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Comparison of potentially real versus hypothetical food outcomes in delay and probability discounting tasks

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ABSTRACT

Much of the research on human delay and probability discounting involves the use of hypothetical outcomes, in which participants indicate preferences for outcomes but do not receive them. Research generally shows that hypothetical and potentially real outcomes are discounted at similar rates. One study, however, shows that potentially real cigarettes are discounted more steeply than hypothetical cigarettes in smokers, calling into question the generality of the finding that potentially real and hypothetical money are discounted at similar rates. Using a within-subject design, we tested the extent to which potentially real and hypothetical monetary (Experiment 1) and food-related (Experiment 2) outcomes were discounted at similar rates. We found mixed results for monetary outcomes, in that potentially real outcomes were discounted more steeply than hypothetical outcomes when all participants were included; however, this effect disappeared when only systematic responders were used. In addition, potentially real and hypothetical monetary outcomes were significantly correlated. For food-related outcomes, we found robust and consistent effects that potentially real and hypothetical food outcomes are discounted similarly and that they correlate strongly. Generally, these findings suggest that using hypothetical outcomes generate similar levels of discounting, in particular for food, which is useful for researchers interested in characterizing food-related impulsivity.

1. Introduction

Delay discounting refers to the tendency for an outcome to lose value as the delay to its receipt increases (Ainslie, 1975; Madden and Johnson, 2010; Rachlin, 1995) and is considered a behavioral process that is a facet of impulsivity (Bickel et al., 1999; Bickel and Marsch, 2001; Green et al., 1994). Relative to controls, higher levels of delay discounting (i.e., impulsivity) have been observed in cigarette smokers (e.g., Bickel et al., 1999), cocaine-dependent (e.g., Heil et al., 2006), heroin-dependent (e.g., Kirby et al., 1999), and obese individuals (e.g., Fields et al., 2011; Hendrickson and Rasmussen, 2013; Jarmolowicz et al., 2014; Rasmussen et al., 2010; Weller et al., 2008). Given that excessive delay discounting is associated with a wide-range of health-related conditions, it is considered a trans-disease process (Bickel and Mueller, 2009; Bickel et al., 2012).

Delay discounting is assessed by presenting choices between a smaller outcome that is immediately available vs. a larger outcome available after a delay (e.g., "Would you prefer $9 now or $10 in a day?" Most choose the large amount to this question). A pattern of preferences for smaller, sooner outcomes are considered impulsive and a pattern of preferences for larger, later outcomes are considered self-controlled (Bickel and Mueller, 2009; Bickel et al., 2012).

Delayed outcomes also inherently include the property of uncertainty. For example, if a person chooses $100 after a year, there is a question of whether the outcome will still be available after this period of time elapses. Therefore, some researchers conceptualize probability discounting as a separate, though related process to delay discounting (Green et al., 1999; Holt et al., 2003; Myerson et al., 2003). Probability discounting, which measures sensitivity to uncertainty, refers to the extent to which an outcome loses its value as the odds against receiving that outcome increase.

In measuring probability discounting, an individual is asked to make choices between smaller, certain outcomes vs. larger, less probabilistic outcomes (e.g., "Would you prefer $3 for sure or $10 with a 50% chance of receiving that outcome"). Individuals who consistently prefer less probabilistic outcomes are characterized as risk averse and those who prefer them are considered risky (Green et al., 1999; Estle et al., 2007; Lawyer et al., 2011; Rasmussen et al., 2010).

Typically in both delay and probability discounting studies using humans, hypothetical outcomes are used for assessing choices; that is, participants do not actually receive the outcome associated with the choice (Madden et al., 1997; Odum et al., 2006; Rasmussen et al.,

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2010). There are good reasons for this. In studies using money, giving real outcomes to participants is cost-prohibitive and in some cases unrealistic (e.g., thousands of dollars). In addition, when using immediately consumable items like food, each receipt of a food reward may alter the establishing operations (or motivation) for food, thereby potentially confounding the study.

Nonetheless, researchers have considered the possible limitations of the use of hypothetical outcomes with discounting procedures (Baker et al., 2003; Johnson and Bickel, 2002). For instance, individuals may discount hypothetical outcomes differently than real outcomes, which would limit the utility of hypothetical outcomes. To address these concerns, researchers have compared discounting for hypothetical outcomes to those that are *potentially real*. For potentially real outcomes, researchers instruct participants to make each choice as if it were for a real outcome because they will actually receive one of the choices that they make during or after the discounting task. Rates of discounting for hypothetical and potentially real outcomes can then be compared to assess the extent to which discounting processes are similar across outcome type.

