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Delay and probabilistic discounting of alcoholic beverages

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Delay and Probabilistic Discounting of Alcoholic Beverages

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Abstract

Discounting tasks were used to determine the degree to which college undergraduates discounted delayed and probabilistic alcoholic beverages. Tasks were framed in terms of gains (i.e., obtaining a hypothetical amount of alcohol) and losses (i.e., losing a hypothetical amount of alcohol). In all gain and loss conditions, discounting was evident and was generally well described by a hyperboloid function. Gains were discounted more steeply then losses. There were no correlations between the median delay gain discounting rates and the median delay loss discounting rates. Likewise, there were no correlations between the median probabilistic gain discounting rates and the median probabilistic loss discounting rates. This pattern of results suggests that each condition is independent from one another, operating under a separate set of mental processes. Future studies with a larger sample size are necessary to validate these findings.

Introduction

When making decisions, individuals typically consider a wide variety of different variables. These include delay (i.e., the time it takes for a specific outcome to occur) probability (i.e., the likelihood that the specific outcome occurs) and magnitude (i.e., the "amount" of the specific outcome) (Green & Myerson, 2004). When the alternatives or outcomes in a given choice differ in only one of these dimensions, the choice the individual makes is relatively predictable. That is, given a choice between two rewards that differ only in terms of delay, probability or magnitude, the individual is likely to choose, respectively, the sooner reward, the more likely reward or the larger reward. This situation, however, becomes significantly more complicated when alternatives differ on more then one of these dimensions, as in most real life situations (e.g., when choosing between a smaller sooner or a larger later reward or between a smaller more certain reward and a larger less certain reward).

To shed light on these complicated decisions, researchers have examined them through the lens of behavioral discounting. This perspective holds that the subjective value of a specific reward tends to decrease as the delay until or the odds against receiving the reward increases (Green & Myerson, 2004). Accordingly, individuals tend to choose the choice with the higher subjective value.

Previous research on delay and probability discounting has supported the above premise. Rachlin, Castrogiovanni, and Cross (1987) found that as the certainty of receiving an outcome decreases, the subjective value of that outcome decreases. Additionally, Raineri and Rachlin (1993) found that as the time to receiving an outcome increases, the subjective value of that outcome again decreases.

Previous research has also shown that the discounting trends of both delayed and probabilistic outcomes are well described by the following hyperbola-like equation, Eq. (1):

$$V=A/(1+bX)^{S}, \quad (1)$$

where *V* represents the subjective value of the delayed or probabilistic outcome, *A* represents the amount of reward, *b* (with *s* held constant) represents the rate of discounting, *s* represents a nonlinear scaling parameter, and *X,* depending on the discounting task, represents the time until or the odds against receiving a reward (Myerson, Green, Hanson, Holt & Estle, 2003).

Substance Abuse/Addiction

Given its effectiveness, the above function (and those of a related structure) has been applied to the topic of substance abuse and other addictive behavior in an attempt to better understand the effects these disorders have on choice patterns. For instance, Holt, Green and Myerson (2003) evaluated whether gambling and non-gambling college students differed in the degree to which they discounted both delayed and probabilistic monetary rewards. Following discounting conditions of varying monetary value ($1,000 and $50,000), it was found that gamblers discounted probabilistic rewards less steeply then non-gamblers, which suggests that they are less affected by risk and more impulsive then non-gamblers.

In terms of addictive substances, Reynolds, Richards, Horn and Karraker (2004) examined the devaluation of monetary rewards as a function of delay or probability in both smokers and non-smokers. Results indicated that smokers discounted significantly more than non-smokers in both delay and probability, seemingly indicative of the individual differences in impulsivity between those in the smoking and non-smoking groups Similarly, Mitchell (1999) found that smokers, on delay discounting tasks, chose smaller immediate monetary rewards over larger delayed monetary rewards more frequently than their non-smoking counterparts.

