



Steeper delay and probability discounting of potentially real versus hypothetical cigarettes (but not money) among smokers



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ABSTRACT

There is a strong relationship between drug use and the tendency to discount the value of outcomes as a function of their delay and probability. Most discounting researchers use hypothetical monetary outcomes to establish discounting patterns among human subjects, who tend to discount the value of hypothetical money and real money similarly. However, no research to date has examined whether hypothetical non-monetary outcomes are discounted similarly to real non-monetary outcomes. In this study, smokers were assigned randomly to complete delay and probability discounting tasks for money and cigarettes that were either potentially real ($n=33$) or hypothetical ($n=31$). Consistent with previous research, smokers discounted the value of hypothetical and potentially real money similarly. However, smokers evidenced steeper rates of discounting for potentially real cigarettes in both delay and probability discounting. These findings suggest domain-specific discounting patterns in which potentially real and hypothetical outcomes may be synonymous in the context of monetary outcomes, but not in the context of non-monetary outcomes.

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1. Introduction

Impulsivity is a broad concept that comprises a variety of behavioral patterns, including those that occur in the context of clear inhibitory cues or in the context of inattention (de Wit, 2009), among others. Discounting, or the tendency to de-value an outcome as a function of its delay or its probability (Ainslie, 1975; Rachlin et al., 1991), represents another fundamental aspect of impulsive choice. In delay discounting, impulsivity is associated with a tendency to prefer smaller, more immediate outcomes over larger delayed outcomes (Ainslie, 1975; de Wit, 2009; Madden and Bickel, 2010). In probability discounting, impulsivity (or risk-taking) is associated with tendency to prefer larger probabilistic outcomes over smaller certain outcomes.

Delay discounting is measured in humans by asking participants to make a series of binary choices between a relatively small reward available right now (e.g., \$10) and a larger reward available after a delay (e.g., \$100 in a day). The smaller amount is adjusted in subsequent questions until an amount that is subjectively equivalent to the larger delayed amount is established. This process is repeated across several different delays to establish a pattern of indifference

values. A similar procedure is used for probability discounting, except that participants make a series of choices between an adjusting certain outcome (e.g., \$10 for sure) and a larger probabilistic amount (e.g., \$100 with a 50% chance). A hyperbolic decay model (Mazur, 1987) characterizes both delay and probability discounting patterns quite well, and is represented as $V=A/(1+bX)$. In this model, the subjective value of the large outcome is represented by V ; the large outcome itself is represented by A , X represents the delay to or odds against receiving the large outcome ($(1/p) - 1$, where p is the probability of receiving the outcome), and b represents a free parameter indexing the discounting rate, where higher values indicate more rapid discounting. High b values represent more impulsive choice (i.e., a tendency to de-value larger delayed outcomes) in delay discounting and low b values represent more risk-taking (i.e., a tendency to devalue smaller certain outcomes) in probability discounting.

A large literature indicates that people who abuse a variety of drugs (e.g., Coffey et al., 2003; Madden et al., 1999; Vuchinich and Simpson, 1998) discount the value of rewards differently from those who do not. A similar literature indicates the same patterns for cigarette smokers. Johnson et al. (2007) compared discounting patterns among non-smokers, light smokers, and heavy smokers and found that light and heavy smokers discounted the value of delayed money at a steeper rate than did non-smokers. These results are similar to previous studies (Heyman and Gibb, 2006; Reynolds, 2006) finding steeper rates of discounting in

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current smokers versus never-smokers and a significant relationship between the rate of discounting and number of cigarettes smoked per day (Ohmura et al., 2005).

One potential limitation of the extant literature concerning discounting and drug abuse is the near-universal use of hypothetical monetary outcomes to characterize patterns of discounting. Using hypothetical outcomes (i.e., where subjects make decisions about outcomes they will not receive) in discounting studies offers several advantages over real outcomes. For example, the sheer number of decisions (over 100 decisions in some studies) a participant makes would make the use of real rewards ethically and financially unreasonable in most studies. Also, some discounting studies use very long delays (e.g., 10 or 15 years), which makes the delivery of real outcomes infeasible. However, it is easy to be skeptical about the extent to which hypothetical rewards serve as meaningful analogs for very real choices that individuals make in their daily lives. Fortunately, numerous independent studies have directly compared patterns of discounting for hypothetical versus both real (in which the subject receives an outcome based on their response to each discounting question) and potentially real (in which the subject receives one or more randomly selected outcomes from their pool of responses) outcomes. The vast majority of research comparing real and hypothetical outcomes has done so in the context of delay discounting using non-drug-using samples and suggests that there is no meaningful difference in patterns of discounting across outcome types (Johnson and Bickel, 2002; Lagorio and Madden, 2005; Lawyer et al. 2011; Madden et al., 2003, 2004). Only two studies allow for a comparison of potentially real and hypothetical outcomes in substance-dependent participants (Baker et al., 2003; Lawyer et al., 2011), but both reported equivalent discounting patterns between outcomes. Only a few studies examine real versus hypothetical outcomes in the context of probability discounting, with somewhat mixed findings. While the majority reported no difference across outcomes in the context of probability discounting (Hinvest and Anderson, 2010; Lawyer et al., 2011), Jikko and Okouchi (2007) reported some tentative evidence that potentially real outcomes are discounted at a shallower rate than are hypothetical outcomes. These findings are encouraging as they are consistent with findings in other samples, but further research is needed to assert this conclusion with more confidence.

