Intertemporal tradeoffs priced in interest rates and amounts: A study of method variance

Daniel Read[1], Mara Airoldi[2], Germán Loewe[3]

[1]Durham Business School
Mill Hill Lane, Durham DH1 3LB

[2]London School of Economics and Political Science
Houghton Street, London WC2A 2AE

[3]University of Barcelona
Avda. Diagonal 690, CP 08034 Barcelona, Spain

Working Paper No: LSEOR 05.77 ISBN: 07530 1699 0

First published in Great Britain in 2005
by the Department of Operational Research
London School of Economics and Political Science

Typeset, printed and bound by:
The London School of Economics and Political Science
Houghton Street
London WC2A 2AE

Working Paper No: LSEOR 05.77 **ISBN No: 07530 1699 0**

Intertemporal tradeoffs priced in interest rates and amounts

Daniel Read*, Mara Airoldi, Germán Loewe

In intertemporal choice experiments people usually choose between smaller-sooner and larger-later amounts of money. That is, they make tradeoffs in terms of ***nominal amounts***. Yet the factor governing intertemporal tradeoffs in the marketplace is usually the interest rate. In this study, we tested whether two major phenomena that occur when trading off nominal amounts, ***excessive discounting*** and the ***hyperbolic-interval effect***, would also occur when trade-offs are made in terms of interest rates. They don't. In a large-scale (N=1,960) internet study of Spanish consumers who made intertemporal tradeoffs for money, tradeoffs described in terms of nominal amounts induced high discount rates and a considerable hyperbolic-interval effect (replicating earlier studies). However, when they were described as both amounts and interest rates, discount rates were much lower, and there was no effect for how finely the interval was partitioned. When the tradeoffs were described as interest rates only, discount rates were even lower, and the hyperbolic-interval effect was ***reversed***. Thus, some of the most-cited results in intertemporal choice research are unique to a specific way of eliciting discount rates.

The economic model of intertemporal choice, first described by Irving Fisher in 1930, unambiguously predicts how rational people will trade off money over time. Given a choice between a smaller amount to be received sooner and a larger amount to be received later, agents will choose based on their current financial status and their opportunities on the capital market. Those who are currently saving will forego the larger later amount if and only if they have an alternate investment that offers a higher rate of return. For example someone currently investing money at 5% will choose £100 now over £104 in a year, because through investment it can be transformed into £105. Conversely, she would prefer £106 in a year, because this is more than she could otherwise earn by investing the $100. Those planning to borrow, on the other hand, will take the smaller-sooner amount if the discount rate implied by doing so is below that offered by their next best borrowing opportunity. For example, imagine someone who can borrow at 10%. Given a choice between £100 now and £109 in a year, he would take the £100, because that would only cost £109 next year, whereas it would cost him £110 to obtain an immediate £100 in the capital market. He would, however, take £111 in a year over £100 now. Given that people vary in their financial circumstances, their discount rates for money can vary, but only within the range dictated by the capital market.

These predictions of Fisher's model have received no experimental support. Two major deviations from the model stand out. First, although few people can earn more than 3% on investments, or have to pay more than 20% to borrow money, the interest rates implied by most experimental results nearly always exceeds 20%, and frequently exceed 100% per year (see review in Frederick, Loewenstein & O'Donoghue, 2002). We call this ***excessive***

* Address for correspondence: Daniel Read, Durham Business School, University of Durham, Mill Hill Lane, Durham, UK; email: daniel.read2@durham.ac.uk

Acknowledgements: We thank Shane Frederick for very useful comments; Santiago Llobet, Oriol Llauradó and Mauricio Edo for their help in administering the online experiment; and David Martin de la Morena and the Marketing Department of www.ya.com for the use of the online panel Metascore. This research was funded by Leverhulme grant F/07 004/Y.

Working Paper No: LSEOR 05.77 ISBN No: 07530 1699 0

discounting. Second, the discount rate is not constant. Rather, it decreases as the interval separating outcomes increases. For example, Thaler found that respondents judged $250 now to be equivalent to $300 in 3 months and $500 in 3 years, for a discount rate of 107% in the short term, and 26% in the long term. We call this the ***hyperbolic-interval effect***.

There is a limitation, however, to the generality of these results. Virtually all studies have used modest variations on what we call the "standard" method introduced by Maital and Maital (1978), and usually associated with Thaler (1981) who used it to document many of the major anomalies in intertemporal choice. In this method, respondents choose between a smaller-sooner (***SS***) and larger-later (***LL***) outcome ("Would you prefer £200 in one month or £400 in ten months?"), or else equate two delayed outcomes, such as stating what ***LL*** is equivalent to a specified ***SS*** ("How much would you demand in ten months to forego receiving £200 in one month?"). This methodological uniformity is troubling, because it is well known that people's stated opinions, beliefs and preferences are highly sensitive to the way in which they are assessed. Different ways of asking formally identical questions can yield strikingly different answers. Consequently, when a pattern of response emerges from a narrow range of methods, it is essential to establish its robustness to methodological variation. This paper addresses the issue by eliciting intertemporal preferences using an apparently modest variation on the standard method.

