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A brief review of choice bundling: A strategy to reduce delay discounting and bolster self-control

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ABSTRACT

Choice bundling is a behavioral economic strategy designed to reduce excessive delay discounting and bolster self-control. Choice bundling entails aggregating a series of individual, identical intertemporal decisions (e.g., should I smoke today?) into a single choice (e.g., should I smoke this month?). In this brief review, we succinctly summarize delay discounting and how it has been linked to lapses in self-control, using substance use as an exemplar. Next, we describe how choice bundling may theoretically work to counter excess discounting rates. Finally, we review the extant empirical research on choice bundling and offer recommendations for future research.

1. Introduction

Individuals often struggle to maintain commitments to long-term goals, such as dieting or exercising. Addictive behaviors (e.g., cigarette smoking) are particularly costly examples of self-control failure. Many individuals who use substances are motivated to quit by the consequences associated with the behavior but find it difficult to do so. For instance, in 2016, a majority (59%) of cigarette users were aware of the health risks of smoking and had made a quit attempt in the past year (Centers for Disease Control, 2018). Nevertheless, most treatment-seeking smokers will relapse (Hughes, Keely, & Naud, 2004). Decision scientists have long been interested in understanding and, ultimately, preventing such outcomes. This review will describe choice bundling, a behavioral economic strategy aimed at overcoming a key barrier to self-control—excessive delay discounting. Choice bundling refers to the process by which a series of individual, identical choices (e.g., "Should I smoke *today?"* asked each day for a month) are aggregated into a single, all-encompassing decision (e.g., "Should I smoke *this month*?*"* asked once); see Ainslie (1975, 2001). First, we briefly summarize delay discounting and its links to self-control failure, focusing on addictive behavior. Next, we describe how choice bundling is proposed to mitigate excessive delay discounting. Finally, we review existing empirical work on choice bundling and highlight areas for future research. Given the authors' areas of expertise, the present review utilizes exemplars from the substance use literature in order to qualify and support arguments. Choice bundling and delay discounting, however, are transdiagnostic constructs that apply to a range of impulsive and health-behaviors, such as gambling, diet, and exercise (Amlung et al., 2019; Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012).

1.1. Delay discounting

Delay discounting is an economic construct that has received significant attention in the study of addictive behaviors, such as tobacco use disorder (e.g., Audrain-McGovern et al., 2009; Bickel & Marsch, 2001; Bickel, Odum, & Madden, 1999; MacKillop & Kahler, 2009; Reynolds, Richards, Horn, & Karraker, 2004). Delay discounting is a phenomenon whereby the subjective value of a future reward is less than that of an immediate reward; thus, delayed outcomes have less of an impact on behavior than immediate ones. Psychologists and other social scientists have used delay discounting as a proxy for impulsive choice (e.g., Andrade & Petry, 2011; Madden & Johnson, 2010; Yi, Mitchell, & Bickel, 2010). In particular, selecting a smaller reward that is available more immediately (smaller-sooner, SS) over a larger, delayed reward (larger-later, LL) has been considered impulsive, while making the opposite choice has operationalized self-control (Rachlin & Green, 1972). It is important to acknowledge that selecting a SS over a LL reward is not always indicative of impulsivity. For instance, if an individual knew that they could invest the SS reward at a high enough interest rate that it's value would exceed the LL reward after the delay, then it would be rational (and non-impulsive) to select a SS option. In addictive processes, however, choosing a SS reward (the hedonic pleasure of a substance) over a LL one (the health and social benefits of abstinence) is frequently at the root of lapse or relapse (Steckler,

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Witkiewitz, & Marlatt, 2013). Accordingly, the present review will focus on situations in which selecting a SS reward is suboptimal.