Researchers have also investigated the discounting rates of individuals addicted to illicit substances. For instance, Kirby, Petry, and Bickel (1999) found that the delay-discounting rates of monetary rewards for heroin users were twice those of the non-heroin users, and that discount rates were positively correlated with impulsivity. Madden, Petry, Badger, and Bickel (1997) found a similar pattern in terms of delay-discounting of monetary rewards and also found that opioid-dependent participants discounted delayed heroin significantly more then delayed money.

The discounting rates of those addicted to alcohol have been investigated as well. Specifically, Petry (2001) evaluated delay-discounting rates in current alcoholics, currently recovering alcoholics and controls for both money (whose magnitude for delayed rewards differed between $1,000 and $100) and alcohol (whose magnitude for delayed rewards differed between 150 and 15 bottles of an alcoholic beverage as rewards). Results showed that the most rapid discounting for both types of rewards (and magnitudes) occurred in active alcoholics, followed by currently recovering alcoholics and control. Similarly, Vuchinich and Simpson (1998) found that heavy social drinkers had steeper delay discounting rates than light drinkers in both a small magnitude monetary condition (i.e., a condition where the fixed monetary value was $1,000) and a large magnitude monetary condition (i.e., a condition where the fixed monetary value was $10,000).

In sum, it would appear that addiction affects how one discounts. Specifically, those suffering from addiction tend to have steeper discounting rates across a multitude of commodities (e.g., the addictive substances, money etc.) than those not suffering from addiction. That is, there appears to be a positive correlation between addiction and discounting rates (i.e., as the severity of an addict's addiction increases, so do their discounting rates).

The present study aims to expand the literature on delay and probability discounting and its relation to abused substances by comparing the delay and probabilistic discounting rates of James Madison University undergraduates for alcohol-related commodities. These tasks will be framed in terms of rewards and costs (i.e., gaining a specific amount of money or alcohol or losing a specific amount of money or alcohol). The researchers also hope to determine the degree to which Equation 1 can predict the general discounting trends found in the study. Furthermore, researchers will analyze the different variables that could be affecting the discounting rates of delayed and probabilistic commodities (e.g., impatience, risk, whether the commodity is being framed as a gain or loss).

Considering that previous research has indicated that a large number of drug related rewards are discounted in terms of both delay and probability (e.g., Holt et al., 2003; Kirby et al., 1999; Madden et al., 1997; Mitchell, 1999; Petry, 2001; Reynolds et al., 2004; Vuchinich & Simpson, 1998), it is hypothesized that the present drug-related reward (alcohol) will follow a similar pattern. Although there is limited research on the topic, it is hypothesized that the alcohol-related losses would be discounted in terms of delay and probability as well. Furthermore, because it has been shown that hyperbolic functions have been able to adequately predict discounting rates in terms of both delay and probability (e.g., Green & Myerson, 2004; Holt et al., 2003; Kirby et al., 1999; Madden et al., 1997; Mitchell, 1999; Myerson et al., 2003; Petry, 2001; Raineri & Rachlin, 1993; Rachlin et al., 1987; Reynolds et al., 2004; Vuchinich & Simpson, 1998), it is hypothesized that Equation 1 will accurately predict the discounting rates found throughout the study. Finally, it is hypothesized that aggregate-level delay discounting data (i.e., aggregate delay, "gain" discounting data and aggregate delay, "loss" discounting data) will be significantly correlated with one another, as will aggregate probabilistic discounting data (i.e., aggregate probabilistic, “gain” discounting data and aggregate probabilistic, “loss” discounting data).

Method

Participants

Participants were 10 undergraduate students (8 women and 2 men) currently enrolled in general psychology classes at James Madison University (JMU). Each volunteered for the study via the JMU participant pool. All received partial course credit as compensation for their participation.

Materials

Three computers (PC) equipped with Windows XP and decision-making software were used in the study. The decision-making software was used to implement the discounting procedure used in the task.

