have observed that simply bringing awareness to the actual experience of habitual behavior can significantly affect the subjective reward value of a behavior and foster behavior change. For example, when individuals paid attention to their moment-to-moment experience while smoking cigarettes, they noticed the unpleasant taste and smell that had previously been outside of awareness (Brewer, 2018; Brewer & Pbert, 2015). These and other findings suggest that mindfulness directly targets core links in the reinforcement process (Brewer et al., 2013). Does this point to a missing explanatory link that brings together principles of reinforcement learning and autonomous behavior change?

## *Reward value and its neural correlates*

The core principle of reinforcement learning is that the acquisition and sustenance of habitual behavior depends on its reward value (Brewer, 2018, 2019; Skinner, 1963). For example, if browsing through social media during work hours is experienced as rewarding, individuals will continue doing so (see Meshi, Tamir, & Heekeren, 2015). As corollary principles, the stability of a behavior depends on whether its reward value changes over time (e.g., whether excessive social-media use becomes less interesting) and whether other behaviors become accessible that are more rewarding (e.g., realizing that making progress on a project is more rewarding than engaging with social media).

Of relevance to deriving testable hypotheses based on our model, here we briefly describe what is known about the neural correlates of reward value. Value is processed in a network of brain regions, including most prominently: the ventromedial prefrontal cortex (vmPFC)/orbitofrontal cortex (OFC), the ventral striatum, and parts of the posterior cingulate cortex (Fig. 3a; Bartra, McGuire, & Kable, 2013; Clithero & Rangel, 2014; Levy & Glimcher, 2012; see also Padoa-Schioppa & Conen, 2017). Activity in the vmPFC/OFC in particular has been shown to correlate with the reward value of different behavioral options (e.g., different types of food), thereby driving decision-making about those options (Chib, Rangel, Shimojo, & O'Doherty, 2009; Hare, Camerer, & Rangel, 2009; Ludwig et al., 2014; Peters & Büchel, 2010; Plassmann, O'Doherty, & Rangel, 2007).

The reward value is a composite of many different factors. For eating specific types of food, these factors could include taste (Rolls, 2015), current level of hunger (Siep et al., 2009), number of calories (Frank et al., 2010), and so on. These factors are thought to be integrated into an overall, composite reward value in the vmPFC/OFC (Lim, O'Doherty, & Rangel, 2013). Furthermore, reward value is thought to be updated by learning (Fig. 3b; Rangel, Camerer, & Montague, 2008). For example, when eating a certain type of chocolate (e.g., milk chocolate), vmPFC/OFC encodes the reward value of the experience. If, on another occasion, someone eats another type of chocolate (e.g., dark chocolate) and enjoys this more, this region will encode its higher reward value. This learning and accompanying memory storage, which also involves other regions of the reward network, directly informs future behavior.

The reward value of a behavior might depend not only on external rewards or punishments but also on internal factors, such as what the behavior subjectively feels like or to what extent it helps people reach their goals (see also Juechems & Summerfield, 2019). For example, perceived ease compared with effort of a behavior or perceived goal alignment compared with goal misalignment of a behavior may be factored into the composite reward value of that behavior (e.g., Botvinick, Huffstetler, & McGuire, 2009). This is in line with proposals that subjective feelings serve to inform optimal action selection (Kurzban, Duckworth, Kable, & Myers, 2013; Tooby, Cosmides, Sell, Lieberman, & Sznycer, 2008). Consider for example what are commonly described as "guilty pleasures": Smoking a cigarette or eating a piece of cake has rewarding properties, but the overall experience is diminished if these behaviors are not aligned with one's goals or values (Hofmann et al., 2013). We argue that this source of (subjective) information regarding goal alignment is most accessible when individuals are aware of their moment-to-moment experience. This is a crucial point in our proposal that we now further explain.

## *The role of awareness in updating composite reward value*

When habitual behavior is learned, its composite reward value is stored in cache format such that it can be efficiently and easily retrieved. This process is termed *model-free*, as opposed to *model-based*, because it does not require an internal model of the world (for in-depth

