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Exchanging the liquidity hypothesis: Delay discounting of money and self-relevant non-money rewards

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Abstract

Evidence that primary rewards (e.g., food and drugs of abuse) are discounted more than money is frequently attributed to money's high degree of liquidity, or exchangeability for many commodities. The present study provides some evidence against this liquidity hypothesis by contrasting delay discounting of monetary rewards (liquid) and non-monetary commodities (non-liquid) that are self-relevant and utility-matched. Ninety-seven (97) undergraduate students initially completed a conventional binary-choice delay discounting of money task. Participants returned one week later and completed a self-relevant commodity delay discounting task. Both conventional hypothesis testing and more-conservative tests of statistical equivalence revealed correspondence in rate of delay discounting of money and self-relevant commodities, and in one magnitude condition, *less* discounting for the latter. The present results indicate that liquidity of money cannot fully account for the lower rate of delay discounting compared to non-money rewards.

Keywords

delay discounting; exchangeability; choice

Introduction

1.1

Rewards available in the future are often valued less than smaller rewards that are immediately available. This tendency to devalue future rewards is known as *delay discounting*, and is associated with increased risk for many impulsive behaviors (Crean, de Wit, & Richards, 2000) including drug dependence (Reynolds, 2006; Yi, Mitchell, & Bickel, 2010), excessive drinking (Petry, 2001; Vuchinich & Simpson, 1998), pathological and problem gambling (Dixon et al., 2003; Petry, 2001), lack of financial planning (Angeletos, Laibson, Repetto, Tobacman, & Weinberg, 2001), overeating (Weller, Cook, Avsar, & Cox.,

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2008; Rasmussen, Lawyer, & Reilly, 2010), physical inactivity (Daugherty & Brase, 2010), HIV-risk (Odum et al., 2000; Chesson et al., 2006), and increased risk for mortality (Boyle, Yu, Gamble, & Bennett, 2013). In contrast, low rates of delay discounting are associated with health-enhancing behaviors (e.g., wearing safety belts and sunscreen; Daugherty & Brase, 2010). Thus, a better understanding of delay discounting processes could inform approaches to enhance decision making associated with numerous health-relevant outcomes.

Typical delay discounting procedures ask individuals to choose between a smaller reward available immediately and a larger reward available following a delay. Until recently, most delay discounting research with humans has focused on monetary rewards (Tsukayama & Duckworth, 2010; Frederick, Loewenstein, & O'Donoghue, 2002). However, an accumulating body of evidence indicates that delay discounting of consumable rewards such as food, tobacco, alcohol, and illicit drugs are discounted at a higher rate than a comparable amount of money (Bickel, Odum, & Madden, 1999; Estle, Green, Myerson, & Holt, 2007; Friedel, DeHart, Madden, & Odum, 2014; Giordano et al., 2002; Jiga-Boy, Storey, & Buehner, 2013; Odum & Rainaud, 2003; Odum & Baumann, 2007; Odum, Baumann, & Rimington, 2006).

One early explanation for this pattern of results, particularly when observed for drug rewards, was that the reinforcing efficacy for immediately consumable rewards was elevated relative to money (Giordano et al., 2002; Madden, Bickel, & Jacobs, 1999) and triggered visceral responses (Loewenstein, 1996); in other words, oversensitivity to immediate rewards was particularly pronounced for drug rewards (Eppinger, Nystrom, & Cohen, 2012). While this likely explains part of the phenomenon, it has been proposed more recently (e.g., Estle et al., 2007; and others) that the lower rate of delay discounting for money is due to the fact that money retains utility over time because it is exchangeable for many things (see also Charlton & Fantino, 2008); i.e., money has the characteristic of *liquidity*¹. According to this view, the functionality of less liquid commodities may fluctuate due to an “inconstancy of desire” (Estle et al., 2007, p. 62), and thus have a level of utility subject to diminishing.

Consider a non-liquid commodity such as a hamburger costing \$10 delayed by 1 week. Even an individual who typically enjoys hamburgers knows that s/he may not have an appetite for the hamburger when the week has passed and it is available to be consumed; this non-liquid commodity may be discounted at a steep rate. In contrast, an equivalent money amount could be used to purchase a variety of commodities consistent with his/her future needs or desires (including the hamburger). As a result of this liquidity, money is more likely to be discounted at a shallow rate. In summary, delayed money guarantees individual flexibility to maximize future utility, while a delayed commodity constrains individual capacity to maximize future utility. This liquidity hypothesis is supported by research that has found higher rates of delay discounting of commodities such as entertainment (Friedel et al., 2014).