Procedure

Upon entering the lab and giving consent, participants were directed to begin the discounting procedure, which was previously loaded onto the computer where they were instructed to sit. In the procedure, participants were asked to make decisions regarding different amounts of alcohol. These choices varied in terms of delay or probability and in terms of gains or losses.

In alcohol "gain" and delay conditions, participants were asked whether they would rather receive a smaller, immediate amount of alcohol or a larger, delayed amount of alcohol (e.g., gain 12 alcoholic drinks now or 24 alcoholic drinks in 1 month). The definition of a drink was up to the interpretation of the participant (e.g., beer, wine, liquor etc.). In the alcohol "gain" and probability conditions, participants were asked whether they would rather receive a smaller, certain amount of alcohol or a larger, less certain amount of alcohol (e.g., gain 12 alcoholic drinks for sure or 24 alcoholic drinks with a 55% chance). In the alcohol "loss" and delay conditions, participants where asked whether they would rather "dump out" (and thus permanently lose) a smaller, immediate amount of alcohol or a larger delayed amount of alcohol (e.g., dump out 12 alcoholic drinks now or 24 alcoholic drinks in 1 month). In the alcohol "loss" and probability conditions, participants were asked to chose whether they would rather "dump out" a smaller, certain amount of alcohol or a larger, les certain amount of alcohol (e.g., dump out 12 alcoholic drinks for sure or 24 alcoholic drinks with a 75% chance).

There were five delay conditions (1 week, 1 month, 3 months, 6 months and 1 year) and five probability conditions (10%, 30%, 55%, 80% and 95%), each crossed with the varying frames (i.e., gain or loss). The order of the tasks in each condition was randomly assigned, as was the order of the small and large amounts within each task.

At each delay and probability condition, participants made six choices. To determine an indifference point within each group of six, researchers utilized a staircase procedure similar to the one outlined by Estle, Green, Myerson and Holt (2003). Specifically, after participants made one of their six choices, the discounting software automatically adjusted the immediate or certain amount (thus making it more or less valuable) so as to converge on an immediate amount that was equal in subjective value to the delayed amount. For example, if the initial scenario was "would you rather have 20 alcoholic beverages now or 40 in one month?," and the participant chose the immediate amount, the delayed amount would increase by half the value between the immediate and delayed amount. Thus, the next scenario would read, "would you rather have 20 alcoholic beverages now or 50 in one month?" If the participant then chose the delayed amount, this amount would decrease by half the value of the first delayed amount and the current delayed amount. Thus, the next scenario would read, "would you rather have 20 alcoholic beverages now or 45 in one month?" This process would then repeat an additional three times before moving on to the next condition. In total, 20 indifference points were collected per participant: five from the delay "gain" alcohol conditions; five from the probability, "gain" alcohol conditions; five from the delay "loss" alcohol conditions; and five from the probability, "loss" alcohol conditions.

The results of the discounting procedure were not associated with the participants name or any other information identifier so as to keep all information collected strictly confidential. This precaution was especially important given the fact that some participants during the study may have disclosed counts of illicit activity (e.g., underage drinking). In order to link participants' results for the discounting procedure and survey, researchers instead used the participants' genders and dates of birth.

The discounting task 1 hour for any of the participants. Once completed, participants were debriefed and the experiment was concluded.

Results

Discounting Tasks

Figure 1 presents the median subjective value of the delayed (top graph) and probabilistic (bottom graph) gains and losses, plotted as a function of the delay until or odds against receiving each gain or loss. In each condition, discounting was evident. Specifically, as the delay until or the odds against receiving or losing alcoholic beverages increased, the subjective value of the beverages decreased. In the delay conditions, participants tended to discount gained alcoholic beverages more than lost alcoholic beverages. This indicates that participants were less willing to wait for appetitive commodities than they were for aversive ones. In the probability conditions, gains, once again, were discounted more steeply than losses. This indicates that participants were more willing to risk a potential aversive loss than a potential appetitive gain. That is, they were more willing to gamble the possibility of avoiding an aversive loss than a possible appetitive gain.

