Time discounting for primary and monetary rewards

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July 2008

TIME DISCOUNTING FOR PRIMARY AND MONETARY REWARDS *

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ABSTRACT

This paper shows that there is a positive and statistically significant correlation between the short-term discount rate over a monetary reward and the short-term discount rate over a primary reward (chocolate). This correlation, however, is absent among subjects who do not like chocolate and are not hungry. This suggests that monetary rewards are suitable for the study of intertemporal choice. In fact, given the problems associated with the use of primary rewards (differing tastes for the good, hunger, and possible satiation), we argue that measurement with monetary rewards is more reliable.

Date of this version: July 2008

Keywords: time preferences; hyperbolic discounting; intertemporal choice

JEL classification: C91, D90, D01

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* We thank the Templeton Foundation for financial support.

1. Introduction

There is considerable evidence indicating individuals are highly impatient. In particular, they exhibit higher discount rates in the short run than in the long run (see Frederick et al., 2002).[1] This result has significant implications for how we model intertemporal decision-making (Strotz, 1955-56)—for example in consumption smoothing (Harris and Laibson, 2001; Choi et al., 2006), credit card use (Shui and Ausubel, 2005), participation in 401 (k) programs (Carroll et al., 2007), and global warming (Karp, 2005). To apply the insights of this literature to portfolio choices and policy making, however, it is necessary to obtain reliable estimates of discount rates. This raises the question of what is the best way of measuring short-term time discounting.

The majority of studies that measure short-term discount rates use monetary rewards (e.g. Thaler, 1981; Ainslie and Haendel, 1983; Kirby, 1997). This fact is unsurprising as monetary rewards have numerous advantages over primary rewards, particularly those that have to be consumed straight away. First, unlike with money, consumption of most goods in a short period of time easily leads to satiation, which means the quantities offered have to be relatively small. Second, between-subject comparisons are more complicated with a good as the subjects' desire for it might vary considerably—for example, due to differences in tastes, hunger, etc. Third, goods introduce additional uncertainty with respect to the future, which could confound the results. For example, a subject might be craving cake today but have little idea whether she will crave cake in one month. In contrast, the subjects' desire for money ought to change much less over (short periods of) time. Finally, some goods (like chocolate) are

[1] This behavior is consistent with models of quasi-hyperbolic preferences (Phelps and Pollak, 1968, Laibson, 1997), as well as with models of dual self-conflict (Bernheim and Rangel, 2004; Loewenstein and O'Donoghue, 2004; Fudenberg and Levine, 2006).

not easily divisible in small enough units to provide "reasonable" return to delay gratification.

Unfortunately, the fact that money is fungible might make it inadequate for the measurement of impatience. In particular—even in the controlled environment of laboratory experiments—easy access to credit decouples money from consumption, which poses difficulties for how we interpret intertemporal choices. For example, a common method to measure impatience is to give subjects the choice between a smaller-sooner reward of x and a larger-later one of $(1 + r)x$, where r is the experimental interest rate. By eliciting the r that makes a subject indifferent between x and $(1 + r)x$, the experimenter hopes to infer the rate at which the subject trades off present for future utility. However, since most studies use experimental interest rates that are above the rate at which subjects can borrow outside the lab, it is not clear whether this is actually the case.[2] As argued by Besharov and Coffey (2003), even if preferences are quasi-hyperbolic and individuals are highly impatient (Laibson, 1997), it is better to choose the later-larger reward and use credit to consume straight way. A solution could be to offer experimental interest rates that lie between the subjects' "real-world" borrowing and lending rates (as done by Coller and Williams, 1999). Even in this case, however, Cubitt and Read (2007) demonstrate that choices in the experiment do not necessarily reveal the subjects' time preferences.

It is nevertheless possible that experiments using monetary rewards do tell us something about the subjects' degree of impatience. We do observe that laboratory measures of impatience correlate with behavior that is associated to high discounting of the future. For example, there is a relatively large literature showing that addicts display more impatience in the lab than non-addicts (for a survey see Green and Myerson, 2004). Alternatively, Tucker et al. (2007) show how farmers with high discount rates in the lab are more likely to plant crops with a short harvesting time and

[2] Cubitt and Read (2007) argue that even with primary goods that are immediately consumed there can be confounding effects as subjects save money by consuming inside the lab.

a low yield than crops with a longer harvesting time but a higher yield. Furthermore, in spite of sensibility to different elicitation methods (Read, 2005), measures of impatience using the same method are quite stable (McLeish and Oxoby, 2007).