Although most experimental studies, following Thaler's lead, ask people to price their tradeoffs in ***nominal amounts***[1] (as in, £50 today versus £100 in a year.), in the 'real' world decisions are commonly based on ***rates*** of return (spending £50 today versus investing it for a year at 5%). Credit cards, mortgages, bonds and savings accounts are all chosen on the basis of the interest rate they demand (or offer). Coller and Williams (1999) put this another way, observing that in experiments tradeoffs are typically priced in a different ***currency*** (i.e., nominal amounts) than they are in the real world (interest rates).

The following experiments investigate whether intertemporal choices differ when expressed as interest rates versus nominal amounts. We find that when they expressed as interest rates the two major stylized facts from studies involving nominal amounts are either eliminated (hyperbolic-interval effect) or greatly reduced (excessive discounting). Moreover, in striking contrast with studies based on nominal amount tradeoffs, when they are priced as interest rates the required rate of return is greater the longer the discounting interval.

Interest rates and excessive discounting

Only one previous study has compared intertemporal tradeoffs using different currencies. This is the aforementioned one by Coller and Williams (1999).[2] They compared intertemporal choices for nominal amounts (the ***Money-only*** description, in our terminology), with those for amounts combined with interest rates (***Interest+Money*** description). The Interest+Money description reduced the median discount rate by 7%.[3]

There are many possible reasons for this. Interest rates may serve to remind people that they have alternative investment opportunities, and so make them more 'rational.' Alternatively, those who are who are unfamiliar or misinformed about interest rates may exaggerate how much any given interest rate yields in terms of nominal paybacks, and thereby decline investment opportunities that exceed market opportunities. To illustrate, a

[1] Nominal amounts do not take inflation into account. For instance, if prices go up by 5% a nominal payment of £110 in one year is a real payment of slightly less than £105.

[2] Harrison, Lau & Williams (2002) studied a sample of Danish consumers using a version of Coller and Williams' Interest+Money questions, but did not compare this description to any other. They did suggest, however, that this was the correct way to ask about discount rates.

[3] Coller and Williams did not conduct a single experiment with random assignment to groups, but rather a series of experiments with differing conditions. Therefore, we cannot rule out the possibility that irrelevant differences between experiments (e.g., non-equivalent samples, maturation, history, etc.) influenced their results.

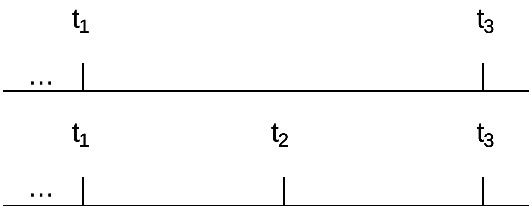
consumer may prefer £100 now over £139 in three years, without fully realizing that she is declining an investment at 11% interest, while retaining money in investments earning less. Thus, her choices or stated indifference amounts may confound her desired interest rate with her interpretation of the interest rates implied by the set of alternative investments[4].

In our experiment we described intertemporal tradeoffs in terms of interest rates, nominal amounts, or both. We predicted tradeoffs made based on the interest rate description would lead to lower discount rates, even when the other description presented concurrently.

Interest rates and the hyperbolic-delay effect

We earlier described the hyperbolic-interval effect, a term we used because it is frequently attributed to (but is not identical to) ***hyperbolic discounting***[5] (e.g., Ainslie, 1975; Kirby, 1997; Mazur, 1987; Rachlin, 1989), according to which the discount rate is decreasing in delay. This effect has recently been challenged as evidence of hyperbolic discounting, because it perfectly confounds the discounting effects of the ***delay*** and the ***interval***.[6]

We illustrate this confound with the aid of the following figure:



In a standard experiment, discounting is measured over intervals that start at the same time, but differ in length, such as $t_1 \rightarrow t_2$ versus $t_1 \rightarrow t_3$. If we use $\boldsymbol{r}_{t_i \to t_j}$ to denote the annual discount rate over an interval with length $\boldsymbol{t_j} - \boldsymbol{t_i}$, the usual result is that $\boldsymbol{r}$ is greater for shorter intervals: $\boldsymbol{r}_{t_1 \to t_2} > \boldsymbol{r}_{t_1 \to t_3}$. When interpreting such results, researchers usually assume that discounting over the long interval is the product of discounting over its parts, or that[7]:

$$\left(1+\boldsymbol{r}_{t_1 \to t_3}\right)^{t_3 - t_1} = \left(1+\boldsymbol{r}_{t_1 \to t_2}\right)^{t_2 - t_1} \left(1+\boldsymbol{r}_{t_2 \to t_3}\right)^{t_3 - t_2}.$$

[4] On the other hand, those who usually think of tradeoffs in terms of nominal amounts, and who are unfamiliar or misinformed about interest rates, might choose the wrong rate because they are mistaken about what it will earn. Consider, for example, an investor who is the mirror-image of the one just described. She wants £140 in a year for each £100 invested, and believes she will get this by investing at 6%. She will agree to a 6% rate as long as she doesn't know how little it will earn.

[5] This should not be confused with ***quasi-hyperbolic*** discounting (Laibson, 1987) or ***present-biased preferences*** (O'Donoghue & Rabin, 2000), according to which the discount rate is stationary after a 'jolt' of excess discounting applied to any delayed outcome.

[6] The argument that follows receives a fuller treatment in Read and Roelofsma (2003).