Historically, economists used exponential models of discounting to explain impulsive behavior (e.g., Becker & Murphy, 1988; Loewenstein & Prelec, 1992). However, some have argued that exponential models are not good fits for empirically derived discounting data in human, animal, or addicted populations (e.g., Madden, Bickel, & Jacobs, 1999). These individuals posit that exponential models have been unsuccessful because they require that SS and LL rewards are discounted at the same, constant rate. Accordingly, these models cannot explain preference reversal, a key phenomenon in impulse-control. Preference reversals occur when an individual selects a LL over a SS reward when both are delayed to some degree but changes their mind as the SS reward grows closer (Frederick, Loewenstein, & O'Donoghue, 2002). Many studies examining exponential models of delay discounting, however, have not used incentivized outcomes and have not allowed for joint estimation of discounting rates and the curvature of the utility function over outcomes. Emerging studies that correct for these methodological shortcomings have offered some support for exponential (constant) discounting models (e.g., Andersen, Harrison, Lau, & Rutstrom, 2008; Andersen, Harrison, Lau, & Rutstrom, 2014). With regards to addictive processes specifically, recent evidence has indicated that exponential, hyperbolic (discussed immediately below) and mixture models of delay discounting can each account for steeper discounting rates in smokers relative to non-smokers (Hofmeyr et al., 2017). Another study demonstrated that the likelihood of non-exponential discounting increases with smoking severity, suggesting that researchers should consider more nuanced approaches to selecting discounting models (Harrison, Hofmeyr, Ross, & Swarthout, 2018).

Several alternative models of delay discounting have successfully accounted for preference reversal, including hyperbolic, quasihyperbolic, and fixed-cost approaches (e.g., Benhabib, Bisin, & Schotter, 2010; Montiel Olea & Strzalecki, 2014; Ainslie, 2001). Even though each of these models offers unique insight into impulsive choice, hyperbolic models will be the focus of the present review. Hyperbolic models, in particular, have received considerable attention in the addictive behaviors literature and have consistently explained empirically derived choice data (e.g., Kirby, 1997; Kirby & Maraković, 1995; McKerchar et al., 2009; Myerson & Green, 1995; Madden et al., 1999; Madden, Begotka, Raiff, & Kastern, 2003). Moreover, as discussed below, choice bundling is an intervention derived from hyperbolic discounting models in order to eliminate preference reversals (readers interested in understanding why bundling is successful in hyperbolic versus quasi-hyperbolic models should see Ainslie [2012]). Hyperbolic models account for preference reversals by allowing future rewards to be discounted at differential rates as a function of their delay, such that SS rewards are discounted more steeply than LL ones (Ainslie, 2001). Thus, at an earlier time (T-1), a SS reward to be delivered soon (T) may be less valuable to an individual than a LL reward delivered much later (T + 1). However, as time T approaches, the subjective value of the SS reward rises more rapidly than that of the LL reward and becomes the more desirable option, thereby accounting for preference reversals.

1.2. Delay discounting and addictive behavior

Cross-sectional studies have demonstrated that individuals with substance use disorders discount monetary and drug rewards more steeply than control subjects; these findings have been replicated with tobacco (e.g., Baker, Johnson, & Bickel, 2003; Bickel et al., 1999; Heyman & Gibbs, 2006; Johnson, Bickel, & Baker, 2007; Mitchell, 1999), alcohol (e.g., Claus, Kiehl, & Hutchinson, 2011; Mitchell, Fields, D'Esposito, & Boettiger, 2005; Vuchinich & Simpson, 1998), and a variety of illicit substances (e.g., Coffey, Gudleski, Saladin, & Brady, 2003; Kirby, Petry, & Bickel, 1999; Monterosso et al., 2007). A meta-analysis aimed at assessing differences in delay reward discounting between individuals who display addictive behaviors and control groups found strong evidence that delay reward discounting is elevated among individuals who use substances (MacKillop et al., 2011). The analysis used a fixed-effects approach to examine if there were significant differences in discounting between groups and if those differences were moderated by sample type or type of substance. Studies using single-item measures of delay discounting, non-monetary discounting measures, or probability discounting measures were excluded. Fifty-seven studies were included; tobacco, alcohol, opiate, stimulant and marijuana use were represented. Overall, the meta-analysis revealed a significant effect of moderate size (Cohen's $d = 0.58$, $p < .00001$). The meta-analysis also found a significant between-studies effect, such that larger effect sizes were found in studies using clinical (versus subclinical) addiction criterion samples; the average effect size among clinical populations was 0.61, and among nonclinical populations it was 0.45 (MacKillop et al., 2011).

