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Delay discounting of hypothetical monetary rewards with decoys

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ABSTRACT

The current research attempted to decrease individuals' rates of delay discounting by introducing decoys that are similar but inferior to delayed rewards. Two experiments in the current study compared patterns of delay discounting generated by repeated choices between two hypothetical monetary rewards in the absence or presence of a decoy. Binary questionnaires (i.e., decoy absent) included questions with two options: a smaller-sooner (SS) reward and a larger-later (LL) reward. Trinary questionnaires (i.e., decoy present) included questions with three options: an SS reward, an LL reward, and a decoy. If an option is at least as rewarding on every dimension of value as an alternative and the option is more rewarding than an alternative on at least one dimension, then the option is considered to *dominate* the alternative (Wedell, 1991). The first experiment assessed the influence of decoys *dominated* by LL rewards (LL^- decoys), which were constructed to be similar (on the dimension of amount) but inferior (on the dimension of delay) to LL rewards. The second experiment examined the effects of counterbalancing the order of binary and trinary questionnaires. In the first experiment, participants discounted to a lesser degree when LL^- decoys were present as compared to when they were absent. In the second experiment, participants only discounted to a lesser degree on trinary questionnaires with LL^- decoys when they had not previously completed binary questionnaires. Patterns of discounting generated by binary questionnaires were similar to those generated by trinary questionnaires when decoys are present; however, the degree to which individuals discounted delayed rewards was affected by the number of and type of options that were available. The current results join previous evidence suggesting that rates of delay discounting are sensitive to a variety of contextual influences.

1. Introduction

Delay discounting describes the tendency for the subjective value of a reward to decrease as the delay to its receipt increases. For instance, most people value receiving $100 tomorrow over receiving $100 in 10 years. There is considerable interest in identifying variables that influence how rapidly the value of a reward decreases with increases in delay due to the relation between discounting and drug addiction. Individuals who regularly engage in behaviors that provide immediate pleasure and delayed unpleasant consequences (e.g., heroin addicts) tend to exhibit rates of delay discounting for rewards that are uncommonly rapid (e.g., Kirby et al., 1999). Among drug addicts who decide to quit, individuals who initially exhibit more rapid rates of delay discounting have a smaller chance of positive outcomes than those who initially exhibit less rapid rates (e.g., Washio et al., 2011). Accordingly, researchers have developed an array of methods to produce decreases in rates of delay discounting with the aim being to increase the likelihood of positive treatment outcomes (Bickel et al., 2015). One method that produces short-term reductions in rates of discounting involves reframing delay discounting questions by making explicit the delayed unpleasant consequences for choices of immediate rewards (Radu et al., 2011). The present investigation uses a novel manipulation of delay discounting questions to produce short-term reductions in rates of discounting by including decoys which are similar but inferior to delayed rewards.

Decoys are choice alternatives that resemble beneficial alternatives but have attributes that make them less rewarding or even harmful. The study of the effects of decoys on rates of delay discounting is appealing because decoy effects found in controlled experimental settings may also be found in naturalistic settings (see Slaughter et al., 2011). To date, decoys have been found to influence decisions in contexts as varied as humans choosing from among hypothetical probabilistic outcomes (e.g., Wedell, 1991) to hummingbirds foraging among flowers (e.g., Bateson et al., 2002). In contrast, manipulations which have been demonstrated to reduce rates of discounting often involve distinctly human activities and are relevant, in large part, due to their potential application in

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controlled settings (see Koffarnus et al., 2013). For instance, DeHart and Odum (2015) found delay discounting rates were more rapid when time was framed in terms of units of days (e.g., "14 days") as compared to when time was framed in terms of calendar dates (e.g., for example if today's date was September 7th, 2015 the option similar to 14 days would be "September 21st, 2015 "). The authors suggested that the strength of their findings is derived from applications to controlled settings (e.g., a clinician helping a participant decide on a smoking quit date; DeHart and Odum, 2015). Such research seems valuable in its own right; however, it also seems useful to identify manipulations which reduce rates of delay discounting that are likely to generate applications relevant to less controlled naturalistic settings.

The study of decoy effects on rates of delay discounting is also appealing because of a notable limitation involved with prior methods used to study decoy effects. When researchers have examined decoy effects using repeated measures designs they tend to measure preferences prior to the introduction of a decoy and then measure how preferences change after a decoy has been introduced (Milberg et al., 2014). This is significant because meta-analyses of previous research found that certain decoy effects were considerably stronger when researchers applied independent groups designs rather than repeated measures designs (Heath and Chatterjee, 1995; Milberg et al., 2014). This relative weakness of repeated measures designs is often attributed to a carryover effect; presumably, participants may remember their initial choice made in the absence of the decoy and simply reproduce their previous choice when the decoys are added (Huber et al., 1982). While decoy effects are often measured by asking an individual question (e.g., to establish a single product or foraging preference; c.f., Wedell, 1991) delay discounting rates are measured by asking a series of questions (i.e., to establish a pattern of choices). Given that discounting is measured by asking a series of questions, it may be possible to assess the effects of decoy effects on rates of delay discounting without participants being able to remember and reproduce their previous choices.