[7] The standard one parameter hyperbolic function due to Mazur, recast in terms of $\boldsymbol{r}$, is given by $\boldsymbol{r} = \left(\frac{1+\boldsymbol{kt_j}}{1+\boldsymbol{kt_i}}\right)^{1/(t_j - t_i)} - 1$. Substituting this in Eq. 1 shows that both the right hand and left hand side are equal to $\frac{1+\boldsymbol{kt}_3}{1+\boldsymbol{kt}_1}$. Eq. 1 is true for every discount function that is a function of ***delays*** and not ***intervals*** (c.f., Read, 2001).

This assumption entails two further relationships: (1) $r_{t_2 \to t_3} < r_{t_1 \to t_2}$; (2) $r_{t_2 \to t_3} < r_{t_1 \to t_3}$. That is, the discount rate for the second segment of the interval $t_1 \to t_3$ is lower than that for either the first segment or for the interval taken as a whole.

Relationships (1) and (2) have rarely been tested directly, and have received little support. Relationship (2) has ***never*** been found, and (1) only rarely. The modal result is that discount rates are equal for the first and second part of the interval, and higher for the second part than for the undivided interval: (1′) $r_{t_2 \to t_3} = r_{t_1 \to t_2}$; (2′) $r_{t_2 \to t_3} > r_{t_1 \to t_3}$ (e.g., Baron, 2001; Gigliotti & Sopher, 2004; Holcomb & Nelson, 1992; Read, 2001; Read & Roelofsma, 2003). If we know all three values of $r_{i \to j}$, therefore, we can distinguish between the two theoretically important effects just mentioned: the ***delay*** effect when the discount rate is lower for intervals that start later ($r_{t_1 \to t_2} > r_{t_2 \to t_3}$ -- this is true hyperbolic discounting); and the ***interval*** effect when the discount rate is lower for longer intervals ($r_{t_1 \to t_2}, r_{t_2 \to t_3} > r_{t_1 \to t_3}$).

In our study, we obtained discount rates for three consecutive 6-month intervals, and for the corresponding 18-month interval that spanned them. We expected an interaction between the interval effect and tradeoff description. When the tradeoff was in nominal amounts, we predicted the standard interval effect of less discounting for longer intervals. But when it was in interest rates, we predicted either no interval effect or even a ***reverse-*** interval effect of ***more*** discounting for longer intervals.

One reason why we might predict the reverse-interval effect is that it is, in fact, the norm in the financial marketplace. That is, longer investment periods yield higher returns. We can see this in bank accounts, which have to offer higher rates in exchange for a longer period of notice before savings can be accessed. And we see it in the yield curve for bonds, which is generally upward sloping (e.g., Brealey & Myers, 2003).[8] In general, the longer the investment period, the higher the ***liquidity premium***. This leads us to expect that when pricing tradeoffs in terms of interest rates, people might demand ***higher*** rates for longer intervals. Indeed, we conducted a pilot study that suggests just this. We asked 112 respondents to an internet survey the following question:

> Imagine that you have won £10,000. As a condition of the prize you can either (a) take all the money immediately, or (b) invest it for three years and earn interest. If you choose (b) you will not receive any of the money until the three years are up. We want to know what is the minimum yearly interest rate you would ask to compensate you for waiting three years to get the prize.

After giving this three-year rate, the same respondents were asked to give a one year rate. On average, they demanded a greater rate for the longer interval than for the shorter one (18% versus 14%), $t(111)=3.1$, $p=.002$. In other words, they showed the opposite of the traditional hyperbolic-interval effect.

Experimental overview and hypotheses

We conducted an experiment with 16 conditions, corresponding to four descriptions (Interest-only, Interest+Money, Money-only, and No-investment) crossed with four discounting intervals per description (1→7 months, 7→13 months, 13→19 months, and 1→19 months – three ***short*** intervals and one ***long*** one). The first three descriptions framed the tradeoff in terms of an investment decision, while the fourth was like the Money-only condition except that no mention was made of investment.

[8] The interest rate over the long term can be thought of as arising from two factors -- a liquidity premium, and expectations about future rates. Any constraint on liquidity pushes rates higher over longer periods, while expectations pushes these rates in the direction of those expectations. Since the expectations are, in the long run, equally likely to be above or below current rates, the norm is for the liquidity premium to dominate and for long term rates to be greater than short term ones.

We tested five hypotheses. The first two concern the effect of describing options in terms of interest rates or nominal amounts. We predicted that providing interest-rate information would decrease discount rates:

> H1. The Interest-only and Interest+Money conditions will yield lower discount rates than the Money-only condition.

We also predicted that providing both kinds of information would yield intermediate discount rates:

> H2a. Discount rates in the Interest+Money condition will fall between those in the Interest-only and Money-only condition.
>
> H2b. Discount rates in the Interest+Money condition will be closer to those in the Interest-only than the Money-only condition.

Three further hypotheses concerns the delay and interval effects. First, we expected no delay effect, and a standard interval effect only for nominal amounts:

> H3. Discount rates for same-length intervals will be unaffected by variations in the delay to their onset.
>
> H4. In the Money-only condition, the discount rate will be higher for shorter intervals.