In addition, a number of longitudinal studies have examined the relationships between substance use, abstinence and heightened delay discounting (e.g., Audrain-McGovern et al., 2009; Khurana et al., 2013; Harty, Whaley, Halperin, & Ranaldi, 2011). A recent systematic review highlighted the etiological role of delay discounting in addictive behaviors, noting that steep discounting is predictive of cigarette, alcohol and drug use in adolescents and young adults (Rung & Madden, 2018). The authors also noted that discounting is often a poor predictor of substance abuse treatment and precedes drug self-administration in animal studies (Rung & Madden, 2018). Results from work examining whether steep discounting is a result of drug exposure are more mixed. For instance, nonhuman animal studies have demonstrated that self-administered cocaine can produce both transient and long-lasting increases in delay discounting rates (Gipson & Bardo, 2009; Mendez et al., 2010). In contrast, Audrain-McGovern et al. (2009) found that discounting rates did not increase after initiation of cigarette smoking in an adolescent sample. Likewise, research examining the impact of abstinence on discounting rates has produced mixed results. A study utilizing data from two clinical trials of treatment for opioid dependence demonstrated that discounting rates significantly decreased over the course of treatment (Landes, Christensen, & Bickel, 2012). Yi and Landes (2012) found, however, that acute abstinence led to increased discounting rates among cigarette smokers.

To better understand the causal relationships between substance use exposure, abstinence and rates of delay discounting, future researchers could begin accounting for individual and contextual influences on discounting. Regarding the former, Odum (2011a, 2011b) has shown that those who steeply discount one commodity (i.e., money) tend to steeply discount other commodities (i.e., substances). A related construct, myopia for the future, describes stable individual differences in one's ability to accurately forecast and consider future events when planning (e.g., Bechara, Dolan, & Hindes, 2002). In addition to this interindividual variability, researchers have demonstrated that delay discounting can be influenced by fluctuations in one's internal environment, acute stress and transient mood states (Hirsh, Guindon, Morisano, & Peterson, 2010; Lempert, Porcelli, Delgado, & Tricomi, 2012). These lines of research highlight the need for contextual interventions that help individuals reduce impulsive choice in high-risk scenarios. In sum, significant evidence suggests that between-person differences in delay discounting are related to the onset, maintenance and cessation of addictive behaviors. At the same time, it appears that these relationships are influenced by a myriad of intraindividual and contextual factors. As such, researchers should investigate a wide range of tools aimed to reduce delay discounting among diverse individuals and environments.

Given the apparent role delay discounting plays in producing and maintaining impulsive choice, it is important to evaluate strategies for reducing excessive discounting. There are a wide range of manipulations, both pharmacological and behavioral, that have been designed to reduce the steepness of delay discounting, and thereby the likelihood of impulsive choice. Given the host of intraindividual and contextual

factors that have been shown to impact discounting rates, it is likely that some of these manipulations will be more effective for certain populations, and/or in certain environments, than others. In their systematic review and meta-analysis of environmental manipulations to reduce discounting, Rung and Madden (2018) qualitatively and quantitatively evaluated clinical, episodic future thinking, framing, perspective, priming, cueing, contextual and learning-based manipulations. The authors input effect sizes (Cohen's *d*) into mixed-effects models to determine which manipulations were effective at reducing discounting. Results indicated that a large number of interventions, including (but not limited to) episodic future thinking, adding delays, and contingency management, were associated with significantly reduced delay discounting across laboratory settings. Episodic future thinking emerged as a relatively well-studied (n = 14) manipulation that demonstrated effectiveness in both laboratory-based studies utilizing convenience samples and as a therapeutic intervention among overweight individuals, college students and healthy adults (Rung & Madden, 2018).