A possible explanation is that individuals derive some utility from receiving the monetary reward irrespective of whether it is immediately used or not. For instance, looking at the neurological data of individuals performing intertemporal choices, one can see that the same limbic areas are activated with the use of monetary rewards (Mc Clure et al., 2004) and an immediate-consumption good (Mc Clure et al., 2007). Hence, money can be seen as a carrier of reward, which as demonstrated by Knutson et al. (2001), can itself provide a utility jolt when received. In other words, money acts like a good. If this is the case, monetary rewards do indeed measure impatience as subjects do forgo utility if they choose the larger-later option.

In this paper we study this conjecture by eliciting, for the same individuals, short-tem discount rates with money and with a primary good: chocolate. We find that discount rates elicited with money and chocolate are highly correlated, which suggests that they both measure an underling trait. We also find that hunger and a preference for chocolate play an important role. Discount rates elicited with money and chocolate are more highly correlated for subjects who like chocolate and are hungry at the time of the experiment.

There are few papers that elicit discount rates with both monetary and primary rewards. To the best of our knowledge, they do so for addictive substances, which for obvious reasons must use hypothetical choices. They all consistently find that addicts have higher discount rates than non-addicts and that they discount money at a higher rate than the addictive substance—see Bickel et al. (1999) for cigarettes, Madden et al. (1997, 1999) and Kirby et al. (1999) for opiates, Petry (2001) for alcohol, and Coffey et al. (2003) for cocaine. Our study uses a more commonly consumed good, chocolate, and real instead of hypothetical choices. Furthermore, we concentrate the analysis on the relation between the two elicited discount rates as opposed to their respective levels.

The paper is organized as follows. In section 2 we describe the task used to elicit discount rates and the experiment's procedures. In section 3 we present the results and in section 4 we conclude.

2. The experiment

In this section we first describe the method used to measure the subjects' discount rate. Thereafter, we describe the experimental procedures.

2.1 Eliciting discount rates

In order to elicit their short-run discount rate, we give subjects a set of nine simple decisions. Each decision consists of choosing between an amount x today and a larger amount $(1 + r)x$ in one week. In the experiment, subjects answer a set of questions where x is a check for \$50 and another set where x corresponds to 5 small chocolates. At the end of the experiment, in each set of decisions, one decision is randomly chosen and implemented.

If, for a given r and x, a subject prefers the amount x today, we can conclude that the subject is willing to forgo an amount rx in order to get the money/good today instead of in a week. Hence, by gradually increasing the interest rate r over the nine decisions, we can observe the r at which a subject switches from x today to $(1 + r)x$ in one week. Therefore, this switching point serves as a measure of the subject's discount rate. We use this method because it is incentive compatible and easily understood.[3]

For the set of decisions where x is a \$50 check, we use the following values of r: 0.00, 0.01, 0.03, 0.05, 0.07, 0.09, 0.10, 0.15, and 0.20. Consequently, at the highest interest rate, subjects can earn an additional \$10 by waiting a week. Furthermore, note that an r of 1% already implies an annual interest rate of 67.76%, which we expect to be higher than the borrowing rate of our subjects. In other words, in the absence of other

[3] Encouraging in this sense is the fact that all subjects either never switched or switched only once from early to late delivery. In other words, even though we did not restrict their choices, none switched more than once or in the "wrong" direction (from late to early delivery).

considerations, an exponential discounter ought to switch to the delayed payment already at this point.[4] For the set where x equals 5 chocolates, we use the following values of r: 0.00, 0.05, 0.10, 0.15, 0.20, 0.40, 0.60, 0.80, and 1.00. Hence, at the highest interest rate, waiting is rewarded wit 5 additional chocolates. Furthermore, an exponential discounter ought to switch at r = 0.05.