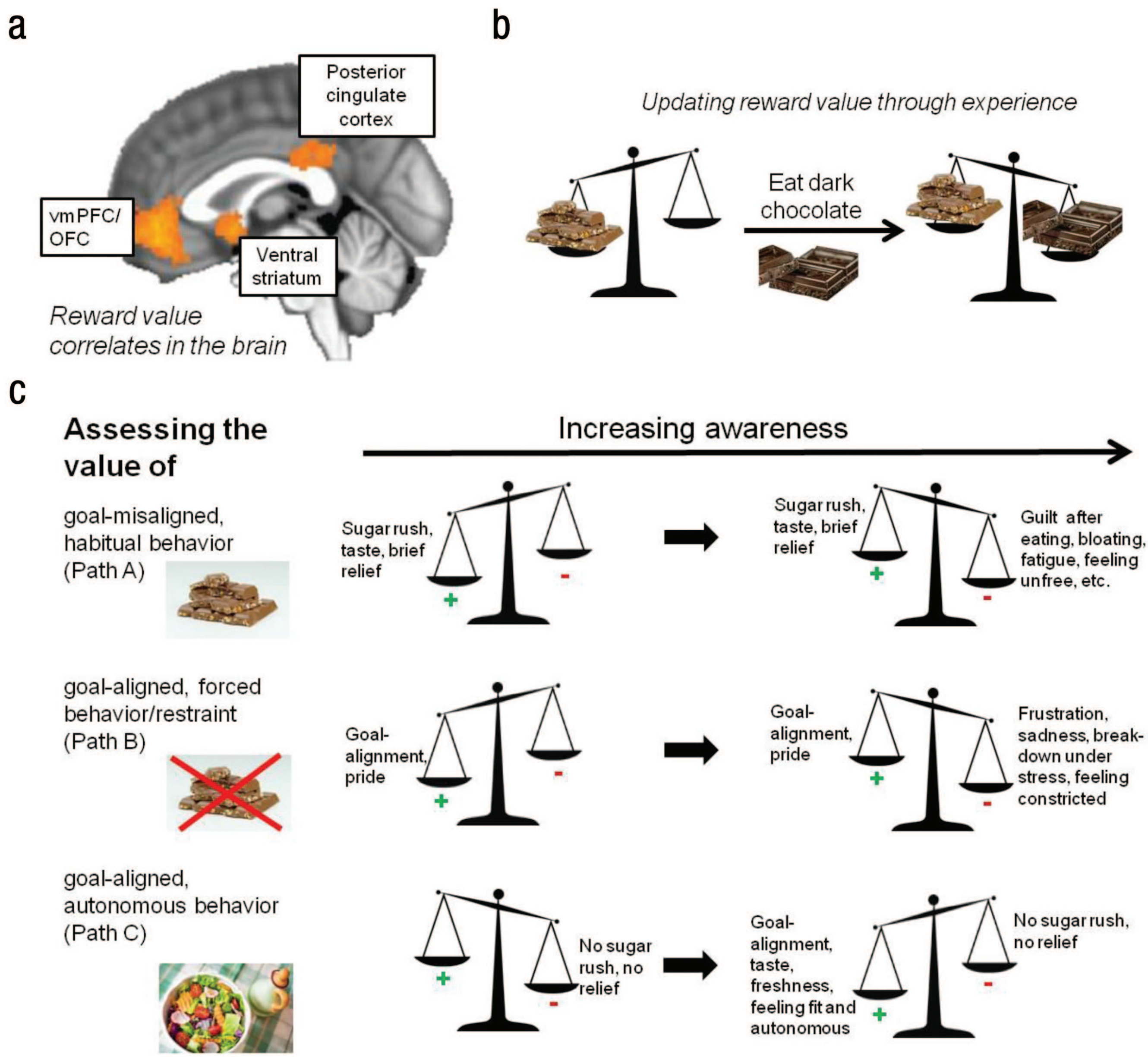


**Fig. 3.** Subjective value representations in the brain and the proposed influence of awareness on valuation processes. The regions of the brain in which activity correlates with reward value are shown in (a). As shown in (b), reward value is thought to be updated by learning (Rangel, Camerer, & Montague, 2008). The hypothesized influence of awareness on reward-value calculations in the brain is shown in (c). The scale symbolizes the reward value calculation in the ventromedial prefrontal cortex (vmPFC)/orbitofrontal cortex (OFC); the plus (+) sign denotes a positive value and the minus (–) sign denotes a negative value. With little awareness applied to the results of a behavior, only the most salient features (e.g., sweet taste) may be incorporated into its reward value (left side). When awareness is applied to behavior and its results (right side), the reward value may shift as more subtle or ignored aspects of experience are incorporated into the value calculation (e.g., resultant physical sensations, emotions, goal alignment, sense of autonomy, etc.). The background in (a) is reproduced from *NeuroImage*, Vol. 76, O. Bartra, J. T. McGuire, & J. W. Kable, "The valuation system: A coordinate-based meta-analysis of BOLD fMRI experiments examining neural correlates of subjective value," pp. 412–427, Copyright 2013, with permission from Elsevier.

reviews on this subject, see Daw, Niv, & Dayan, 2005; Dolan & Dayan, 2013). Although it has been suggested that model-free and model-based systems—roughly corresponding to habitual and goal-directed behaviors, respectively—interact (Cushman & Morris, 2015; Kool, Cushman, & Gershman, 2018), for the purposes of this article, we focus on the model-free system as most relevant for habit change. Here is an example of model-free habit formation: In a person's formative years, because of a preponderance of birthday parties, the person may learn to associate eating cake with celebration, friendship, play, receiving presents, and other positive experiences. Over time, this becomes engrained and inflexible (model-free, habitual learning) such that even when the environment changes, as when metabolism slows down in middle age and the person is now trying to moderate sugar and empty calorie intake, when triggered (seeing cake at a work party), the cached values urge the person to action (eat cake!) even when that action is misaligned with current goals or values. With environmental change, the "entire set of cached values needs to be relearned through experience" (Kool et al., 2018, p. 1). In other words, to change behavior, individuals need accurate and updated information on how rewarding a behavior is currently. This example highlights the double-edged sword of habit learning: It is efficient, requiring few cognitive resources, yet difficult to change because of its inflexibility (Kool et al., 2018).