Although there are many promising avenues to reduce steep delay discounting, the review and meta-analysis by Rung and Madden (2018) highlighted encouraging preliminary research on learning-based approaches, which are rooted in the principles of classical and operant conditioning, reinforcement and/or modeling (e.g., delayed reward exposure techniques, modeling, reward-magnitude conditioning). Although learning-based strategies have not been studied as extensively as other types of experimental manipulations, initial evidence suggests that they are effective at producing reliable reductions in experimentally-measured discounting and impulsive choice (notwithstanding excessive discounting) in both humans and animals. Reward bundling, a subtype of learning-based approaches, was found to have a large effect size (Cohen's $d = 1.16$, $p < .001$) that included both human (n = 3) and animal (n = 2) studies, suggesting that bundling may be an especially promising avenue for continued exploration (Rung & Madden, 2018). The authors concluded that while these results were promising, more research on learning-based strategies such as bundling is needed to determine if it is a viable manipulation to reduce discounting in humans. In particular, the authors noted that more studies were needed to answer key questions about learning-based approaches (e.g., how long their effects last, for which commodities they work) and to determine if they function well in non-laboratory settings. The remainder of this review will describe choice bundling and recommend key avenues for future research to address the questions of generalizability raised in Rung and Madden's review (2018).

1.3. Choice bundling

Choice bundling is rooted in picoeconomics, which treats the individual as a marketplace with various interests (e.g., abstinence versus drug use) competing for control over a person's behavior (Ainslie, 1975). Picoeconomics argues that a person is comprised of multiple selves that lobby for a variety of human behaviors; when two behaviors are in direct opposition of one another, a process of intrapersonal bargaining must take place (Ainslie, 2001). From a picoeconomic perspective, choice bundling is one of a host of tools an individual may employ to precommit themselves to a non-impulsive decision to prevent a maladaptive self from winning the internal negotiation.

An additive process, choice bundling extends the decision maker's temporal horizon, pushing them to weigh the sum of multiple short-term rewards against the sum of multiple long-term consequences. The summation of a series of hyperbolic discounting curves converges to an exponential one; thus, choice bundling theoretically works to bolster self-control by removing the allure of preference reversal (Ainslie & Monterosso, 2007). Specifically, bundling has been proposed to reduce impulsive choice via two pathways: (1) increasing the likelihood that an individual will accurately take into account all of the future benefits and consequences, and (2) increasing an individual's expectancy that they will continue to make non-impulsive choices to the extent that they view their first choice as a "test case" for the entire bundling period (Ainslie, 2013).

To date, much of the literature on choice bundling is theoretical. In particular, Bénabou and Tirole (2004) have formulated a model of self-control based on "personal rules" that is, in part, influence by choice bundling's second proposed mechanism—that individuals who view an individual, aggregated choice as a "test case" for future decisions will be more likely to be self-controlled. Bénabou and Tirole (2004) theory suggests that people behave in self-controlled ways when they see themselves as having willpower, and that when they fail to self-regulate, it is because they view lapses as indicators of future dysregulation. Given the relative paucity of empirical evidence for choice bundling, we will briefly review several related self-control literatures which can offer indirect support for some elements of bundling.

For instance, the economic construct of choice bracketing shares significant overlap with choice bundling. In choice bracketing, individuals group decisions (though not necessarily identical ones, as in bundling). Choice bracketing asserts that considering a group of decisions (e.g., "Should I smoke today?," "Should I go to the bar with my friends who smoke?," "Should I throw away my cigarettes?") can lead to more self-controlled behavior than considering decisions in isolation. That is, broader, more expansive groupings (e.g., considering accumulated health, social and/or hedonic facets) are linked to improved self-control (e.g., Read, Loewenstein, Rabin, Keren, & Laibson, 1999). Choice bundling, in turn, emphasizes the need for decisions to be identical for the aggregation to be impactful (e.g., "Should I save 15% of my paycheck?" versus "Should I save 15% of my next 5 paychecks?"). In laboratory-based studies, choice bracketing has been operationalized in similar ways as choice bundling—as sequential versus aggregated choices. Accordingly, they can be interpreted as offering some support for choice bundling as a manipulation. In one study, for example, participants made decisions with higher expected values, and rated their experience as more enjoyable, when they selected sets of three gambles, relative to selecting three sequential gambles (Read, Antonides, Van den Ouden, & Trienekens, 2001). Similarly, a laboratory study using real (versus hypothetical) monetary stakes demonstrated that broad bracketing (aggregating a group of real money choices) and narrow bracketing (making a series of isolated money choices) were associated with monetary gain and monetary cost, respectively, at least among participants who demonstrated risk aversion (Rabin & Weizsacker, 2009).