On the other hand, however, we predicted a reverse-interval effect for the Interest-only condition:

> H5. In the Interest-only condition, the discount rate will be higher for longer intervals.

Our final question concerns the No-investment condition. We formed no specific hypotheses about it, although we anticipated it would mirror the Money-only condition (i.e., show the effects predicted in H2, H3 and H4). If there was any additional effect, we expected it to have higher rates than any of the investment-frame conditions.

Methods

Sample

On October 14th, 2004 an invitation to participate in a study of "financial preferences" was sent to 3,936 members of ***Metascore***, a representative panel of Spanish Internet users. The e-mail contained a link to one of the 16 questionnaire versions, programmed so that no respondent could reply more than once. The data-collection was successful: 64% of those invited opened the e-mail, 83% of these clicked on the link, and 94% of these finished the questionnaire, for a total of 1,960 completed.

The incentive to participate was a random lottery (e.g., Cubitt, Starmer & Sugden, 1998). Participants were (truthfully) informed that one respondent would be paid for real, and their payment would be based on the choice made to one randomly drawn question.

Materials

Participants made 20 choices between smaller-sooner and larger-later options, presented in a tabular format as in Figure 1. The ***SS*** option was €400 and the ***LL*** option was the result from investing €400 for 6 or 18 months. Table 1 depicts the values used. The timing of outcomes was described using both the month and year of receipt, and the time until receipt. Participants chose the preferred option by clicking on a radio button. Table 2 shows how the options were described.

Figure 1. Sample screenshots from Experiment

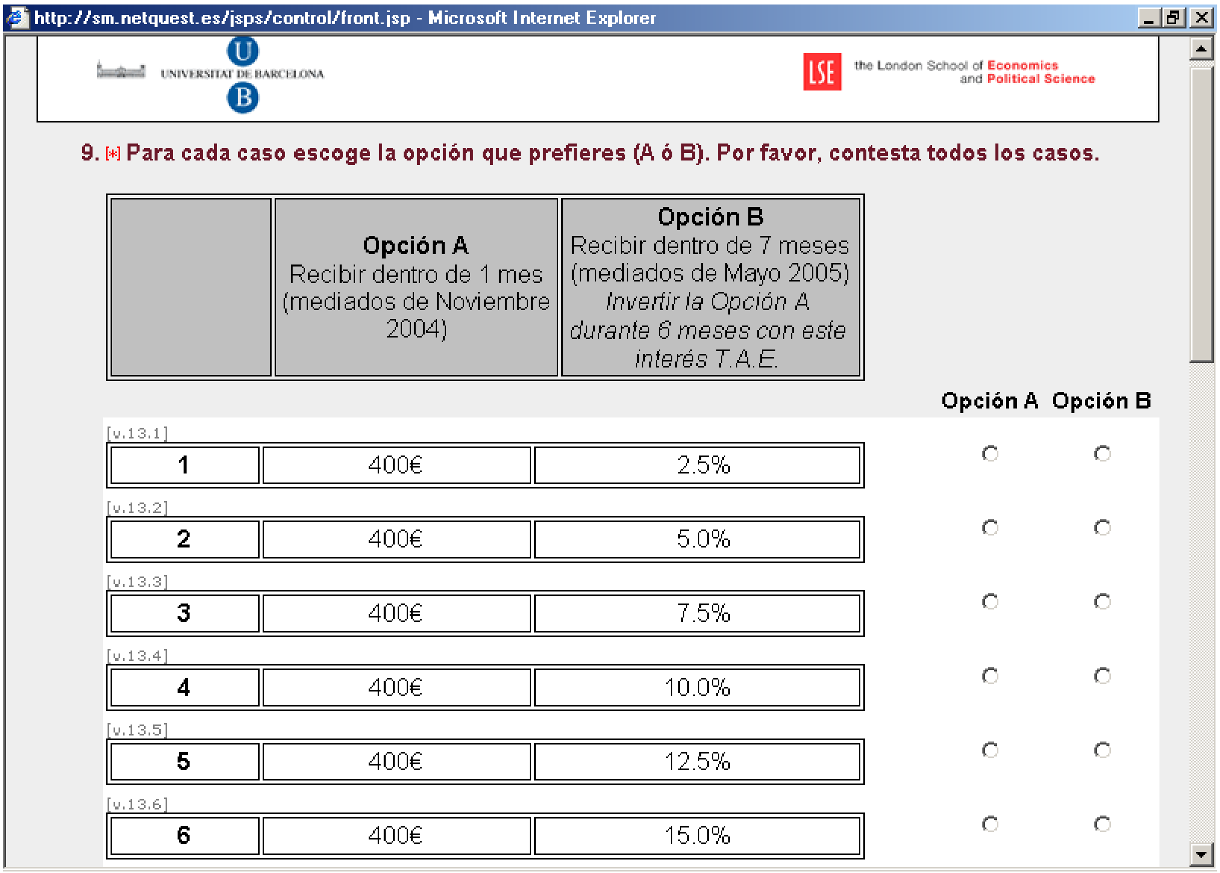


Table 1. Interest rates and corresponding LL amounts. The values represent the amount received after investing € 400 for the specified period at the specified AER.