We suggest that bringing present-moment or mindful awareness to current behavior is instrumental for new learning such that the reward value of habitual behaviors can be updated (Fig. 3c). Note that we are not referring to a thought-based process (e.g., reflecting on the behavior and its consequences) but to a direct, in-the-moment, curious awareness (and this may include awareness of thought). For example, many people know about the negative long-term effects of smoking or overeating yet keep engaging in these behaviors despite the fact that they are goal or value incongruent (APA, 2012). Contributing to this self-regulation failure is the fact that the reward value of the behavior is discounted over time—imagined behaviors lose a proportion of their value according to how far they are projected into the future (termed *delay-discounting*; for a review, see Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013). For example, the rational thought of "I might be healthier in the future if I do not eat this second piece of cake now" does not influence reward value as much as seeing a delicious piece of cake.

We propose that to update reward value (and to mitigate the effects of delay-discounting), experiencing the affective correlates and consequences of behaviors in the present moment is crucial. For example, people who overeat would benefit from paying close attention to their bodily and affective experience of overfullness, guilt (if incongruent with goals or values), or negative self-judgment in a receptive or nonjudgmental way to immediately update the reward value for that behavior. We suggest that awareness will not only foster realization of the direct, immediate consequences of one's behaviors (e.g., feeling overfull) but also the affective experience while the behavior is carried out (e.g., a sense of ease vs. effort) as both contribute to the composite reward value (e.g., see Botvinick et al., 2009). We next describe how awareness leverages reward valuation to shift behavior from automatic or effortfully controlled to autonomous—that is, toward a mode of self-regulation that may require less force than current willpower-based behavior change paradigms (and in theory, no force at all).

## Seven Testable Points in Which Awareness Can Bring About Unforced Self-Regulation

Figure 4 shows seven points of intervention (denoted with the numbers 1–7) in which present-centered awareness can be applied to shift behavior from goal-incongruent automatic behavior (Path A), or goal-congruent yet effortfully controlled and extrinsically motivated behavior (Path B), to goal-congruent autonomous behavior (Path C). Note that the role of awareness at each point of intervention can be tested empirically. Updating of the reward value of various behavioral options is expected to occur at Points 2, 5, and 7 (i.e., the points that involve awareness of the *results* of one's behaviors; see Fig. 4). The seven points are shown here in a temporal order in which behavior generally unfolds, although in the real world, intervention may not proceed in this order (e.g., a person might progress from Path A to Path C without needing to first proceed through Path B).

Box 1 includes two case studies of participants of a mindful eating program that provide real-world examples of progress through the seven points of intervention outlined below. The mindful eating program specifically incorporates the theoretical position outlined in this article: Individuals are taught to bring awareness to their current eating behavior and to focus on the results of the type and amount of food consumed (i.e., reward value; Brewer et al., 2018). Note that the term *results* refers to all correlates and consequences of one's behaviors (e.g., affect, feelings in the body, vitality) during and directly after engaging in a behavior.

Preliminary studies have shown that using mindfulness training as a way to foster greater awareness helps to shift individuals toward what here is termed Path C (Mason et al., 2018); studies have also shown that interventions involving mindful awareness can decrease craving (e.g., Cavicchioli et al., 2018; Westbrook et al., 2013), which depends on reward value (Konova, Louie, & Glimcher, 2018; but see Tapper, 2018). However, empirical studies taking a behavioral and biological perspective to specifically test changes in reward value are still needed.