The set of rates for chocolate differ from the one we offered for money for technical constraint. Offering a 5% return over 5 pieces of chocolate requires delivering one fourth of a chocolate, and we could not reliably cut the chocolate in smaller parts. An alternative approach would have been to reduce the divisibility problem by increasing the amount of chocolate delivered, but we fear this would cause a satiation problem.

2.2 Experimental procedures

The experiment was conducted in a single session on the 13th of October 2007 with MBA students from the Kellogg School of Management. Upon arrival subjects were randomly assigned to a seat by picking a USB drive with seat labels from a box. Once all subjects were seated, the experimenter reminded them not to communicate with one another and that their interaction with others will remain anonymous. Thereafter, they were asked to sign a consent form. The experiment was run from the subjects own laptop computers by double-clicking on a file located in the USB drive they just received. The experiment was programmed and run with zTree (Fischbacher, 2007). It lasted one and a half hours. Furthermore, as a prerequisite for participation in the experiment, subjects filled an online survey a few days before.

For taking part in the study, subjects were informed they would receive a participation fee of $50 (in addition to their experimental earnings which averaged

[4] There might be reasons for exponential discounters to prefer an early delivery even if $r > 1\%$. For example, uncertainty with respect to transaction costs in cashing the check can induce even a patient subjects to ask for immediate delivery (Reuben et al., 2008).

$51.87).[5] These are the $50 that were used to elicit their discount rate. Specifically, as their first choice in the experiment, subjects answered the set of nine questions designed to elicit discount rates with money (described above). They were informed at the end of the experiment which decision would be used to determine their payment.

In order to make the delivery times as similar as possible, we decided to pay subjects with a check. Checks were delivered to the subjects' university mailboxes a couple of hours after the experiment or at the same time one week later. We chose this procedure to keep constant the uncertainty of receiving the check (in neither case did the subjects receive the check right away). Furthermore, since payment was done in days in which subjects have to be present at the university, we do not expect the transaction costs to vary between delivery times.

Later on, subjects were informed that as additional compensation for participating, they were entitled to at least 5 Leonidas Napolitain Belgian chocolate squares (a picture was provided on the screen). Then they were given the set of nine decisions designed to elicit discount rates with the primary reward. In addition, in the next screen subjects were asked to self-report with seven-point Likert scale their fondness for chocolate and how hungry they felt at that moment; the precise questions were: (i) how much do you like chocolate? (ii) how hungry are you right now? Again, subjects were informed until the end of the experiment which decision would be randomly picked and implemented.

We used this type of chocolate as they are a well-regarded brand that is not easily available. In this way, subjects who choose the later delivery must forgo the consumption of this type chocolate on the day of the experiment. Furthermore, the relatively small size of each chocolate—around 6 grams per square—makes it less likely that subjects reach a satiation point where they would not want more chocolate.

[5] In addition to the two sets of decisions to elicit discount rates, subjects played in a series of lotteries, a beauty-contest game, and few trust games. Subjects participated in all these games in the same sequence and in order to prevent spillovers; they received no feedback in-between choices.

Subjects that received the chocolate the day of the experiment did so once the experiment had finished. Subjects who received the chocolate one week later did after a class scheduled at the same time as the experiment.[6] The instructions for these two set of questions are available in the appendix.

3. Results

In the experiment, a majority of subjects display a preference for a $50 check today instead of a larger one in a week. This can be seen in Figure 1A, which shows the distribution of the subjects' discount rates—that is, the interest rate at which subjects switch from early to late delivery of the check. In total, 19 subjects (33.33%) switch at a discount rate (over one week) of 1%, which is the choice a rational exponential discounter is expected to select and happens to be the modal switching point. Most subjects, however, choose to switch at a much higher rate. For instance, 12 subjects (21.05%) switch at $r \geq 10\%$, which in annual terms corresponds to discount rates greater than 8734%. The average one-week discount rate elicited with money equals 5.46%. Other summary statistics are available in Table 1.[7]

A preference for immediacy is also evident with the primary reward. This is seen in Figure 1B where we plot the distribution of discount rates elicited with chocolate. In this case, only 10 subjects (17.54%) switch as exponential discounters—that is, at $r = 5\%$. Moreover, the modal switching point is now $r = 20\%$ (chosen by 19 subjects), which corresponds to the rate at which waiting a week is rewarded with one additional chocolate (as opposed to a fraction). The average one-week discount rate elicited with chocolate equals 28.77%.