Payoff Alternative	AER	**Interval** 6 months	**18 months**
1	2.5	**€ 405**	**€ 415**
2	5.0	**€ 410**	**€ 430**
3	7.5	**€ 415**	**€ 446**
4	10.0	**€ 420**	**€ 461**
5	12.5	**€ 424**	**€ 477**
6	15.0	**€ 429**	**€ 493**
7	17.5	**€ 434**	**€ 509**
8	20.0	**€ 438**	**€ 526**
9	22.5	**€ 443**	**€ 542**
10	25.0	**€ 447**	**€ 559**
11	27.5	**€ 452**	**€ 576**
12	30.0	**€ 456**	**€ 593**
13	32.5	**€ 460**	**€ 610**
14	35.0	**€ 465**	**€ 627**
15	37.5	**€ 469**	**€ 645**
16	40.0	**€ 473**	**€ 663**
17	42.5	**€ 477**	**€ 680**
18	45.0	**€ 482**	**€ 698**
19	47.5	**€ 486**	**€ 717**
20	50.0	**€ 490**	**€ 735**

Table 2. Instructions for all experimental conditions

Condition	SS	LL
Interest-only	**OPTION A**: received in 1 month (mid November 2004).*	**OPTION B**: received in 7 months (mid May 2005). Invest Option A for 6 months at the following AER.
	€ 400	**2.5%**
Interest+Money	**OPTION A**: received in 7 months (mid May 2005).	**OPTION B**: received in 13 months (mid November 2005). Invest Option A for 6 months and receive the following at end of the investment period (AER in parentheses).
	€ 400	**€ 404 (2.5%)**
Money-only	**OPTION A**: received in 13 months (mid November 2005).	**OPTION B**: received in 19 months (mid May 2006). Invest Option A for 6 months and receive the following at end of the investment period.
	€ 400	**€ 404**
No-investment	**OPTION A**: received in 1 month (mid November 2004).	**OPTION B**: received in 19 months (mid May 2006).
	€ 400	**€ 404**

* All conditions included all intervals for a complete 4 × 4 design. To avoid redundancy, this table shows each description assigned to one interval only.

Results

The results are summarized in Figure 2 in the form of box plots, and in tabular form in Table 3. The dependent variable is ***Min***, the lowest discount rate consistent with the respondent's choices. ***Min*** was computed as follows:

1. ***Min*** = ***X***%, if the respondent preferred ***SS*** for every interest rate up to ***X***% and then switched to ***LL*** for ***X***+2.5%;
2. ***Min*** = 0%, if the respondent preferred ***LL*** for every interest rate;
3. ***Min*** = 50%, if the respondent preferred ***SS*** for every interest rate.

Case 1 describes the normal situation in which the respondent chooses ***SS*** for low interest rates, and then changes to a preference for ***LL***. The true discount rate will then be between ***Min*** (the highest rate at which they chose ***SS***) and ***Min***+2.5% (the lowest rate at which they chose ***LL***)[9]. The discount rate of respondents who always chose ***LL*** could take any value below 2.5%, so we coded this as a ***Min*** = 0%. The discount rate of respondents who always chose ***SS*** could take any value above 50%. Because there is some uncertainty about the range of possible discount rates when ***Min*** is 0% or 50%, the ***median Min*** is the most accurate measure of central tendency.

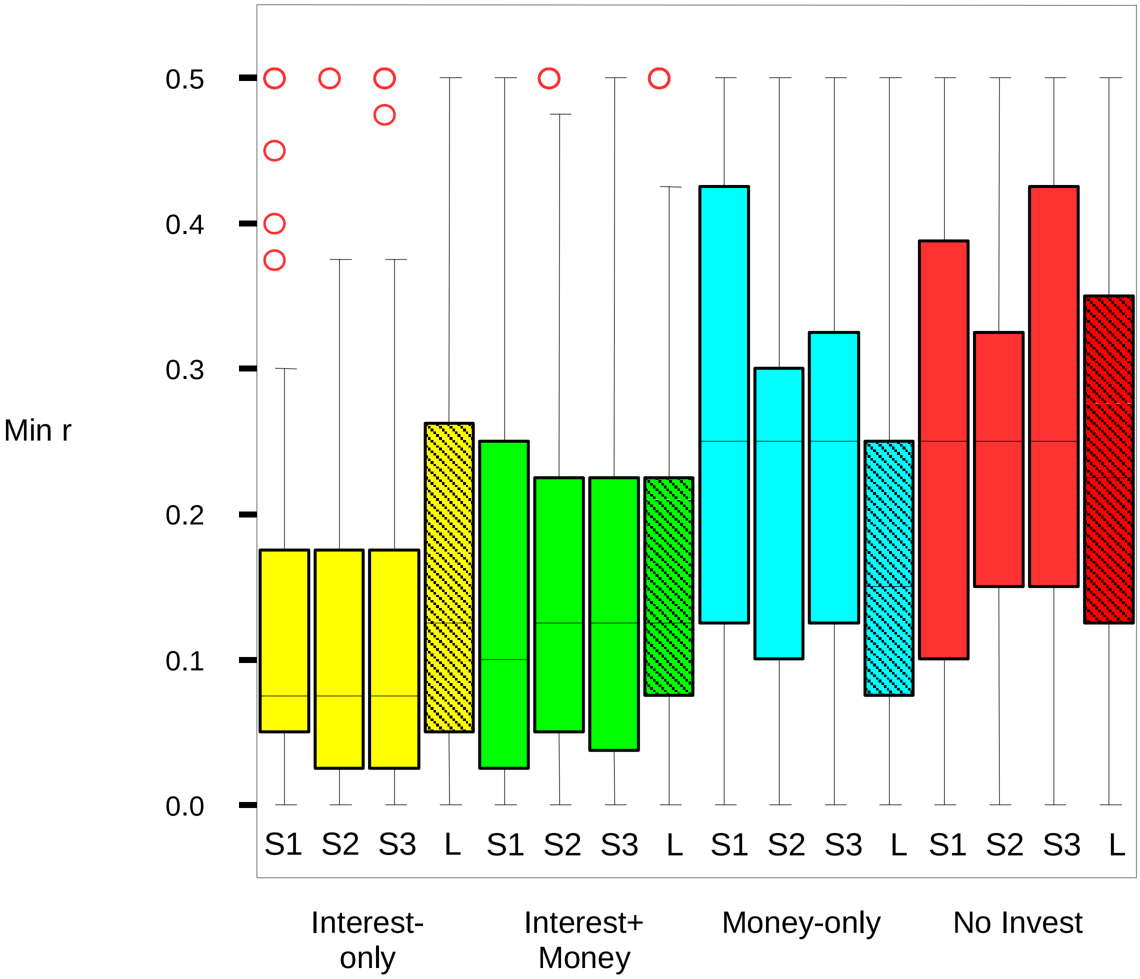
[9] It is not possible to interpret the responses of those who switched back and forth, or chose ***LL*** at lower interest rates and ***SS*** at higher ones. Data from these respondents were not analyzed.