Likewise, choice bundling is consistent with the increasingly popular applications of construal-level theory (CLT) to self-control (Fujita, Trope, Liberman, & Levin-Sagi, 2006). CLT approaches argue that self-control is a conflict between motivations (i.e., between near and far desires), and that self-control dilemmas often involve proximal gains with distant costs. Further, CLT posits that construing objects globally (focusing on abstract, overarching, long-term features) versus locally (focusing on concrete, contextualized, components) should encourage people to more comprehensively consider the long-term benefits and costs of their actions, and thus prompt self-controlled behavior (Fujita et al., 2006; 2018; Fujita & Han, 2009). Thus, both CLT and choice bundling highlight the ways in which considering the collective consequences of one's actions will engender controlled behavior. Initial laboratory-based tests of CLT applications to self-control have demonstrated that college students primed to global construal, compared to those primed to local construal, were more likely to select healthier options in hypothetical food choice tasks, form more self-controlled behavioral intentions, and hold an incentivized handgrip for longer (Fujita et al., 2006; Fujita & Han, 2009). While the outcome measures used in these studies are of uncertain construct and external validity, they offer preliminary evidence that manipulations similar to choice bundling can produce reliable changes in behavior.

Finally, according to the self-signaling model, small choices can at times serve as intermediary signals ("diagnostic rewards") of one's

future success in the pursuit of a long-term goal (Prelec & Bodner, 2003). According to this view, if an individual subconsciously anticipates diagnostic reward or diagnostic pain following a "small" decision, they will be more likely to behave in ways consistent with self-control. Both self-signaling and choice bundling approaches to self-control emphasize that a single choice (controlled or not) can serve as a "test case" which influences future, related behavior. Research on self-signaling may then provide indirect support for bundling's second proposed mechanism: i.e., that making a self-controlled choice will increase an individual's expectancy that they will succeed in being self-controlled throughout the bundling period (Ainslie, 2013). Laboratory-based studies with undergraduate participants have demonstrated that individuals behave in ways consistent with their personal goals (e.g., more personal satisfaction, selection of a healthier food item, lower willingness to pay for tempting items) when opportunities for self-signaling are present (Dhar & Wertenbroch, 2012). Others have found evidence that self-signaling, versus altruistic motives, drives prosocial behavior such as making donations (Dube et al., 2017).

We now consider direct tests of choice bundling. A small number of nonhuman animal studies have provided preliminary evidence for the efficacy of choice bundling in reducing impulsive behavior. Although there are challenges to translating animal models of addiction to human behavior (see Field & Kersbergen, 2020), recent reviews have demonstrated that in certain circumstances they can provide significant contributions to the study of substance use disorders. In particular, Smith (2019) highlights that drug self-administration and complex reinforcement procedures afford both basic science and translational potential. Nonhuman animal studies of choice bundling (described immediately below) utilize response-contingent reward administration with rats and pigeons (both have proven useful as models of human choice behavior). Given that animal studies of bundling use appropriate nonhuman animal populations and methods which have demonstrated translational value, they will be included in the present review. Ainslie (1974) presented pigeons with a key that would provide a small, immediate food reward when pecked; not pecking the key resulted in the delivery of a larger, delayed food reward. Most pigeons pecked the key and selected the SS reward on greater than 95% of trials; however, when another key was made available that prevented the SS from becoming delivered when pecked, three out of ten pigeons consistently pecked it, apparently preferring to precommit themselves to the LL reward. Later studies demonstrated that rats preferred rewards presented in parallel (summed at a single point in time) to equal rewards presented sequentially (Brunner, 1999; Brunner & Gibbon, 1995). In a more direct test of bundling conducted by Ainslie and Monterosso (2003), rats were presented with a choice between SS and LL rewards. In the sequential condition, rewards were delivered after each individual choice, and in the bundled condition, the selected reward was delivered three times before the next choice. All of the rats required a larger SS reward to produce impulsive choice in the bundled versus sequential condition. Stein and colleagues (2013) extended these findings, demonstrating that rats' preferences for LL rewards was maintained even after the automatic bundling was removed. These studies indicate that bundled choices can contribute to less impulsive decision making in nonhuman animals.