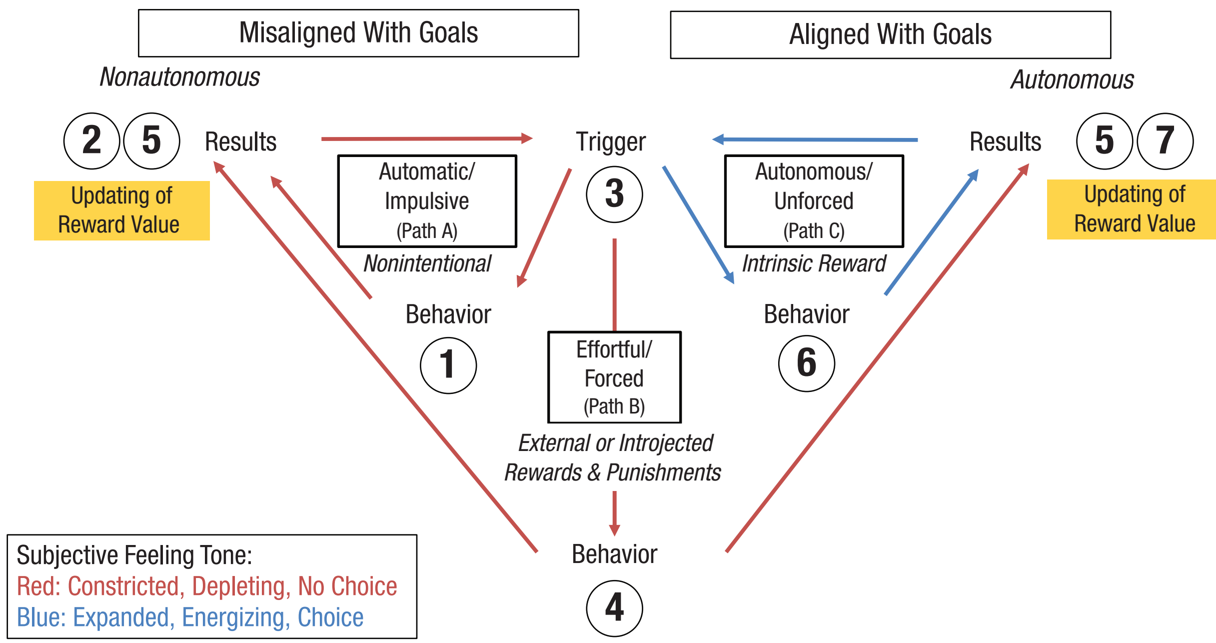


**Fig. 4.** Framework for progression of self-regulation from nonautonomous to autonomous, unfolding through deployment of present-centered awareness at seven points in the enactment of behavior. There are seven points at which awareness can leverage differentials in reward value to shift behavior from goal-incongruent, automatic behavior (Path A) and effortful, extrinsically motivated self-control (Path B) to unforced, autonomously motivated and goal-congruent action (Path C). Path A corresponds to situations in which habitual actions are cued by encountering previously learned triggers but may be misaligned with one's goals (e.g., eating high-calorie food when stressed but wanting to lose weight). Path B corresponds to the application of effortful self-control. Although the results of this may be partly goal-aligned (arrow to the right; e.g., restraint may result in initial weight loss), there are potential effects that are goal-misaligned (arrow to the left; e.g., increased craving leading to binging). Path C corresponds to unforced, autonomously motivated behavior that is goal-aligned (e.g., eating healthfully because it is valued or tastes good). Red arrows denote a subjective feeling/reward value of having no choice, of contraction and depletion; blue arrows denote a subjective feeling of freedom of choice that in itself can feel expansive (rather than constricted). Numbers denote a progression through the reinforcement-learning pathway that unfolds through deployment of present-centered awareness at various points in the enactment of behavior, beginning with automated, habitual behavior and ending with autonomous self-regulation.

We now describe each of the seven points of intervention included in the model. To enhance practical utility, for each of the points we also note concrete approaches that can serve to target the respective point in the context of a practical intervention. Note that an intervention would likely be most effective not as targeting a single specific point but rather by taking into account all the seven steps: That is, coaches, trainers, or clinicians who would like to use this framework for their work may explain all the steps to participants of their programs/trainings and then help them map out their habit loops over the course of their program.

### *Point 1. Awareness of goal-incongruent behavior*

At this point, individuals become aware of a current behavior that is not in line with their long-term goals (Fig. 4, Path A, Point 1). For example, individuals may realize that they are eating a lot of junk food despite having the goal of being healthy or that they are procrastinating on getting started with an important task at work (corresponding to the far left in Fig. 2). This is a critical step in motivating change because it brings into awareness the affectively uncomfortable cognitive dissonance (which contributes to a reduced reward value) of behaving in a way that is inconsistent with a long-term goal (see also Juechems & Summerfield, 2019). Spotting behavior can be relatively straightforward; many people are indeed aware of their behavior being misaligned with their long-term goals (APA, 2012). At this first point of behavior change, present-centered awareness can also help to "catch" oneself in the midst of automatic behavioral enactment. Crucially, Point 1 is not yet about experiencing the subjective feeling tone of the results or consequences of actions; rather, it simply involves becoming aware of the fact *that* one acts in certain ways ("Oh, I am eating too much!"). A practical intervention targeting this first point might ask participants to become aware of moments in which they engage in a behavior of interest (e.g., eating junk food, smoking) in daily life.

**Box 1.** Examples From Online Diaries of Participants in a Mindful-Eating Program

### *Case study J.J.*

***Point 1: Awareness of goal-incongruent behavior.*** "Last night after eating a bit too much Thai food . . . I felt the too-much-fullness coming on—I thought of how my other option would have been to eat less instead of leaving feeling heavy and with remorse—I could have left feeling light and not out of control."

***Point 2: Awareness of the results of goal-incongruent behavior.*** "And my friend had this apple cake, with a big layer of frosting. And she said 'have a bite!' . . . And it was like eating a tablespoon of sugar directly out of the bag. . . . Something that once seemed like 'a treat' suddenly read almost like a toxin . . ."

***Point 3: Awareness of the triggers of goal-incongruent behavior.*** "It feels like my immediate response to almost every contraction of stress is to think of food and eating something. Seeing this feels like progress."

***Point 4: Awareness of forced or effortful restraint of behavior.*** "I feel like fighting the craving doesn't work, but giving in doesn't work either. I am trying to remember that the craving is not a problem. The problem comes when I try to push it away or feed it."