One limitation of the literature concerning real, potentially real, and hypothetical outcomes in discounting is the predominant focus on monetary outcomes. Research using monetary outcomes provides important data about how individuals and/or groups make decisions regarding money, but the sole use of monetary outcomes fails to provide much-needed information about how individuals from health-problem groups (i.e., drug-dependent) make decisions regarding problem-specific outcome types. Numerous studies make it clear that consumable outcomes (e.g., food, drugs) are discounted at a steeper rate than are non-consumable outcomes (Estle et al., 2007; Green and Myerson, 2004; Odum and Rainaud, 2003) and the same follows for smokers. Smokers not only discount the value of food and cigarettes more steeply than they do money and health outcomes, but they also discount the value of health outcomes at higher rates than do never-before smokers (Odum et al., 2002).

Given the differences in patterns of discounting for monetary and non-monetary outcomes among smokers, it is possible that the empirical equivalence of hypothetical and real monetary outcomes may not generalize to non-monetary outcomes. No research to date has examined the empirical equivalence of potentially real versus hypothetical non-monetary outcomes in a substance-dependent sample. This is an important limitation in the literature, as impulsive decisions made in a drug use context are typically made for drug-related—not money-related—outcomes. If decisions for real drug outcomes are different from those for hypothetical

drug outcomes in a substance-dependent sample, then one may draw the conclusion that discounting for hypothetical outcomes are not synonymous with discounting for potentially real outcomes. On the other hand, establishing the empirical equivalence of hypothetical drug outcomes in relation to real drug outcomes would increase researcher confidence in the validity of using hypothetical, discounting-related decisions for drug-related outcomes.

The purpose of the study was to examine whether decision-making for hypothetical cigarettes is equivalent to decisions for potentially real cigarettes in a sample of cigarette smokers. A secondary purpose was to replicate previous research concerning the equivalence of decisions made between hypothetical and potentially real money in smokers. We hypothesized that smokers would make more impulsive decisions (exhibit steeper discounting rates) for real cigarettes than they would for hypothetical cigarettes. This study also employed a between-subjects design to control for methodological limitations (e.g., contamination of responses due to repeated presentations) associated with within-subject designs used in previous studies (e.g., Lawyer et al., 2011).

2. Materials and method

2.1. Participants

Participants ($n = 73$) were recruited from undergraduate psychology courses at Idaho State University using course announcements advertising the study. All participants were at least 18 years of age. The sample was primarily female (56.2%) and European-American (76.7%). The mean age of the sample was 26.9 ($SD = 5.8$) years of age. Participants were included if they reported smoking cigarettes on a daily basis and scored, on average, 3.85 ($SD = 2.4$) on the Fagerstrom Test for Cigarette Dependence (FTCD; Fagerstrom, 2012; Heatherton et al., 1991).

2.2. Materials

2.2.2. Delay and probability discounting tasks

Delay and probability discounting rates for both money and cigarettes were established using a computerized discounting program similar to that used in previous research (Lawyer et al., 2011; Richards et al., 1999). The large amount for the monetary tasks was \$10, and the large amount for the cigarette tasks was 20 cigarettes. Indifference points for both outcomes were established across five different delays (1 day, 2 days, 1 week, 1 month, and 6 months) and five different probabilities (90%, 75%, 50%, 25%, and 10%) with the smaller/sooner and certain amounts adjusted incrementally. All four discounting tasks (delay and probability for money and cigarettes) were completed during an individual session.

2.3. Procedure

2.3.1. Experimental groups

Procedures were modified from those used by Madden et al. (2004) and Lawyer et al. (2011). After arriving at the laboratory and consenting to participate in the study, participants were assigned using a block randomization procedure to either the potentially real or hypothetical condition. In the *potentially real rewards condition*, participants could potentially receive any of the choices made on any of the discounting tasks completed during the study. In the *hypothetical rewards condition*, all choices the participant made were completely hypothetical; participants in this condition did not receive compensation based on their choices.

2.3.2. Compensation

Participants received research credit toward their undergraduate courses for their participation. In addition to course credit,

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