Studies of delay discounting often include repeated presentations of binary questions (see Odum, 2011). In individual binary questions, a participant is asked to choose between a small reward that is immediately available (i.e., a smaller-sooner or SS reward) and a larger reward that is available only after a delay (i.e., a larger-later or LL reward). For instance, a binary question in a discounting questionnaire constructed by Kirby et al. (1999) (the Monetary Choice Questionnaire [MCQ]) asked participants to choose between $14 today (SS reward) and $25 in 19 days (LL reward). A characteristic of this type of binary question is that the LL reward is more valuable than the SS reward on the dimension of amount, and the SS reward is more valuable than the LL reward on the dimension of delay. Using binary choice procedures, researchers have observed patterns of choice that are consistent with the hypothesis that the subjective value of a reward decreases as delay to its delivery increases.

An equation that elegantly summarizes this pattern, the hyperbolic model of discounting delayed rewards, was proposed by Mazur (1987).

$$V = \frac{A}{1 + k(D_i)} \tag{1}$$

In Eq. (1), the term V represents the value of a reward; the term A represents a measure of the reward on the dimension of amount; the term D_i represents a measure of the reward on the dimension of delay; and the term k is a free parameter that estimates the rate at which the value of a reward decreases with increases in D_i. Eq. (1) was first experimentally demonstrated to accurately describe patterns of human choice behavior by Rachlin et al. (1991). While Mazur's procedures applied real rewards in an operant choice context, Rachlin and colleagues' procedures applied hypothetical monetary rewards in the context of instructing participants to behave as if they were making choices between real rewards. As mentioned by Rachlin et al., what both procedures have in common is they attempt to establish equivalence between an individual subject's value of a delayed reward and the researcher's stated value of the immediate reward. For this reason, Eq. (1) may be reinterpreted such that the term V is considered a measure of subjective value.

An abundance of evidence suggests the hyperbolic model of discounting generally performs well at describing patterns of binary choices between SS rewards and LL rewards (see Odum, 2011). Yet, there is a scarcity of evidence suggesting that the model can accurately describe patterns of choices when more than two rewards are available in each question (c.f., Weatherly and Derenne, 2011), and no previous studies have examined the effects of decoys on rates of delay discounting. The authors are aware of only one study (i.e., Hinson et al., 2003) that compared how well this equation describes patterns of choices generated by binary questions and patterns of choices generated by questions in which three rewards were available (i.e., trinary questions). The results of Hinson and colleagues' study showed the hyperbolic equation could describe patterns of choices generated by trinary questions well; however, their questions did not intentionally include decoys, and no analysis of possible decoy effects was conducted. Therefore, no previous investigations are available to definitively suggest whether or not decoys may be used to influence rates of delay discounting.

In order to maximize the possibility of finding an effect of decoys on rates of discounting, a review of different types of decoys used in previous studies of decoy effects was conducted. From among the available decoys perhaps the most promising candidate for generating changes in choice behavior on delay discounting tasks is the use of asymmetrically dominated decoys (see Huber et al., 1982; Wedell, 1991). An asymmetrically dominated decoy is a type of decoy that is less rewarding than all other options on one dimension and is less rewarding than, or is as equally rewarding as, only one option on another dimension (Royle et al., 2008). For instance, a binary question which included the choice between $5 available today and $10 in 7 days could be increased to a trinary question with an asymmetrically dominated decoy by adding the option to take $10 in 8 days. The option of $10 in 8 days is an asymmetrically dominated decoy because it is as equally rewarding as the $10 in 7 days option on the dimension of amount but is lower in value than (i.e., dominated by) both the option of $10 in 7 days and the option of $5 today on the dimension of delay.

Researchers have demonstrated that the presence of an asymmetrically dominated decoy often increases the probability that participants will choose an option that is at least as rewarding as the decoy on every dimension as compared to the probability of choosing the same option in the absence of the decoy (see Heath and Chatterjee, 1995). For example, Huber et al. (1982) found the probability of participants choosing an expensive beer was affected by an asymmetrically dominated decoy. They asked participants to choose between a competitor beer ($1.80 beer with a quality rating of 50) and a target beer ($2.60 beer with a quality rating of 70) in the presence or absence of an asymmetrically dominated decoy ($3.00 beer with a quality rating of 70). The researchers found that individuals had a higher probability of accepting the expensive, target beer when a more expensive, decoy beer was present. The decoy beer ($3.00 beer with a quality rating of 70) was equal in value with the target beer on the dimension of quality rating but was dominated by the target beer on the dimension of price ($2.60 beer with a quality rating of 70). Thus, the decoy beer ($3.00 beer with a quality rating of 70) can be considered an asymmetrically dominated decoy. The current study tested the empirical generalization that asymmetrically dominated decoys, which influenced the