***Point 5: Awareness of the results of forced or effortful restraint of behavior.*** "Sort of an interesting insight today around not stopping eating when full . . . I have the urge to just try to force myself to stop even though it doesn't feel good at all."

***Point 6: Awareness of choice and exploration of new behaviors.*** "I have basically never been able to put less food on my plate when it comes time to serve dinner—but tonight I was suddenly able. I took much smaller portions and I really slowed down my eating and tried to put awareness on what the food was like in my mouth."

***Point 7: Awareness of the results of the new behaviors resulting in unforced freedom of choice.*** "We shared a big soft brownie with caramel on it and ice cream and we both ate it very mindfully and it was amazing. I think it is really good for me to not completely cut off sweets or sugar. . . . It felt really good to be able to eat it, really enjoy it and then feel fine afterwards."

### *Case study M.K.*

***Point 1: Awareness of goal-incongruent behavior.*** "Oh habits, I can see how you've been driving my actions mindlessly! I just sat down at our camp site and immediately searched for food! I'm not even hungry."

***Point 2: Awareness of the results of goal-incongruent behavior.*** "Just ate a piece of cake for birthday celebrations. . . . The sugar tasted nice at first however now I feel sluggish and my stomach doesn't feel satisfied."

***Point 3: Awareness of the triggers of goal-incongruent behavior.*** "Today I ate because I was angry. I reached for food which was healthy and overcame the urge to shove it all in at once. I was aware that anger was triggering it, however didn't want to stop."

***Point 4: Awareness of forced or effortful restraint of behavior.*** "During previous weight loss efforts I would always feel deprived of food and yes the weight returned after . . . calorie consumption resumed. This triggered me to beat myself up as being a failure."

***Point 5: Awareness of the results of forced or effortful restraint of behavior.*** "My brain still thinks I can eat my way out of feeling tired rather than going to bed really early and getting the rest I need. The habit loop goes like this: Feel tired → try to distract myself from being tired or push through → eat 3 times the amount of food at dinner → eat more food in front of the TV → feel regret and uncomfortably full. Yep, a completely unhelpful habit loop."

***Point 6: Awareness of choice and exploration of new behavior.*** "Now that I was able to see this old habit loop when camping, I can set up and practice [a] new habit loop. Arrive at camping [site] and sit down with a cup of coffee. Practice, practice, practice . . . new food habits and be kind and patient with myself."

***Point 7: Awareness of the results of the new behaviors resulting in unforced freedom of choice.*** "Today I used a positive activity rather than food to soothe my overwhelmed mental state. I took myself off for a brisk walk. It helped soothe me and expend my nervous energy. Then I sat down and ate my lunch mindfully. I'm very proud of myself for making this choice."

### *Point 2. Awareness of the results of goal-incongruent behavior*

At this point of intervention, one brings awareness to *the effects* of one's actions. We propose that in linking action to outcome, awareness of the embodied effects of actions (rather than mere intellectual insight) leads to a behavioral shift by updating the reward value of the behavior in memory. In other words, if a behavior that had previously been encoded as rewarding is now being acted out automatically, its *current* reward value is accurately gauged, updated (if different from the past), and stored in memory.

For example, after eating a full bag of potato chips triggered by stress, one can bring awareness to the results of that behavior: short-term distraction or relief of stress, body sensations (e.g., stomach bloating), and unpleasant emotions (e.g., guilt). By paying attention to these, one can more accurately ascertain the embodied cumulative effects of the experience. If the overall results are net negative (e.g., fatigue afterward outweighs short-term stress relief; see Fig. 3C), the reward value of this behavior is updated, leading to a disenchantment with the behavior (Fig. 4, Path A, Point 2). An important source of disenchantment about habitual behaviors, we suggest, is that they feel constricted, as if one had no choice but to act in that way.

Awareness of the cause-and-effect relation between the behavior and result is important for registering the current reward value in memory. Studies have shown that simply paying attention to negative or positive current or future results of enacting a behavior changes activation in reward-related or affect-related regions in the brain, including the vmPFC/OFC (Hare, Malmaud, & Rangel, 2011; Kruschwitz, Ludwig, et al., 2018; Kruschwitz, Waller, et al., 2018). Yet almost by definition, people typically spend little time paying attention to habitual actions and are thus "doomed to repeat" old patterns.

But does goal-misaligned behavior really feel unpleasant? Eating chocolate, after all, is initially rewarding, and rising early in the morning to exercise often does not feel pleasant. Using experience sampling, Hofmann et al. (2013) investigated how much pleasure people experienced when they gave in to desires that were not in line with their long-term goals. They found that the pleasure was significantly reduced compared with similar activities that were congruent with participants' long-term goals, and this was explained largely by emotions such as guilt, pride, and regret. Hence, failures to self-regulate not only have negative long-term consequences but also can feel unsatisfying or aversive in the *present*. This supports the idea that by simply becoming aware of such reductions in pleasure, one might unlearn these behaviors through reward revaluation.

And what if the behavior does not clearly have negative results? Here, present-moment awareness may also determine when a behavior "crosses the line" from the reward of simple enjoyment (e.g., eating a little dessert or briefly engaging with social media) to the punishment of negative emotional consequences (e.g., overeating or spending hours on social media).