¹The term *fungibility* has been used interchangeably in this literature with the term *liquidity*, though *fungibility* specifically refers to a commodity's capability to be mutually substituted for itself.

Helpful in parsing these explanations is research implementing *cross-commodity* delay discounting tasks. Specifically, one study by Bickel and colleagues (2011) examined delay discounting of money and cocaine by cocaine-addicted individuals. Binary-choice delay discounting tasks were completed, where the immediate/delayed rewards were: money/money, cocaine/cocaine, money/cocaine, and cocaine/money. If oversensitivity to immediate drug rewards caused higher delay discounting of drugs compared to money, the highest rates of delay discounting would have been observed in cocaine/money and cocaine/cocaine conditions. In contrast, the rank order of delay discount rates (from highest to lowest) was: money/cocaine, cocaine/cocaine, cocaine/money, and money/money. These results provide evidence against the oversensitivity hypothesis and partial support for the liquidity hypothesis, as preference was typically biased towards the money alternative independent of delay (i.e., high and low rates of delay discounting in the money/cocaine and cocaine/money conditions, respectively).

1.2 Present Study

A noteworthy feature of the study by Bickel and colleagues (2011) was that participants were treatment-seeking cocaine users who would putatively disprefer the availability of (particularly delayed) cocaine. Thus, the purpose of the present study was to explore a hypothesis similar, but distinct, from the liquidity explanation. Specifically, we believe that the higher rates of delay discounting for non-liquid commodities in much of previous research is due to the fact that, like delayed cocaine for individuals seeking to stop using cocaine in the Bickel study, the delayed commodity may not have future utility for the individual. Even in studies where participants were allowed to specify a preferred item within a commodity category (e.g., preferred food item and alcoholic beverage; Odum and Rainaud, 2003), the commodity category likely constrained potential utility of the delayed commodity. Moreover, this constraint could have resulted in differences in motivation to maximize money and the commodity (the *motivational account* proposed by Paglieri, Addessi, Sbaiffi, et al., 2015). The present hypothesis is that delay discounting of self-relevant and utility-matched commodities, by virtue of minimizing constraint on commodities that have future utility at the individual level, will be equivalent to delay discounting of money.

In the first of two sessions, participants completed a conventional binary-choice (immediate vs. delayed) delay discounting of hypothetical money task. After completing this assessment, participants were asked to identify how they would spend the immediate and delayed sums of money in each binary choice of the delay discounting task. In the second session, the monetary amounts in the delay discounting task of session 1 were replaced with participant- and trial-specific commodities. As the self-relevant commodities are less liquid than money, greater delay discounting of commodities compared to money would be consistent with the liquidity hypothesis. We hypothesized equivalence in rate of delay discounting of money and self-relevant commodities, suggesting that liquidity alone cannot account for greater delay discounting of non-monetary commodities.

Method

2.1 Participants

Ninety-seven (97) undergraduate psychology students (Mean age was 19.45 years [2.46]; 73.3% female) from the University of Maryland, College Park, were recruited for a two-session study, and received course credit for participation.

2.2 Materials

Money Delay Discounting—The original 27-item Monetary Choice Questionnaire (MCQ; Kirby, Petry, & Bickel, 1999) uses 9 items to determine a delay discount rate for each of three magnitudes (small, medium, large). Each binary choice item requires the participant to indicate preference between a delayed amount of money (7 days – 186 days) and a smaller, immediate amount of money. Because of some very short delays (e.g., 7 days) and significant overlap in the money amounts across the magnitude conditions in the MCQ, a modified delay discounting assessment was created with no magnitude condition overlap and only longer delays (89 - 186 days). The resulting 18-item money delay discounting (Money DD; Table 1) assessment included nine items based on the medium magnitude items from the original MCQ, with the delays for some items adjusted so that all delays were at least 89 days. In order to keep scoring identical to the MCQ, the amount of the immediate alternative was concurrently adjusted so that the associated rate of delay discounting (k) remained the same with the MCQ. The remaining nine items for a large magnitude condition were created by multiplying the amounts of the medium magnitude items by 10 while keeping the delays the same. Our rationale for magnitude conditions with minimal overlap was to allow for greater distinctions and flexibility in the subsequent commodity discounting assessment.

Commodity Identification Assessment—Following completion of the Money DD assessment, participants were asked to write specifically what they would do with each of the immediate and delayed money amounts in the 18 binary-choice items, given their respective values and delays. Participants were allowed one line of text per item, and were reminded to respond to both immediate and delayed reward scenarios separately, regardless of their choices on the Money DD assessment, and to be specific (e.g., specify “video games” rather than broadly “electronics”).