[6] In the case of chocolate we opted for immediate delivery as unlike with the check, subjects can consume the good as soon as it is received.

[7] In order to calculate summary statistics, we assigned a discount rate of 25% to the 1 subject who never switched to the late delivery of the check. Similarly, we assigned a discount rate of 120% to the 1 subject who never switched to the late delivery of the chocolate.

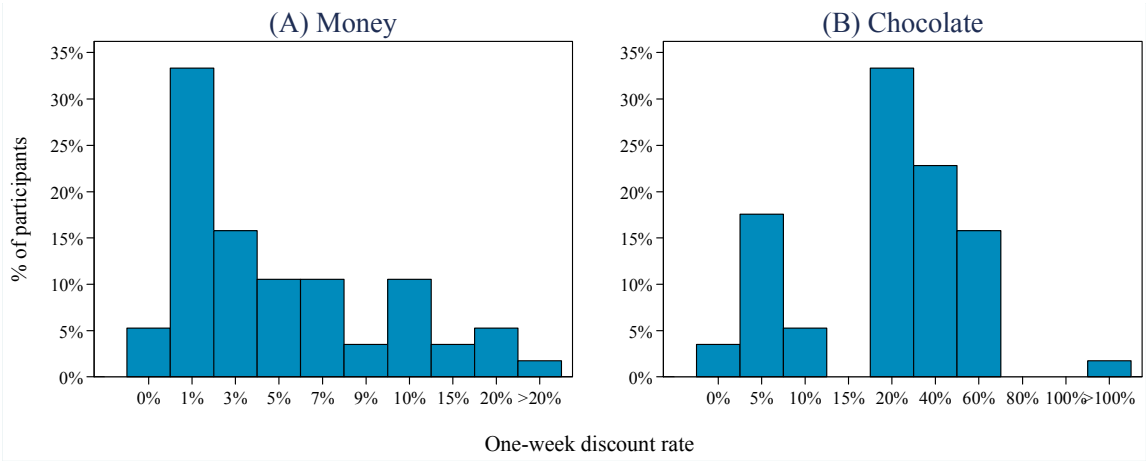

FIGURE 1 – DISTRIBUTION OF DISCOUNT RATES ELICITED WITH MONEY AND CHOCOLATE

Consistent with other studies we find that discount rates are higher if they are elicited with the good compared to money (e.g. Bickel et al., 1999; Petry, 2001; Brown et al., 2007). If we look at the number of subjects whose switching points are consistent with discounting chocolate and money at the same rate we find that only 9 (15.79%) fall in this category. The vast majority, 45 (78.95%), discount chocolate at a higher rate than money, and a small number, 3 (5.26%), discount money more than chocolate. The difference in magnitude can be due to the different interest rates used to elicit discount rates. Furthermore, there could also be a "magnitude" effect as the $50 check is worth more than the 5 chocolates (Green et al., 1997). However, this does not affect the main purpose of this study which is to observe the relationship between two discount rates.

A simple look at the correlation between the two discount rates reveals a positive and statistically significant relationship between the discount rates elicited with money and those elicited with chocolate. The correlation coefficient between the two discount rates is 0.35, which is significantly different from zero ($p = 0.01$). This can also be seen as a regression with the discount rate elicited with money as the dependent variable and the discount rate elicited with chocolate as the independent variable (plus a constant). The resulting OLS estimates as well as their standard errors are presented in the first

TABLE 1 – SUMMARY STATISTICS

Note: Fondness for chocolate and hunger are measured in 7-point scales. For the discount rate statistics, we assigned a discount rate of 25% (120%) to the one subject who never switched to the late delivery of the check (chocolate).