With the repetition of interventions at Points 1 and 2, dissonance increases between habitual behavior and its previously stored reward value as the brain collects repeated data points that the behavior is not as rewarding as previously remembered. Indeed, individuals who bring awareness to their experiences may perceive eating unhealthy food items as less attractive and thereby choose those behaviors less (Arch et al., 2016; Jensen et al., 2014; Papies, Pronk, Keesman, & Barsalou, 2015) or stop eating unhealthy food earlier than usual (Higgs & Donohoe, 2011; Jordan, Wang, Donatoni, & Meier, 2014; Robinson, Kersbergen, & Higgs, 2014). In a practical intervention, Point 2 could be targeted by asking individuals to mindfully engage in the behavior of interest (even if it is an unwanted behavior) and note to themselves *how they feel* and what *consequences* they notice during and directly after the behavior (e.g., during and after they ate different types and amounts of food).

### *Point 3. Awareness of the triggers of goal-incongruent behavior*

Individuals can also become aware of what typically triggers their behavior (Fig. 4, Point 3). Awareness can then leverage the updated reward value from Point 2 to induce successful behavior change when a trigger is encountered. One may, for example, notice that stress, certain thoughts, or simply the smell of a delicious food item triggers eating in the absence of hunger—a behavior that one might have discovered to have a low reward value in Point 2. This awareness may help to break behavioral patterns. In line with this, Westbrook and colleagues (2013) asked smokers to mindfully attend to their own responses (e.g., emotions, craving) when looking at pictures of smoking cues (i.e., triggers of smoking behavior). This instruction (compared with simply looking at the pictures) resulted in lower self-reported craving as well as reduced activity in parts of the vmPFC, which is in line with a decreased reward value of smoking.

Although one may become aware of triggers earlier than usual, in the real world they usually do not come into consciousness until the habit loop is more fully understood and mapped out in direct experience; this is why it appears here as a third point of intervention.

For example, many smokers report "waking up" in the middle of having smoked half a cigarette with no awareness of the preceding moments, such as pulling out a cigarette, lighting it, and so on. Fostering awareness of triggers helps the individual shift from automatically and habitually acting to being aware of both the trigger and the action. Often this may be enough to stop the action from being carried out (Mason et al., 2018). In an intervention, individuals may be asked to observe and note to themselves what triggers appear to cue the behavior of interest (e.g., which emotions, thoughts, or external events lead to overeating).

## *Point 4. Awareness of forced or effortful restraint of behavior*

A common strategy to suppress goal-incongruent behavior is bringing forth self-control through restraint or force (APA, 2012; Siep et al., 2012; Waldron & Krane, 2005), corresponding to moving from the left to the middle on the autonomy continuum in Figure 2. For example, instead of eating the bag of chips when stressed, one forcefully restrains oneself, trying to ignore craving and stress (Fig. 4, Path B, Point 4). In the fourth point of intervention, one can become aware of this forceful approach without attempting to stop the self-controlled behavior from occurring. This model suggests that trying to actively interfere with the self-controlled behavior could *increase* the degree of effort and inner struggle during self-control (e.g., see Friese & Hofmann, 2016). In contrast, simply observing the subjective experience of self-control (e.g., the sense of effort or tension) might allow individuals to better understand how unpleasant this type of behavior feels (Botvinick et al., 2009; Kool et al., 2013). Relatedly, the subjective sense of effort has been demonstrated to be dissociable from executive control itself both in case studies of individuals with cortical lesions (Naccache et al., 2005) and in experienced meditators (Garrison et al., 2013).

An intervention targeting this point may ask people to mindfully observe whenever they experience that they are forcefully trying to engage in some behavior (e.g., exercising, studying) or refrain from doing something (e.g., eating cake, reacting emotionally in a conflict) by detecting the subjective experience of effort, struggle, frustration, or force during that behavior.

## *Point 5. Awareness of the results of force or effortful restraint of behavior*

At Point 5, one becomes aware of the results of forceful restraint: Effortfully restraining or forcing behavior can help to bring about goal-congruent results, which can be rewarding (Fig. 4, Path B, arrow toward the right) but also brings with it affectively unrewarding results (e.g., Fig. 4, Path B, arrow toward the left). Specifically, the affective quality of effortful self-control is unpleasant (indicated by red arrows; but see also Inzlicht, Shenhav, & Olivola, 2018). For example, individuals might pressure themselves to exercise in the morning, which is aligned with the goal of being healthier. However, unwanted side effects may include frustration, resistance to the pressure exerted, and energy depletion from the effort (Appleton & McGowan, 2006; McFarlane et al., 1999). Instead of reacting to, for example, the feeling of frustration or trying to suppress it, a person may now bring receptive awareness to the frustration itself. This is the basis for a number of mindfulness programs that help individuals step out of habitual activity (e.g., addiction, anxiety, chronic pain; Brewer et al., 2013; Brewer et al., 2018; Goyal et al., 2014). Moreover, at Point 5, one may also become aware that the desire for the goal-incongruent behavior has been inhibited in the short term but may reemerge as soon as self-control is released or the temptation to indulge in it becomes too strong. As proposed by Gross (2015), reward value may not only be assigned to behaviors as such but also to different self-regulatory strategies (e.g., suppressing one's emotional response to a difficult situation vs. actively modifying the situation).