There is less research concerning the efficacy of choice bundling in humans. Kirby and Guastello (2001) conducted two studies, one with monetary rewards and another with food rewards. First, they estimated participants' discounting rates in order to design a one-time choice between a SS and LL reward, such that the SS reward would likely be selected. Next, they offered this choice to participants as the first in a series of five, with rewards to be delivered over the course of a few weeks. Specific delays varied between participants to ensure that an impulsive temptation was utilized; no delay was longer than 36 days. Participants were assigned to one of two conditions: one in which all five choices were made as a set (bundled) and another in which the choices were made sequentially each week. Participants in the bundled condition were less impulsive (i.e., they more often chose the LL reward) than those in the sequential condition.

Hofmeyr, Ainslie, Charlton, and Ross (2010) conducted a similar study in which they asked smokers and nonsmokers to select a SS or LL monetary reward four times, with each reward opportunity spaced two weeks apart. Participants were randomly assigned to one of three conditions: (1) those in the free condition made the choices sequentially; (2) those in the suggested bundling condition made each choice individually but were told that they could view each as part of a series; and (3) those in the forced bundling condition were told that their first choice would be used for all the remaining selections. They found that smokers, but not non-smokers, displayed less impulsive choices under either suggested or forced bundling (Hofmeyr et al., 2010). We discuss directions for future research on choice bundling in detail below, with a focus on the importance of designing tasks that better model real-world impulsive choice; however, it is also important to note that future research should also examine how individual differences in trait delay discounting (Odum, 2011a; 2011b) impact the efficacy of bundling.

1.4. Future directions

While the studies reviewed above indicate that choice bundling may be a helpful strategy for combating the excessive discounting associated with addictive behaviors, we would like to offer key suggestions for future work. Most broadly, we believe that it is essential to test many of the assumptions surrounding the translation of laboratory-based research on bundling to in vivo health-related behavior change. Empirical research on choice bundling has assumed that all moments that could be bundled are equal, that people are aggregating *identical,* independent decisions, that decisions about monetary reward are equivalent to those about non-monetary reward, and that the reward ratio required to select a non-impulsive choice is consistent across magnitudes. It is possible, however, that one or more of these assumptions do not hold true. For instance, there are countless environmental and contextual factors that may shape individual's impulsive choices in complex ways, such as nicotine withdrawal symptoms that emerge over time during an attempt to quit smoking. As noted above, studies suggest that mood and stress both impact rates of delay discounting, so it is reasonable to assume that transient variables like fluctuating withdrawal would impact the efficacy of choice bundling (Hirsh et al., 2010; Lempert et al., 2012). Research employing momentary methods (i.e., ecological momentary assessment) is needed determine if choices made at different points in time and under various conditions during a health behavior change are in fact equivalent. We elaborate on the issues of ecological validity in the choice bundling literature below.

Assuming that choice bundling can be efficacious in real world settings, there is a need for studies on choice bundling in which the delivery of rewards is contingent upon the successful completion of a behavior or task (maintaining abstinence) rather than the formation of an intention. Making rewards contingent on task completion would more closely model the experience of attempting to discontinue addictive behavior—patients only begin to receive the benefits of abstinence when they have consistently enacted it. Relatedly, choice bundling should be tested as a strategy to facilitate the performance of an unpleasant behavior given that tolerating discomfort (e.g., coping with unpleasant urges) is often a key part of recovery from addiction. Prior studies have focused on choices between two competing rewards, which does not match the choices often faced by those trying to abstain from substances (i.e., choosing to incur short-term costs, such as withdrawal symptoms, in order to obtain long-term benefits, such as improved health). In order to address the issue of making bundled rewards contingent upon the completion of an aversive task, future researchers could consider modifying existing contingency management interventions targeting addictive behavior. These interventions generally offer participants rewards based on biochemically verified abstinence and have demonstrated success at promoting abstinence