Table 3. Descriptive statistics for all conditions. Means and medians are based on the minimum discount rate (***Min***). True discount rates fall between ***Min*** and ***Min***+2.5%.

Frame	Interval	Mean	σ	Median	Max*	Included	Excluded**	N
Interest-only	**1→7**	11.5%	.12	7.5%	4%	109	16	125
	7→13	10.2%	.11	7.5%	2%	106	12	118
	13→19	12.0%	.13	7.5%	6%	105	17	122
	1→19	17.5%	.16	12.5%	10%	112	6	118
Interest+Money	**1→7**	16.1%	.16	10.0%	12%	99	12	111
	7→13	15.4%	.15	12.5%	7%	107	8	115
	13→19	14.5%	.13	12.5%	7%	123	9	132
	1→19	16.8%	.14	12.5%	8%	112	8	120
Money-only	**1→7**	26.4%	.17	25.0%	19%	105	2	107
	7→13	23.7%	.16	25.0%	13%	135	0	135
	13→19	23.8%	.16	25.0%	16%	122	5	127
	1→19	16.8%	.12	15.0%	2%	124	6	130
No-investment	**1→7**	24.9%	.17	25.0%	19%	111	3	114
	7→13	24.8%	.15	25.0%	13%	117	3	120
	13→19	26.6%	.16	25.0%	17%	133	5	138
	1→19	23.9%	.15	22.5%	8%	124	4	128

* Percent of respondents who always chose the SS option. (€400 in one month).
** Number of subjects who switched more than once. They were excluded from the analysis.

Figure 2. Box plot showing results from all conditions **S1, S2, S3**: Short intervals, 1→7, 7→13, 13→19 months respectively. **L**: Long interval, 1→19 months



Hypothesis 1 was that the Interest-only and Interest+Money conditions would show the lowest discount rates. Figure 2 shows clear evidence for this: the median ***Min*** was 20% in the Money-only condition and 10% in the two interest-rate conditions. A median test comparing the combined Interest-only and Interest+Money conditions to the Money-only condition confirmed this, $\chi^2(1)=89.4$, $p<10^{-5}$. As can be seen in Figure 2, however, this relationship holds only for the 6-month intervals, an observation confirmed by separate median tests:

Interval (months)	$\chi^2(1)$	
1→7	33.1	$p<10^{-5}$
7→13	44.2	$p<10^{-5}$
13→19	34.8	$p<10^{-5}$
1→19	0.8	***p*** ns

This finding is examined below, when discussing Hypotheses 4 and 5.

Hypothesis 2, that discount rates in the Interest+Money condition would fall between those in the Interest-only and Money-only condition, but be closest to the Interest-only condition, was also supported. As already discussed, the Interest-only and Money-only conditions differed only when the interval was six months, and for all six month intervals there was intermediate discounting in the Interest+Money condition. Median tests comparing the combined Interest+Money description to the separate ones revealed they differed significantly:

	Interest+Money compared to:			
Interval (months)	Interest-only		Money-only	
1→7	2.7	***p***=.10	19.0	$\boldsymbol{P}<10^{-4}$
7→13	6.5	***p***=.01	20.5	$\boldsymbol{P}<10^{-4}$
13→19	5.7	***p***=.02	21.8	$\boldsymbol{P}<10^{-4}$

In line with our earlier discussion, this suggests the interest rate description makes people more "patient," and the money description makes them less so. Moreover, as we had expected, the Interest+Money rates were much closer to the Interest-only than Money-only ones, suggesting the primacy of interest-rate information when it is available.