Commodity Delay Discounting (Commodity DD)—Before second session appointments, research staff prepared a custom-made cross-commodity delay discounting assessment for each participant, where all items directly paralleled items on the Money DD assessment in terms of value and delay, and substituted monetary rewards with the actual uses for money listed in each participant’s commodity identification assessment on a per-item basis; custom questionnaires included commodities written just as the participant had written them, with minor adaptations for readability in the new format. For example, “dinner with my friends” on the Commodity Identification Assessment response for \$50 today became “Would you rather have: dinner with your friends (valued at \$50) today”. Where responses on the commodity identification assessment were not fully covered by the reward value, the Commodity DD assessment modified wording (e.g., “tuition” became “a tuition

payment (valued at \$350).” The resulting 18-item assessment, prompted participants to choose between one commodity available immediately and another (which could be the same or different) commodity available following a delay.

2.3 Procedure

During session 1, participants provided informed consent and completed a brief demographics questionnaire. They then completed the Money DD task, followed by the commodity identification assessment. Before dismissing participants, research staff examined responses on the commodity identification assessment and clarified unknown or ambiguous commodities. Participants returned for session 2 exactly one week later, and completed the Commodity DD task.

2.4 Data Analysis

Discount rates (k) for Money DD and Commodity DD were calculated for each participant at both medium and large reward magnitudes, consistent with the approach of Kirby and colleagues (1999). Natural-log transformations of discount rates were performed to normalize skewed distributions. Discount rates for Money DD and Commodity DD were compared using a 2 (money vs. commodity) $\times$ 2 (medium vs. large magnitude) repeated measures ANOVA. To test for statistical equivalence between Money DD and Commodity DD by magnitude, we utilized the inferential confidence interval method (ICI; Tryon, 2001; Tryon & Lewis, 2008) as done previously to establish equivalence among measures of delay discounting (Yi, Pitcock, Landes, & Bickel, 2010). ICIs are created by reducing the standard descriptive 95% confidence interval by a mean E (a reduction factor which accounts for the sample size and standard deviation of each group being compared, considering their correlation as dependent means) such that ICIs are algebraically equivalent to a null hypothesis test. Under this method, to meet the statistical threshold for equivalence, the ICIs for each dataset must overlap, and their range (the upper confidence interval of the greater mean parameter minus the lower confidence interval of the lower mean parameter, R_g) must be less than an *a priori* range of inconsequence (in our case, range of the 95% Confidence Interval for the Money DD or Commodity DD). Statistical non-equivalence is reported when two ICIs do not overlap (Tryon, 2001).

Results

3.1 Commodity Identification

Participant responses for the Commodity Identification were varied (Table 2), though common responses included items that were necessities (e.g., groceries, bills, tuition), non-necessities (e.g., electronics, concert tickets), and savings. For participants who responded they would use monetary amounts toward “savings,” the replacement “money to save” was employed in the Commodity DD assessment to reflect decreased liquidity at time of receipt.

3.2 Money versus Commodity Delay Discounting

Table 3 shows point estimates and summary statistics of $\ln(k)$ for each choice questionnaire by magnitude. A two-way ANOVA revealed a statistically significant interaction [$F(1, 94) = 5.19, p = .025, r = 0.23$], with simple effects tests revealing significantly lower discount

rates in the Commodity DD compared to the Money DD in the medium magnitude condition [$p = .005$; difference = 0.62, CI = (0.19, 1.05)] but no difference in the large magnitude condition [$p = .839$; difference = 0.04, CI = (-0.33, 0.41)]. Despite the significant interaction, we report that the main effect for reward magnitude was significant [$F(1, 94) = 154.43, p < .001, r = 0.79$], with a lower discount rate in the large magnitude ($M = -6.47, SE = 0.14$) compared to the medium magnitude ($M = -4.84, SE = 0.16$). The main contrast of Money DD and Commodity DD was also significant [$F(1, 94) = 4.38, p = .039, r = 0.21$], with lower discount rates for Commodity DD ($M = -5.82, SE = 0.17$) than for Money DD ($M = -5.49, SE = 0.13$).