during treatment for substance use disorders (e.g., Notley et al., 2019; Prendergast, Podus, Finney, Greenwell, & Roll, 2006). By design, contingency management interventions incorporate the natural costs associated with resisting temptation. For instance, future studies of choice bundling could examine whether individuals participating in a contingency management treatment are more successful when reward vouchers (or "fishbowl draws") are delivered in a bundled versus sequential manner.

Another potential issue is that empirical work on choice bundling has almost exclusively been conducted with monetary rewards. A key question relevant to the application of these findings is whether people make decisions about cigarettes (or diet, alcohol, etc.) in the same way that they make decisions about money. This issue is far from straightforward given the complex social, emotional and personal factors that may inform a health-related decision. Making a non-impulsive choice to endure withdrawal symptoms or other discomforts by not smoking could have many idiosyncratic benefits. For instance, a person may add years to their life by reducing their risk of cardiovascular disease or stroke or they may have fewer feelings of guilt that they are modeling an unhealthy behavior for their child. It may be difficult or impossible to place a monetary value on such rewards, and thus more difficult to sum them in the context of a bundling intervention. Future studies on choice bundling will need to explore if the intangible rewards associated with engaging in a health-behavior change can be aggregated, and how such aggregation compares to that of money. One practical concern when evaluating choice bundling is that participants may be hesitant to report impulsive choice or lapse in the hopes of earning rewards for achieving health-behavior change or to guard against the embarrassment of admitting failure. Accordingly, future research on choice bundling should include strategies for addressing this possibility. For example, researchers could consider employing biochemical verifications and study compliance bonuses (vouchers which can be redeemed for goods and services consistent with the health-behavior change participants are attempting to enact) to help ensure that participants are honest about their health behavior changes. Lastly, it is possible that individuals' motivation and/or readiness to change will impact the way in which they bundle the rewards of abstinence; these should be measured and tested as moderators of bundling's efficacy.

Prior research has also assumed that the ratio between an impulsive and non-impulsive reward that leads individuals to select the non-impulsive option is consistent across magnitude. For instance, a person choosing $100 delivered in a week over $50 today would also be expected to choose $1 in a week over $0.50 today. Research on delay discounting has shown that the magnitude of reward can impact a person's subjective valuation of it (e.g., Baker et al., 2003). The literature demonstrating the magnitude effect is relatively robust; however, much of it has been conducted with convenience samples, hypothetical rewards, or relatively small real monetary rewards. A more recent examination of the magnitude effect, which utilized large, real (non-hypothetical) monetary incentives and a representative Danish sample, found a small magnitude effect that was interpreted as economically insignificant (Andersen, Harrison, Lau, & Rutström, 2013). To date, the extent to which choice bundling is impacted by a magnitude effect remains unclear. Accordingly, this issue should be examined directly in future work. Similar to contingency management, however, there will be practical limits as to how much money is feasible to use in a bundling intervention study.

2. Conclusions

Research on choice bundling is in its infancy, and as such, it is not surprising that it is characterized by several unanswered questions and unchallenged assumptions. Nonetheless, choice bundling holds significant potential as a novel, economically informed strategy to reduce impulsive choice. In this review, we offer several recommendations for advancing research on choice bundling, primarily by enhancing ecological validity—by more accurately modeling the costs of self-control, utilizing non-monetary rewards, and employing momentary assessment techniques. Doing so would help behavioral economists and psychologists alike realize the full potential of choice bundling as a strategy to counteract delay discounting and bolster self-control.

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Contributors

The first author conceptualized the paper, conducted the literature review and wrote the first draft of the manuscript. The second author provided guidance, feedback on framing the paper and contributed to the final draft of the manuscript. Both authors approve the final draft of the manuscript.

Declaration of Competing Interest

None.

Appendix A. Supplementary material

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