Hypothesis 3 is that discount rates for same-length intervals will be unaffected by the front end delay. This received strong support. Within each question frame, discount rates were virtually identical for all the short intervals. An overall median test ($\chi^2(2)=1.3$), as well as separate analyses for each frame ($\chi^2(2)=0.87$, 0.85, 3.69 and 0.49 respectively) indicated no hint of a significant effect.

Hypothesis 4 and 5 will be discussed together. We predicted that the discount rate would decrease with interval length in the Money-only condition, and increase with interval length in the Interest-only condition. Both predictions were supported. Median tests comparing long with short intervals revealed a significant effect in both the Money-only ($\chi^2(1)=28.1$, $\boldsymbol{p}<10^{-5}$) and Interest-only ($\chi^2(1)=15.0$, $\boldsymbol{p}<10^{-3}$) conditions.

Indeed, discount rates increased enough in the Interest-only condition, and decreased enough in the Money-only condition, that they were virtually identical. Consequently, we expected the Interest+Money condition (predicted to fall between them) to yield the same discount rate, and this is what happened. A median test comparing the 18-month interval in all three investment frame conditions revealed no hint of a difference, $\chi^2(2)=0.87$.

No-investment condition. We predicted the No-investment condition to mirror the Money-only condition, perhaps with higher discount rates if the 'Investment' instruction made a difference. In all 6-month interval conditions, the discount rates in the Money-only and No-investment condition were identical. For the 18-month interval, however, the rate was considerably higher in the No-investment condition – indeed, while it was significantly higher than in the same-length Money-only condition ($\chi^2(1)=9.3$, $\boldsymbol{p}=.003$), it was not significantly lower than the 6-month discount rates for either the Money-only or the No-investment condition.

The most significant observation from the Investment-only condition, however, is that it supports our predictions about the relationship between discount rates and the interest-rate frame. When no interest rate information is provided, the discount rates are ***much*** higher than when it is.

Comparison with Coller and Williams

Coller and Williams compared discounting over 2-month intervals, in a Money-only versus an Interest+Money frame (their Experiments 1 and 2). They found that discount rates were lower in the Interest+Money description, as we did for the 6-month interval. As can be seen in the table below, the implicit discount rates were slightly lower in our study than theirs. But the differences are small, and can be readily attributed to the different populations studied: they studied students, whereas we studied members of the general population who were found by Harrison et al. (2002) to have higher discount rates than other groups.

	Our study		Coller & Williams	
Interval (months)	Interest+ Money	Money-only	Interest+ Money	Money-only
1→3			17.7%	25.2%
1→7	11.25%	26.25%		
1→19	13.75%	16.25%		

Discussion

This study is one of the largest intertemporal choice experiments ever, and differs from most others in that (a) the respondents were members of the general public and not students, (b) discounting was measured over several intervals differing only in the delay to their onset and, most importantly, (c) future payments were described in terms of interest rates as well as (the usual) nominal amounts. The effect of this modest change in description was striking. For short intervals, discounting was much greater when payments were framed as interest rates. And when both kinds of information were given – in the Interest+Money frame – the pattern of discounting was consistent with two principles of economic rationality. First, the average discount rate was close to the market rate: the mean was between 15 and 17.5%, the median between 10 and 12.5%, somewhere between what it would cost to borrow such a small amount and what could be earned from investing it. Second, the discount rate was stationary (or constant), being affected by neither the delay nor the interval length. In short, two allegedly robust findings in intertemporal choice – those we called excessive discounting and the hyperbolic-interval effect – are largely eliminated by the simple provision of the implied annual interest rate. Such a striking case of method variance has great implications for how we interpret experimental studies of intertemporal choice.

In general, studies of individual judgment and choice, including intertemporal choice, can be divided into two categories based on the kinds of conclusions sought. The first looks for generalizations about groups that hold across circumstances; the second looks for generalizations about circumstances that hold across groups. An example of a group generalization is found in the study of confidence judgments, which focuses on the generalization that "people are overconfident." Researchers have tested this in many ways, and although some controversy remains, it appears that while overconfidence can be reduced, it does not go away. Therefore, we are justified in accepting that people are generally overconfident.

The focus of research into circumstance-generalization is method variance, or the effects on preference of changing normatively and semantically irrelevant aspects of the task. This research is exemplified by Kahneman and Tversky's (1984) study of framing effects. People's preferences over the same gamble differ depending on whether it is framed as a gain or loss – in one frame they are risk averse, in the other they are risk-seeking. These studies show we are not warranted in concluding that "people are risk-averse." Rather, we have to offer contingent conclusions, such as "risk attitude depends on the question frame ***in such-and-such way***." Because very few generalizations survive the scrutiny of multiple-methods, most research programs in decision making are of the second type, investigations of how people's preferences between A and B reverse between circumstances X and Y.

The conclusions from studies of intertemporal choice are usually presented as being of the first type. The generalizations tested are that 'people can be characterized by excessive discounting and the hyperbolic-interval effect.' But, unlike the study of overconfidence, very few alternate research methods have been attempted. Indeed, as already discussed, virtually everyone has adopted minor variations on the method used by Thaler (1981), who first proposed these generalizations.