Using a within-subjects design, Johnson and Bickel (2002) were the first to compare delay discounting for hypothetical vs. potentially real monetary outcomes. They found that hypothetical and potentially real outcomes were discounted at similar rates with six participants – that is, there were no differences between them. Madden et al. (2003) replicated this study using a larger sample size ($n = 20$) and separated the hypothetical and potentially real tasks by a 20-min interval to reduce carry-over effects. This study also revealed no differences in hypothetical and potentially real monetary outcomes. Matusiewicz et al. (2013) also investigated the extent to which rates of delay and probability discounting for hypothetical vs. potentially real outcomes were similar using equivalence testing and found that, for both delay and probability discounting, hypothetical and potentially real outcomes were discounted at similar rates. Subsequent research comparing rates of discounting for hypothetical vs. potentially real outcomes has been conducted and has resulted in similar conclusions with monetary outcomes in typical populations (Madden et al., 2004), as well as drug-dependent populations (Baker et al., 2003; Lawyer et al., 2011).

To date, only one study (to our knowledge) has investigated hypothetical vs. potentially real outcomes with outcomes other than money. Green and Lawyer (2014) reported on potentially real vs. hypothetical comparisons with cigarettes as the outcome in a sample of smokers. The authors first replicated that discounting rates did not differ between hypothetical vs. potentially real monetary outcomes. However, potentially real cigarettes were discounted at a steeper rate for both delay and probability discounting than hypothetical cigarettes. There are a number of possible reasons for this finding. One, it may be that outcomes that are specifically related to the population of interest (i.e., cigarettes with cigarette smokers) generate these differences. Two, the finding may also have to do with the immediately consumable nature of these outcomes (i.e., cigarettes are more immediately consumable than money).

The current study had two aims. First, to replicate previous work, we tested the extent to which delay and probability discounting for money differed as a function of hypothetical or potentially real outcome type. Second, we tested the extent to which delay discounting for food differed as a function of hypothetical or potentially real outcome type. Importantly, in this study we used three types of statistical information to answer these questions. The first was the extent to which there are significant differences between the two types of outcomes, which can be assessed in within-subjects designs by a dependent samples *t*-test. This type of information is limited, however, in the sense that failing to reject the null hypothesis does not lead to a conclusive statement about whether data from two variables are similar. That is why the second type of statistical information is critically important – equivalence testing, which determines the extent to which two variables are statistically equivalent (Matusiewicz et al., 2013). Finally, correlations describe the extent to which the two types of variables (outcomes, in this case) are related (i.e., as one increases, so does the other), though not necessarily equivalent. We reported all three in this study.

Table 1
Mean and standard deviation for demographic and health variables across entire sample for money discounting.

	Total ($N = 40$) Mean (SD)	Hypothetical	Potentially Real	*p* value
Age	22.85 (8.97)			
% Female	80%			
% Caucasian	77.5%			
% Income < $10,000	10%			
% Smokers	8%			
Time since last meal		9.83 (5.77)	9.76 (5.75)	$p = 0.44$
Time since last snack		7.25 (3.35)	9.76 (5.75)	$p = 0.002$
Subjective Hunger		58.84 (28.33)	56.22 (26.94)	$p = 0.065$
Estimated IQ	103.58 (6.33)			
DAST	1.28 (1.04)			
Audit	1.61 (2.10)			

2. Study 1

The first study is a systematic replication of previous research that examined differences and similarities in hypothetical vs. potentially real outcomes in delay and probability discounting for money using a within-subjects design.

2.1. Method

2.1.1. Participants

Forty college students (80% female) from Idaho State University enrolled in introductory psychology classes were recruited via SONA participant pool database. Participants were an average age of 22.85 ($SD = 8.97$) years old and 77.5% were Caucasian. Researchers instructed participants not to eat for at least four hours prior to the session and not to drink anything for at least two hours prior to the session. Participants were compensated for participation with course credit. Table 1 describes participant demographics.

2.1.2. Delay and probability discounting for money

A computerized program (see Richards et al., 1999 for details) pseudo-randomly presented questions in which the participant chose between smaller, sooner vs. larger, delayed outcomes (delay discounting) or smaller, more certain vs. larger, less certain outcomes (probability discounting). The monetary amount varied between $1–$10 and delays were varied between 1–365 days; the larger, later amount was held constant at $10. For example, the participants were presented with the question, "Would you rather have $9 now or $10 after 1 day?" (most choose the larger, delayed option). The smaller, sooner amount was systematically decreased until the participant reversed his or her preference (e.g. chooses the immediate outcome). From this, an indifference point was generated for that delay that was the median value of the two smaller, sooner options that flanked the indifference point. Indifference points were determined in the same manner for all of the delays (1, 2, 30, 180, and 365 days). The same procedure was used to generate indifference points across 5 different probabilities (10%, 25%, 50%, 75%, and 90%). Probability and delay discounting questions were intermingled in the program. This discounting task has been utilized in other studies (e.g., Rasmussen et al., 2010; Hendrickson et al., 2015).

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