The curves in each graph represent the fit of Eq. (1) to the median indifference points. For the curve in the delay "gain" condition, R^2 = 0.998, s = 0.753 and k = 0.169. For the curve, in the probability "gain" condition, R^2 = 0.553 s = 0.625 and k =6.099. For the curve in the probability "loss" condition R^2 = 0.452, s = 0.832 and k = 1.142. Finally, for the curve in the delay "loss" condition, R^2 = 0.000 s = 0.138 and k = 0.254. Thus, Eq. (1) had the strongest predictability and fit in the delay "gain" condition followed by the probability "gain" condition, the probability "loss" condition and the delay "loss" condition. In general, larger k values indicate steeper rates of discounting while smaller k values indicate shallower rates of discounting.

Area Under the Discounting Curve (AUC)

Area under the curve (AUC) values were used to determine the degree of correlation between both delay conditions (gain and loss) and also both probability conditions (gain and loss). AUC provides a single value indicating the extent to which a delayed or probabilistic commodity is discounted. It is calculated on the basis of separate proportions (i.e., the subjective value of a commodity as a proportion of value of the maximum commodity and the delay until or odds against receiving the commodity as a proportion of the maximum delay or odds against) (Myerson, Green & Warusawitharana, 2001). In general, smaller AUC's reflect steeper rates of discounting. This is contrary to *k* values where a larger *k* value indicates steeper rates of discounting. AUC measures for the obtained subjective values were used as apposed to the AUC measures under the theoretical curve given the fact that different theoretical discounting functions have been utilized in prior research. Table 2 indicates the areas under the curve for each participant in each condition.

In terms of delay discounting, a Pearson correlation revealed that there was no significant correlation between the gain and loss conditions, $r = -.360$, $p = .306$. As a result, no reliable prediction can be made as to the rate of discounting between delay gains and losses. In terms of probability discounting, a second Pearson correlational analysis reveled that there was no significant correlation between the gain and loss conditions, $r = -.403$, $p = .248$.

Discussion

The present study sought to expand the literature on delay and probabilistic discounting and its relation to substances of abuse by comparing the delay and probabilistic discounting rates of alcoholic beverages by undergraduates at James Madison University. Additionally, the researchers sought to analyze the extent to which Eq. (1) could describe the general delayed and probabilistic discounting trends found in the study. Finally, the researchers wished to analyze potential variables that could be affecting the rates found in participants (e.g., impatience, risk, whether the commodity is being framed as a gain or loss).

In line with the findings of previous studies regarding discounting and substance abuse (e.g., Holt et al., 2003; Kirby et al., 1999; Madden et al., 1997; Mitchell, 1999; Petry, 2001; Reynolds et al., 2004; Vuchinich & Simpson, 1998), the present study illustrated that discounting of alcoholic beverages in terms of delay and probability does occurred within college undergraduates. In terms of temporal discounting, losses were discounted more steeply than delayed gains, indicating that participants were more willing to wait for, or essentially "push off," a delayed loss then a delayed gain. In other words, participants were less patient when presented with delayed gains as opposed to delayed losses. In terms of probabilistic discounting, losses were again discounted less steeply, indicating that participants were more willing to risk a potential loss than a potential gain. In other words, participants were more risk averse when presented with potential gains then losses. In general, previous research tends to support the trends found in the data. For instance, Estle, Green, Myerson and Holt (2006) found that across delayed and probabilistic gain and loss conditions, gains were discounted more steeply then losses. Additionally, Murphy, Kucinich and Simpson (2001) found that participants discounted delayed rewards to a greater extent then delayed losses.