For the test of statistical equivalence, we established a mean E (reduction factor) to produce ICIs for Money DD and Commodity DD at both reward magnitudes. Figure 1 plots ICIs for both conditions, by magnitude. The ICIs for the medium magnitude do not overlap, indicating that discount rates are statistically different (e.g., not equivalent). In contrast, the ICIs for the large magnitude do overlap. To next test for equivalence between assessments in the large magnitude condition, we established the ICI range (Rg) and an *a priori* range of inconsequence (the 95% Confidence Intervals shown in Figure 2). The Rg is within the Delta bar established by the 95% Confidence Interval [$Rg (.41) < Delta (.59)$], indicating that discount rates for the large magnitude Money DD and Commodity DD are equivalent.

Discussion

4.1

The present study examined whether high rates of delay discounting typically observed for non-monetary rewards could be accounted for by non-liquid commodities that were self-relevant and utility-matched. The primary analysis supported the hypothesis that discount rates for non-liquid commodities that are self-relevant for individuals are *not* greater than discount rates for equivalent amounts of (highly liquid) money, and discounted *less* in the medium-magnitude condition. Importantly, we did not rely on conventional hypothesis testing to conclude equivalence between discounting of money and commodity conditions. Rather, we applied the more-stringent criterion of statistical equivalence.

This pattern of results suggests that “inconstancy of desire” (Estle et al., 2007) does not necessarily result in higher rates of delay discounting of non-liquid rewards relative to liquid rewards. Rather, greater discounting of commodities in previous research relative to money appears to be a function of the specific commodities used. When making decisions for a commodity that has delayed utility, as specified by the individual in the present study, rate of delay discounting is equivalent if not diminished relative to discounting of money. This is a small but perhaps significant distinction from the liquidity hypothesis. The results are consistent with the recently proposed *motivational account* of Paglieri and colleagues (2015), which hypothesizes that the high rate of delay discounting of non-money commodities is due to lower baseline motivation to maximize the reward, independent of delay. The present study, by allowing the individual to specify non-liquid commodities that s/he values in the future, may have functionally equated baseline motivation to maximize both the money and non-money outcomes.

In comparing discount rates for money versus other commodities, the present study is the first study that has tailored commodities on an individual level in order to maximize self-relevance. While some previous studies incorporated somewhat self-relevant consumable commodities (e.g. preference for chips vs. beer vs. candy; Tsukayama & Duckworth, 2011, or favorite foods; Odum & Rainaud, 2003), only single-commodity tasks that did not address commodity relevance for both immediate and delayed outcomes were employed. By ensuring in the present study that the delayed alternative maintained utility to the individual, we believe the results illuminate another possible reason that a drug-dependent individual (for instance) prefers immediate rather than delayed drug: not only is an immediately available drug appetitive, but a delayed drug has diminished utility for additional reasons other than delay. One can imagine that the prospect of delayed availability of drugs, alcohol, cigarettes, fattening foods, and other health-compromising commodities has disutility to an individual who hopes to minimize exposure to those commodities in the future. Single-commodity discounting tasks for certain commodities may equate to a choice between reward now and non-reward later.

Lastly, our study underlines the already-established importance of considering reward magnitude in studies of delay discounting. Though reward magnitude was a main effect throughout all analyses, with larger rewards being associated with lower discount rates within all task types, a significant interaction also indicated while discount rates were equivalent for money and commodities for large reward magnitudes, Commodity DD was significantly lower for medium magnitude commodities relative to money. This effect indicates relative preference for the delayed commodity in the medium magnitude condition, while no similar effect was observed in the large magnitude condition. The distribution of selected commodities (Table 2) may provide some insight into this pattern. For example, bills (including tuition, food, and groceries) was the most common immediate commodity in the medium magnitude condition. However, given the small immediate values of these commodities (as small as \$2), one could examine that a college student might be more willing to wait for any delayed commodity that is worth substantially more (i.e., \$50-\$60). In contrast, even the smallest value of the immediate commodity in the large magnitude condition (\$20) may prove useful towards any of the commodity categories.

The present results should be considered in light of study limitations. First, the time and effort required to create customized commodity choice questionnaires restricted our study design such that the discounting of money condition always preceded the discounting of commodity condition. While counterbalancing is possible, obtaining the information to customize the delay discounting task without first completing the discounting of money condition would have been difficult. Furthermore, counterbalancing would have resulted in the unusual requirement of initial exposure to the Money DD condition without assessing choice, followed by assessment of choice on those items one week later. Importantly, we note that this fixed order of assessment (money first, commodity second) is not uncommon in research that has found higher rates of delay discounting for commodities relative to money; order is an unlikely explanation for the present results.