When we explore the effects of adopting different methods of measurement, the results become quite different. In this paper, we showed that both the discount rate and its functional form vary with the currency in which intertemporal choices are made. Other studies have shown that the magnitude of the discount ***rate*** depends on how time is described (Read, Frederick, Orsel & Rahman, in press), on whether the tradeoff involves delaying or speeding up the receipt of an outcome (Loewenstein, 1988), and that the form of the discount ***function*** depends on whether questions are answered using choice or matching (Ahlbrecht & Weber, 1997; Read & Roelofsma, 2003), and on whether people answer a series of questions by moving backwards or forwards in time (Malkoc & Zauberman, 2005).

To sum up, we suggest that research into intertemporal choice needs to develop in the way that other areas of judgment and decision making have, by focusing on the decision circumstances (c.f., Hogarth, 2005). Any claims made about either the magnitude of the discount rate, or the form of the discount function, should be recognized as contingent claims that are not generalizations from multiple methods, but a description of what happens when a specific methodological choice is made.

References

Ahlbrecht, M., & Weber, M. (1997). An empirical study on intertemporal decision making under risk. Management Science, ***43***, 813–826.

Ainslie, G. (1975). Specious reward: A behavioral theory of impulsiveness and impulse control. ***Psychological Bulletin, 82***(4), 463-496.

Ainslie, G. (1992). ***Picoeconomics: The strategic interaction of successive motivational states within the person***. Cambridge: Cambridge University Press.

Baron, J. (2000). Can we use human judgments to determine the discount rate? ***Risk Analysis***, ***20***, 861-868.

Benzion, U., Rapoport, A., & Yagil, J. (1989). Discount Rates Inferred from Decisions - an Experimental-Study. ***Management Science, 35***(3), 270-284.

Brealey, R. A., Myers, S. C. (2003). ***Principles of Corporate Finance, 7th edition***. New York: McGraw Hill.

Coller, M., & Williams, M. B. (1999). Eliciting individual discount rates. ***Experimental Economics***, 2, 107-127.

Cubitt, R., Starmer, C. and Sugden, (1998)., On the validity of the random lottery incentive system, ***Experimental Economics***, ***1***, 115-31.

Fisher, I. (1930). ***The theory of interest***. New York: Macmillan.

Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time discounting and time preference: A critical review. ***Journal of Economic Literature, 40***(2), 351-401.

Gigliotti, G. & Sopher, B. (2004). Analysis of Intertemporal Choice: A New Framework and Experimental Results. ***Theory and Decision***, 55, 209-233.

Harrison, G. W., Lau, M. I., & Williams, M. B. (2002). Estimating individual discount rates in Denmark: A field experiment. ***American Economic Review***, 92, 1606–1617.

Hogarth, R. M. (2005). The Challenge of Representative Design in Psychology and Economics. ***Journal of Economic Methodology***, ***12***, 253-264.

Holcomb, J. H., & Nelson, P. S. (1992). Another experimental look at individual time preference. ***Rationality and Society***, ***4***, 199-220.

Kahneman, D. & Tversky, A. (1984). Choices, values and frames. ***American Psychologist***, ***39***, 341-350.

Kirby, K. N. (1997). Bidding on the future: Evidence against normative discounting of delayed rewards. ***Journal of Experimental Psychology-General, 126***(1), 54-70.

Loewenstein, G. (1988). Frames of mind in intertemporal choice. ***Management Science***, ***34*** (2), 200-214.

Maital, S. and S. Maital. 1978. Time Preference, Delay of Gratification, and Intergenerational Transmission of Economic Inequality: A Behavioral Theory of Income Distribution. In Orley Ashenfelter and Wallace Oates, eds., ***Essays in Labor Market Analysis***. NY: Wiley.

Malkoc, Selin and Gal Zauberman. (2005). ***Deferring versus Expediting Consumption : The Effect of Temporal Framing on Sensitivity to Time Horizon***. Working paper.

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. L. Commons, J.E. Mazur, J. A. Nevin, & H. Rachlin (Eds.). ***Quantitative analyses of***

behavior. 5. The effect of delay and of intervening events on reinforcement value. Hillsdale, NJ: Erlbaum.

O'Donoghue, T., & Rabin, M. (2000). The economics of immediate gratification. ***Journal of Behavioral Decision Making***, 13 (2), 233-250.

Rachlin, H. (1989***). Judgment, decision, and choice: A cognitive/behavioral synthesis***. New York: Freeman.

Read, D. (2001). Is time-discounting hyperbolic or subadditive? ***Journal of Risk and Uncertainty***, 23, 5–32.

Read, D. (2004). Intertemporal choice. In D. Koehler & N. Harvey (Eds.), The Blackwell handbook of judgment and decision making. Oxford: Blackwell.

Read, D., & Roelofsma, P. H. M. P. (2003). Subadditive versus hyperbolic discounting: A comparison of choice and matching. ***Organizational Behavior and Human Decision Processes***, 91, 140–153.

Read, D. Frederick, S., Orsel, B. & Rahman, J. (In press). Four score and seven years from now: The date/delay effect in intertemporal choice. ***Management Science***.

Strotz, R. H. (1955). Myopia and inconsistency in dynamic utility maximization. ***Review of Economic Studies***, 23, 165–180.

Thaler, R. (1981). Some empirical evidence of dynamic inconsistency. ***Economics Letters***, ***8***, 201-207.