Because a Pearson correlation revealed no significant correlation between the two delayed conditions (i.e., gains and losses) and because a second correlational analysis revealed no significant correlation between both probability conditions (i.e., gains and losses) it would appear that these processes are independent events, contrary to the above hypothesis. Thus, predictions cannot be made between delayed gain and loss conditions or between probabilistic gain and loss conditions. With that said, because of the limited sample size of the study, the study may have limited power, which could potentially explain the lack of significant correlation. That is, there may indeed be a correlation between the delay conditions and a correlation between the probability conditions but the study lacks the power to detect it.

Contrary to previous research illustrating that hyperbola like equations have been able to adequately describe the rates of delayed and probabilistic discounting (e.g., Green & Myerson, 2004; Holt et al., 2003; Kirby et al., 1999; Madden et al., 1997; Mitchell, 1999; Myerson et al., 2003; Petry, 2001; Raineri & Rachlin, 1993; Rachlin et al., 1987; Reynolds et al., 2004; Vuchinich & Simpson, 1998), the present study, overall, illustrates that Eq. (1), a hyperbola-like equation, was not as strong of a descriptor of the discounting rates found throughout the study. Specifically, excluding the delay gain condition, group level median R^2 values averaged to .335. This value is significantly less then the R^2 values found in previous research, which tend to be in the .800 and .900 range.

A potential explanation as to why the group level R^2 values were so low as compared to past research is the notion that our sample of participants was simply to small to mimic the actual group level discounting rates of college undergraduates. With a sample size of only 10 students, this is certainly in the realm of possibility and a significant limitation to the above study. Another potential explanation as to why R^2 values tended to be so low, at least in the loss conditions, was general task confusion. Because loss conditions tended to pose scenarios that are rarely seen in real life situations, many participants during experimentation became confused and were forced to stop and ask questions. Even after questions were answered, it is possible that participants still remained slightly confused and thus tended to make erratic choices.

Given the findings of the present study and its limitations, future research should aim to use a sample much larger then the one used here so as to determine the validity of these findings. To specifically tackle the issue of task confusion, future replications of this study should provide a multitude of practice scenarios to help the participant become accustomed to the loss scenarios they will experience in the task. This process should help to eliminate confusion and subsequently lead to more predictable responding. Additionally, future research should seek to determine other variables besides gains and losses and delay and probability that could be affecting the discounting rates of those sampled. For instance, a study analyzing various commodities (e.g., alcohol related commodities and money), varying commodity magnitudes (e.g., a small and large commodity amount), varying substance abuse levels (e.g., non-drinkers, social drinkers and heavy drinkers), gains and losses and their subsequent effect on delayed and probabilistic discounting could have drastic implications for the present state of discounting research. Specifically, if it were found that various commodities commodity magnitudes, and substance abuse levels, significantly affect rates of discounting in terms of delay, probability and gains and losses, it would indicate that these factors are underlying variables affecting an individual's decision-making processes. Furthermore, such an understanding of these variables would lend itself nicely to better predicating the discounting rates of individuals in the future. That is, it will help rationalize and make sense of an individual's general decision making processes from situation to situation. Equipped with this type of understanding, researchers may be in a better position to implement therapeutic interventions that have the potential to serve both as a predictor for future problems in certain individuals and as a predictor of treatment outcomes for these individuals.

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Table 1

Area under the curve for each participant for each delay and probability condition

Participant	Delay		Probability	
	Gains	Losses	Gains	Losses
1	0.3290	0.8657	0.3033	0.5304
2	0.3579	0.4390	0.0835	0.7364
3	0.7431	0.7629	0.1686	0.3509
4	0.5772	0.2263	0.3750	0.2210
5	0.4252	0.6680	0.3285	0.2263
6	0.3176	0.3819	0.2954	0.6631
7	0.1758	0.9930	0.0341	0.3874
8	0.7275	0.5628	0.2361	0.3513
9	0.1067	0.7960	0.1070	0.5304
10	0.3591	0.7888	0.2409	0.3785
Mean	0.4119	0.6424	0.2172	0.4376