A second limitation is that some participants did respond that they would use money for “savings” or “pay bills” in the commodity identification assessment. Inclusion of such

options in the commodity tasks does result in somewhat more-liquid commodities than other consumables (food or electronics, for example). We do note however that savings or paying bills is still *less* liquid than cash with no qualifiers, and our broad efforts to restricting exchangeability did not make future rewards less desirable. Lastly, our findings are limited by our convenience sample of college students. Though monetary choice intentions may be different for this population than the broader population, the commodity identification assessment responses reflected a wide range of uses for money, from practical applications (e.g.: food, gas, and student loan payments) to those that are more recreational (alcohol, electronics, and concert tickets).

Despite these limitations, results from the present study suggest an alternative explanation for the oft-cited increased discounting for consumable commodities compared to money; neither the degree to which a commodity is consumable nor liquid can fully explain this effect. Commodities that are self-relevant such that they are known to have future utility do not appear to be discounted more than highly-liquid commodities like money.

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Highlights

- Non-monetary commodities are delay discounted more than money.
- The liquidity of money has been proposed to explain this phenomenon.
- The present study compared delay discounting of self-relevant commodities to money.
- Statistical equivalence was observed between conditions, providing evidence against the liquidity hypothesis.

Figure 1.

Inferential Confidence Intervals (ICI) for statistical difference between delay discount rate ($\ln k$) for Money and Commodity at each magnitude. ICIs for the medium magnitude condition do not overlap, which indicates that Money DD and Commodity DD measures are *different* at the medium magnitude. ICIs for the large magnitude questionnaires do overlap, indicating that Money DD and Commodity DD measures are *not different* at the large magnitude.

Figure 2.

Test for statistical equivalence between delay discount rate ($\ln k$) for the large magnitude Money and Commodity assessments depicts the ICIs and their range (R_g , which is the difference between the upper limit of the higher mean and the lower limit of the lesser mean). R_g is within the Delta bar, indicating that discount rates are statistically equivalent.

Table 1

Items from the Money Delay Discounting Assessment.

Order	Immediate Amount	Delayed Amount	Delay	Magnitude	Discount Rate (k)
18	\$54	\$55	117	medium	.0002
14	\$540	\$550	117	large	.0002
6	\$47	\$50	160	medium	.0004
8	\$470	\$500	160	large	.0004
4	\$54	\$60	111	medium	.0010
12	\$540	\$600	111	large	.0010
1	\$49	\$60	89	medium	.0025
15	\$490	\$600	89	large	.0025
3	\$35	\$55	92	medium	.0062
13	\$350	\$550	92	large	.0062
5	\$16	\$50	133	medium	.016
9	\$160	\$500	133	large	.016
17	\$9	\$50	114	medium	.040
2	\$90	\$500	114	large	.040
11	\$4	\$60	140	medium	.10
16	\$40	\$600	140	large	.10
10	\$2	\$55	106	medium	.25
7	\$20	\$550	106	large	.25

Table 2

Percentage in Each Classification of Selected Commodities in the Commodity Identification Assessment, Separately by Magnitude and Immediate/Delayed.

Commodity	Medium Magnitude		Large Magnitude	
	Immediate	Delayed	Immediate	Delayed
Bills ^A	45.79%	19.48%	20.00%	13.33%
Entertainment ^B	12.11%	19.78%	22.48%	32.92%
Save	11.47%	19.58%	22.29%	25.85%
Clothing	12.53%	21.69%	16.70%	8.77%
Transportation ^C	4.95%	7.63%	5.60%	8.14%
Drugs/Alcohol	3.16%	2.01%	2.94%	2.50%
Other ^D	10.00%	9.84%	10.00%	8.50%

^A - bills, tuition, food, groceries;

^B - travel, electronics, recreation, shopping;

^C - car, gas, public transportation;

^D - gifts, personal hygiene, health, home improvement, wallet money

Table 3

Descriptive Statistics for Discounting Parameters for the Money and Commodity DD Assessments.

Discounting Condition	Mean k	Mean $\ln(k)$	r	t_{95}	E	t_x	SE	ICIs	95% CI
Medium Reward DD									
Money	.0109	-4.52	.37	1.99	0.58	1.15	.15	(-4.70, -4.35)	(-4.83, -4.22)
Commodity	.0059	-5.14	--	--	--	--	.22	(-5.40, -4.89)	
Large Reward DD									
Money	.0014	-6.55	.41	1.99	0.55	1.10	.15	(-6.61, -6.29)	(-6.74, -6.15)
Commodity	.0015	-6.49	--	--	--	--	.19	(-6.69, -6.28)	

Note: ICI = Inferential Confidence Interval