Variable	mean	std. dev.	median	min	max
Discount rate with money	5.46%	5.80%	3%	0%	25%
Discount rate with chocolate	28.77%	22.58%	20%	0%	120%
Fondness for chocolate	4.70	1.71	5	1	7
Level of hunger	2.98	1.76	3	1	7

row of Table 2.[8] The resulting coefficient is positive and statistically significant (p = 0.01).[9] According to the estimate, a one standard deviation increase in the discount rate elicited with chocolate is associated with an increase of 2.05 percentage points in the discount rate elicited with money. See also Figure 2, which shows the scatterplot[10] of the data and the estimated regression line. Next we study the effect of liking or disliking chocolate and of hunger.

Overall, subjects seem to be fond of chocolate but not very hungry. On the seven-point scale measuring how much subjects like chocolate, the average choice is 4.70 (see also Table 1). On the scale measuring how hungry subjects felt, the average choice is 2.98. In order to study the effect of these two variables on the relationship between discount rates, we divide subjects into those with an above-average liking for chocolate and those with a below-average liking. We refer to them as subjects who *like* or *dislike* chocolate. Similarly, we divide subjects into those that are *hungry* (above-average

[8] Standard errors are calculated using White's (1980) heteroscedasticity consistent covariance matrix estimator.

[9] We get very similar estimates if we censor the independent variable at it's maximum and minimum values (Tobit estimates, coefficient = 0.101, p = 0.007). The same is true if we run the regression with subjects whose discount rate with chocolate is 20% or higher—that is, subjects who might dislike getting chocolates in fractions (OLS estimates, coefficient = 0.081, p = 0.034).

[10] Points are drawn with a slight amount of noise in order to better observe points which would otherwise lie in the same location.

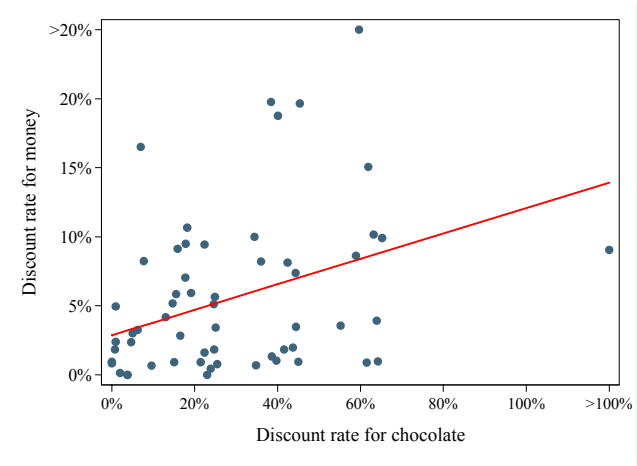

FIGURE 2 – SCATTERPLOT OF THE DISCOUNT RATES ELICITED WITH MONEY AND CHOCOLATE

hunger) or *not hungry* (below-average hunger). We then run the same regression as before for each combination of these two groups. The resulting estimates are shown in rows 2-5 of Table 2.

As can be seen from the value and significance of the estimated coefficients, hunger and fondness for chocolate have an important effect on the relationship between discount rates. For subjects who are not hungry, regardless of their passion for chocolate, the relationship between discount rates is weaker and no longer statistically significant ($p > 0.13$). For subjects who are hungry but dislike chocolate, the coefficient is of similar magnitude as the ones for non-hungry subjects, but in this case, it is (weakly) significantly different from zero ($p = 0.08$). However, the marked difference is observed for subjects who are hungry and like chocolate. For these subjects the coefficient is much larger—a one standard deviation change in the discount rate with chocolate is associated with an change of 3.67 percentage points in the discount rate with money—and statistically significant ($p = 0.02$).[11] In summary, we find that discount rates elicited with money and discount rates elicited with chocolate are strongly correlated, in

[11] If we test the alternative hypothesis that the coefficient of hungry subjects who like chocolate is bigger that those of the other groups we find we can accept it at the following significance levels: vs. not hungry subjects who dislike chocolate $p = 0.05$, vs. not hungry subjects who like chocolate $p = 0.06$, and vs. hungry subjects who dislike chocolate $p = 0.09$.

TABLE 2 – REGRESSIONS OF THE RELATIONSHIP BETWEEN DISCOUNT RATES

Note: OLS regressions with the discount rate elicited with money as the dependent variable and the discount rate elicited with chocolate as the independent variable. Robust standard errors in parenthesis (White, 1980). ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels.