Therefore, for Point 5, the same principles apply as for Point 2 in that awareness may lead to downgrading the reward value of forceful regulation (relative to less forceful regulation) because of its aforementioned negative side effects (Berkman, Hutcherson, Livingston, Kahn, & Inzlicht, 2017; Etkin, Büchel, & Gross, 2015; Gross, 2015). We do not argue that effortful self-control is never successful or needed. In fact, one might hypothesize that this mode of self-regulation might be helpful to foster autonomously motivated behaviors—a process termed *integration* (Ryan & Deci, 2000; e.g., pushing oneself to exercise in the beginning and discovering value or enjoyment in it later). However, when attention is paid to the results of forcing or pressuring oneself to perform or refrain from performing an action, a person might over time become disenchanted with this mode of self-regulation and rely on it less, especially when compared with autonomous self-regulation; the latter may come to outcompete the former because of the higher composite reward value of autonomous behavior. Thus, as in Point 2, also in Point 5, reward value is hypothesized to be updated by the mere process of becoming aware of the immediate affective and embodied results of one's self-controlled behavior. An intervention may ask participants to pay close attention to their subjective experience while they forcefully try to do something or refrain from doing something, focusing in particular on what effort, struggle, frustration, or force feel like. Moreover, they may observe and note to themselves how successful they are when using this type of strategy.

### *Point 6. Awareness of choice and exploration of new, autonomously motivated behaviors*

Once an individual experiences the aversive side effects and limits of effortful self-control, new options for goal-congruent, autonomous behaviors emerge in the behavioral repertoire (Fig. 4, Path C, Point 6 and right side of Fig. 2). Thus, through awareness of the consequences of efforts to change behavior (e.g., disenchantment with feeling unhappy as a result of forcing oneself to exercise or from categorically denying oneself calorie-rich foods), one may begin exploring other behaviors instead of habitually performing old ones. For example, individuals may eat small portions of ice cream while paying close attention to know when they are satisfied or eat fruit instead of calorie-dense foods. This awareness-based development of choice has been described as an "unforced freedom of choice, emerging from embodied awareness" in qualitative analyses of statements by participants in a mindful-eating intervention as those individuals moved from Path A (and B) to Path C (Beccia, Ruf, Druker, Ludwig, & Brewer, 2020).

Note that this point of intervention builds on a revaluation of behavioral results from Paths A and B and thus leverages the updated reward values for behavior change. Awareness of a lower than previous (or expected) reward value of a goal-incongruent behavior (Path A) and of forceful, controlled motivation (Path B) allows for the exploration of more rewarding, unforced behaviors (Brewer, 2019). In line with this, one study found that when individuals were in a mindful state in day-to-day life, they used fewer control-based self-regulatory strategies such as suppression, distraction, self-stopping, and avoidance (Friese & Hofmann, 2016).

To further illustrate, one may become aware that ceasing to eat cake after one slice rather than two or three is more satisfying. Examples of this type of devaluation of reward (and concomitant brain activity) have been described previously with research participants eating increasing amounts of chocolate, resulting in an experience that is less and less pleasant (Small, Zatorre, Dagher, Evans, & Jones-Gotman, 2001). By paying attention to the drop in reward value over time, one may more readily adapt an alternate behavior that is reinforced by new, positive experiences associated with it. Likewise, one may notice that the pursuit of certain goals (e.g., connecting with others during exercising) may be more rewarding than the pursuit of other goals (e.g., getting approval for one's looks; see Cushman & Morris, 2015; Ryan et al., 1996). During an intervention, individuals may be asked to pay attention to and note to themselves what types of novel, unforced (more autonomously motivated) behaviors they are trying out (e.g., eating strawberries instead of chocolate) and how often in order to become aware of changes in their behavioral patterns.

### *Point 7. Awareness of the results of new, autonomous behaviors*

Finally, present-centered awareness can be applied when one feels the effects of new, autonomously motivated behaviors (Fig. 4, Path C and Fig. 2, right side) in order to update reward values in the brain once again. For example, one may notice how pleasant or energized the body feels after eating a healthy food or after going for a run. This also applies to "inner behaviors": For example, one may feel the positive effects of being curious about or "just being" with an emotion instead of reacting or of bringing kind attention to one's subjective experience in the face of failure instead of being judgmental.