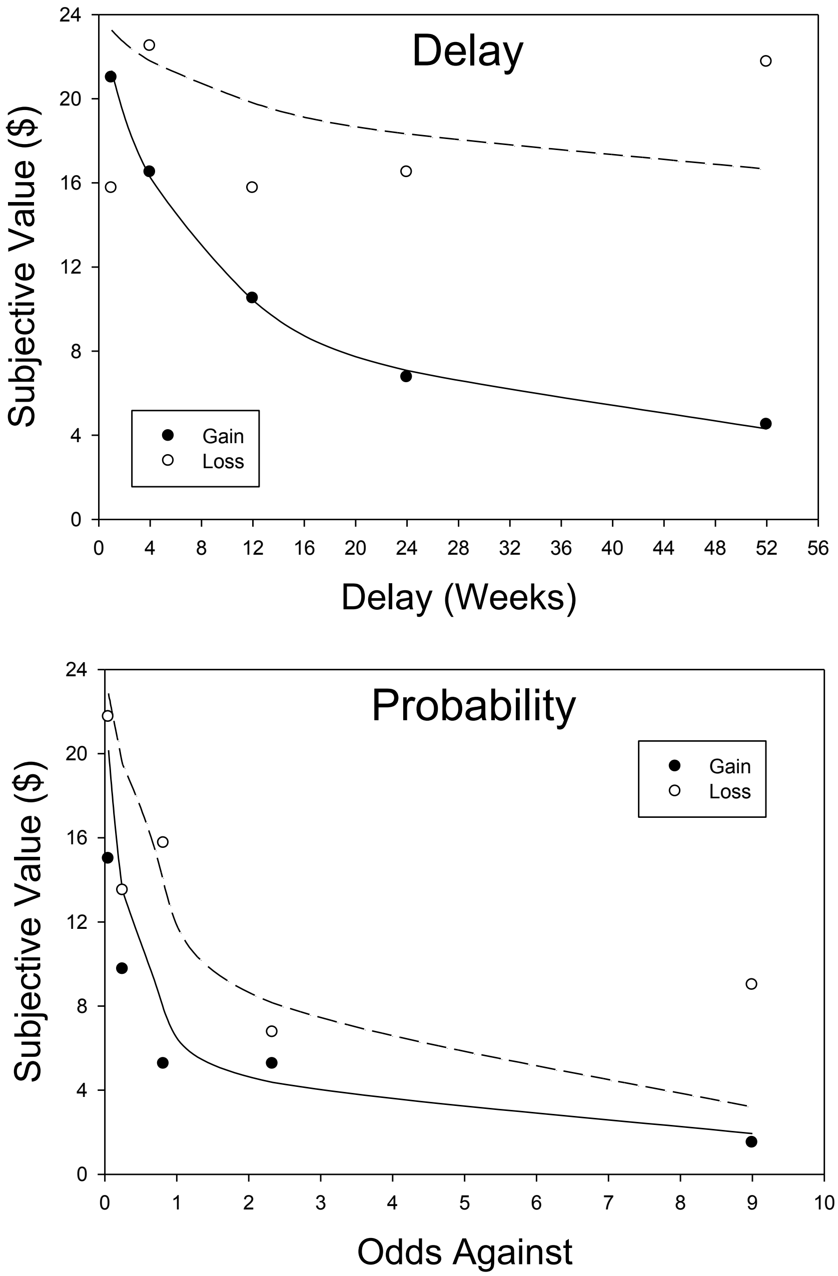

Figure 1. Subjective value as a function of the delay until or odds against the receipt of an alcohol related reward or loss for college undergraduates. The top graph represents the median delay discounting rates for delayed gains or losses while the bottom graph represents the median probabilistic discounting rates for gains and losses.