	Discount rate with Chocolate		Constant		R^2	Obs.
All	0.09***	(0.03)	2.84***	(0.86)	0.13	57
Not hungry & dislikes chocolate	0.06	(0.03)	4.90*	(2.30)	0.08	11
Hungry & dislikes chocolate	0.07*	(0.03)	1.38	(1.16)	0.24	11
Not hungry & likes chocolate	0.08	(0.06)	3.03*	(1.51)	0.09	15
Hungry & likes chocolate	0.23**	(0.10)	-0.61	(2.03)	0.31	20

particular for subjects who both like chocolate and are hungry at the time of the experiment (for this subsample, the correlation coefficient between discount rates is 0.55, $p = 0.01$).

4. Conclusions

Consistent with recent neurological evidence, we show that people who exhibit impatience in receiving monetary rewards also do so for non-monetary rewards. In spite of the different framing, for people who like the primary reward (chocolate) and are hungry—that is, those who really want the chocolate—the correlation between discount rates for money and discount rate for primary reward is 0.55.

Given the problems associated with the administration of experiments with primary rewards (idiosyncrasies in the taste for the reward, divisibility problems, risk of satiation, etc.), this study suggests that in the future monetary rewards should be used. Furthermore, the evidence of a strong correlation between discount rates for money and discount rate for chocolate increases the interest in uncovering the

neurological mechanisms that cause this impatience even in the absence of immediate consumption.

Appendix – Instructions

The instructions used to elicit discount rates are below. The instructions of the other games in the experiment (not reported in this paper) are available from the authors.

Instructions to elicit discount rate for money

For completing the LEAD survey, you get $50. Now we ask you to determine when you will receive this amount.

For each row below, choose to be paid *$50 today* or a higher amount *in one week*. If paid today, a check will be delivered to your mailfolder during the afternoon on the *13th of August*. If paid *in one week*, the check will be delivered during the afternoon on the *20th of August*. One of these rows will be randomly selected by the computer and implemented.

1. Receive $50.00 *now* or receive $50.00 *in one week*.
2. Receive $50.00 *now* or receive $50.50 *in one week*.
3. Receive $50.00 *now* or receive $51.50 *in one week*.
4. Receive $50.00 *now* or receive $52.50 *in one week*.
5. Receive $50.00 *now* or receive $53.00 *in one week*.
6. Receive $50.00 *now* or receive $54.50 *in one week*.
7. Receive $50.00 *now* or receive $55.00 *in one week*.
8. Receive $50.00 *now* or receive $57.50 *in one week*.
9. Receive $50.00 *now* or receive $60.00 *in one week*.

Instructions to elicit discount rate for chocolate

As part of your compensation for participating in the LEAD game, you get 5 Leonidas Napolitain Belgian chocolates (see picture). Moreover, you can get a higher number of chocolates if you delay their delivery.

For each row below, choose *5 chocolates today* or a higher number *in one week*. If delivered today the *13th of August*, they will be given to you as soon as the LEAD game finishes. If delivered in one week, they will be given to you on Monday the *20th of August* after the feedback class. One of these rows will be randomly selected by the computer and implemented.

1. Receive 5 chocolates *today* or receive 5 *in one week*.
2. Receive 5 chocolates *today* or receive 5¼ *in one week*.
3. Receive 5 chocolates *today* or receive 5½ *in one week*.
4. Receive 5 chocolates *today* or receive 5¾ *in one week*.
5. Receive 5 chocolates *today* or receive 6 *in one week*.
6. Receive 5 chocolates *today* or receive 7 *in one week*.
7. Receive 5 chocolates *today* or receive 8 *in one week*.
8. Receive 5 chocolates *today* or receive 9 *in one week*.
9. Receive 5 chocolates *today* or receive 10 *in one week*.

Please answer the following questions:

1. How much do you like chocolate? [7-point scale ranging from: 1 = "Not at all" to 7 = "My favorite food"]
2. How hungry are you *right now*? [7-point scale ranging from: 1 = "Not at all" to 7 = "Extremely hungry"]

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