Autonomously motivated behavior is known to be accompanied by more pleasant affective experience than is nonautonomous behavior and includes feelings of interest, curiosity, and enjoyment (see Ryan & Deci, 2017; Stanko-Kaczmarek, 2012). In line with this, autonomous behaviors are expected to have a higher reward value for four reasons. First, autonomous behaviors, by definition, bring people closer to their own goals rather than to others' goals, which are commonly extrinsically motivated. In line with SDT, goal-equilibrium theory suggests that the reward value of an action can be calculated by taking into account the extent to which the action helps people to approach their goals (Juechems & Summerfield, 2019). Second, autonomous behavior is linked with a sense of agency and choice rather than coercion, duty, and control by external or internal forces. Having choice (vs. having no choice) is rewarding in itself and has been shown to activate a central region of the brain's reward network (ventral striatum; Leotti & Delgado, 2011). Third, autonomous behavior is typically accompanied by a sense of ease, effortlessness, and vitality (Nix et al., 1999). Because effort itself discounts or takes away from the composite value of the behavior, effortless activities have a higher overall reward value than effortful activities (also evident in higher activity of the ventral striatum; Botvinick et al., 2009). Fourth, curiosity, a characteristic of many autonomously motivated behaviors, has been shown to be rewarding in itself, with monkeys even sacrificing primary rewards (water) in order to obtain information

(Blanchard, Hayden, & Bromberg-Martin, 2015; Bromberg-Martin & Hikosaka, 2009). Thus, for example, a person who autonomously chooses healthier food (e.g., a self-endorsed desire to feel fitter or enjoyment of such food) is predicted to have a more positive affective experience during healthy eating (Fig. 4, blue arrows in Path C) compared with someone doing it for extrinsic reasons (e.g., other people expect the person to lose weight; Fig. 4, red arrows in Path B).

However, key to the recognition of the rewarding value of autonomous behavior, and thus the shift to this behavior, is the *awareness* of its affective correlates and consequences relative to those of nonautonomous behavior. A person acting automatically and habitually is not likely to notice the rewarding value of autonomous behavior. When behavior, environment, and internal states (including level of effort) are brought together in awareness of one's immediate experience, the stage is set for a movement from automatic or effortful behavior to that which is autonomously driven by reward valuation.

To sum up Step 7, present-moment awareness may be necessary to find new, alternative behaviors (Path C) that are autonomous and in line with one's longer-term goals. In autonomously motivated self-regulation (Path C), no explicit action is prescribed as being "the right one" (as in forced or extrinsically motivated self-control); rather, individuals are more likely to act in ways that meet appetitive and aversive stimuli with an awareness of what they value and find inherently satisfying (Brown & Ryan, 2003; Brown, Ryan, & Creswell, 2007a, 2007b). One might predict that this mode of self-regulation gives rise to modulated rather than extreme behavior (e.g., eating in moderation rather than adhering to strict diets) because this mode of self-regulation involves being aware of and flexibly responding to the demands and needs of each moment rather than responding to learned rules. This gives rise to a subjective feeling of reward that results from increased freedom of choice (Beccia et al., 2020).

To target this seventh point in an intervention, individuals may be asked to become aware of and take note of how they feel during and after engaging in the novel behaviors. This is hypothesized to consolidate the behavioral change by more permanently changing the composite reward value of behaviors.

## Conclusions and Future Directions

People often know what behaviors are healthy for them and yet struggle to change unhealthy behavior. Effortful self-control often fails, especially in times of stress, when self-regulatory regions of the prefrontal cortex "go offline" (Arnsten, 2009, 2015; Milyavskaya & Inzlicht, 2017). In addition, the application of extrinsic rewards and punishments often leave one feeling controlled and undermines psychological well-being. In contrast, a more sustainable route to behavior change and well-being may begin with present-moment awareness of one's actions and their effects—which entails observation of the very learning process that produces habitual behaviors in the first place.

Specifically, we suggest that with the application of awareness, the reward value of behaviors can be more accurately assessed and updated, providing the opportunity for behavior to shift—in a less effortful and more pleasant way—toward that which is autonomously motivated and even intrinsically satisfying. If potato chips no longer are attractive (i.e., have a low reward value), people will have less difficulty resisting them than if they apply pressure to refrain from eating them. If exercising, eating healthily, and so on becomes valuable or enjoyable to people—that is, has a high reward value—they are more likely to engage in it. Such predictions can be tested straightforwardly in behavioral and neuroscientific experiments by, for example, examining whether the response of the reward system to unhealthy food stimuli is lower after eating them with awareness as opposed to without awareness and whether this influences subsequent food choices.

We also described seven specific points of intervention wherein awareness can leverage reward valuation, creating a natural gradient from automatic and effortful to comparatively less effortful and more sustainable behavior change. This extension of SDT and standard reinforcement-learning models may help to explain a key mechanism of mindfulness programs in inducing behavior change. Moreover, this framework may be useful for developing and empirically testing theory-derived hypotheses and may stimulate the development of novel interventions fostering a less effortful, more sustainable form of behavior change that is not reliant on willpower.

### Transparency

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*Declaration of Conflicting Interests*

J. A. Brewer and V. U. Ludwig hold or have held positions at the Mindfulness Center at Brown University, which is a nonprofit entity with an education unit that provides mindfulness-based program delivery to the general public for fees. However, their salary is/was not tied to quantity or content of programs offered through the Mindfulness Center. J. A. Brewer owns stock in MindSciences, the company that developed the mindfulness app referenced in this study. This financial interest has been disclosed to and is being managed by Brown University, in accordance with its Conflict of Interest and Conflict of Commitment policies.

The remaining author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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