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Discounting over subjective time: Subjective time perception helps explain multiple discounted utility anomalies☆

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ABSTRACT

Consumers often face choices involving intertemporal tradeoffs. Existing research suggests that, in general, decision makers do not obey discounted utility theory because their discount rates are context dependent. Recent literature incorporates decision makers' subjective perception of time into the classic discounted utility model and finds relatively constant discount rates over subjective time. In the current study, we investigated the magnitude effect with subjective time, provided a holistic view via a more comprehensive experiment including multiple anomalies, and found that subjective time perception was able to explain most of the anomalies simultaneously in a single scenario.

1. Introduction

Discounted utility theory is widely accepted in marketing and many other fields (Samuelson, 1937). It employs a single discount rate to model a consumer's preferences over time. However, researchers have found that consumers' behaviors often are inconsistent with this theory (Frederick, Loewenstein, & O'Donoghue, 2002; LeBoeuf, 2006; Read, Frederick, Orsel, & Rahman, 2005; Thaler, 1981). Important anomalies include the magnitude effect, long term/short term asymmetry (or hyperbolic discounting), gain/loss asymmetry, and delay/date asymmetry.

Earlier literature has proposed several mechanisms to understand the observed anomalies (Loewenstein & Prelec, 1992), most of which attributed the anomalies to changes of discount rates caused by variations of contextual factors, but left time objectively defined. More recently, subjective time perception has been investigated and used to explain intertemporal preferences (Zauberman, Kim, Malkoc, & Bettman, 2009). For example, researchers have found that consumers are not sufficiently sensitive to changes in objective time, which could help in explaining hyperbolic discounting (Zauberman et al., 2009); time intervals described by dates seem shorter than those described by the delay in time units, which could help in explaining delay/date asymmetry (LeBoeuf, 2006; Read et al., 2005); and consumers perceived temporal durations before losses as shorter than those before gains (Bilgin & LeBoeuf, 2010), which potentially could help explain gain/loss asymmetry, although in the original paper the authors didn't test the asymmetry explicitly using standard discounting scenarios with monetary outcomes. However, to the best of our knowledge, there is little research on perceived temporal distance on the magnitude effect, nor on bringing multiple anomalies together in a single monetary discounting scenario and testing them simultaneously (see Table 1 for a brief summary of existing research on this topic). In this paper, we fill these gaps in the literature. Testing multiple anomalies in one study with a single discounting scenario will provide a comprehensive test of the ability to explain anomalies using the perceived time length, and potentially will provide empirical support for the discounting over subjective time model for future theoretical developments.

2. Experiment 1: Outcome sizes and perceived temporal distance

2.1. Procedure

Seventy-four undergraduate students (mean age = 20.2; 73% female) at a university in the U.S. completed the study online for course credit. We employed a between-subject design with two

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Table 1
Summary of current and existing studies.

Paper	Focus	Time perception measured?	Discounting over monetary values	Discount rates calculated?	Multiple anomalies in a single framework?
Thaler, 1981	Time discounting anomalies	No	Yes	Yes	Yes
Read et al., 2005	Date/delay asymmetry	No	Yes	Yes	No
LeBoeuf, 2006	Date/delay asymmetry	Yes	Yes	No	No
Zauberman et al., 2009	Long term/short term asymmetry	Yes	Yes	Yes	No
Bilgin & LeBoeuf, 2010	Gain/loss asymmetry	Yes	No	No	No
Current research	Date/delay asymmetry, Long term/short term asymmetry, Gain/loss asymmetry, Magnitude effect	Yes	Yes	Yes	Yes

randomly assigned groups. Participants were first asked to imagine that they had just won $4,000 (vs. $20) in a lottery, and the winnings would be paid to them in 3 months. They were then asked, "How long does this time period until you get the winnings seem to you?" Participants indicated their responses on a 7-point scale from 1 to 7, ranging from "seems very short" to "seems very long" (LeBoeuf, 2006).

2.2. Results

An independent samples t-test revealed that the mean subjective time perception in the $4,000 condition ($M_{\$4,000} = 4.41$, $SD_{\$4,000} = 1.79$) was significantly shorter than in the $20 condition ($M_{\$20} = 5.78$, $SD_{\$20} = 1.40$, $t(72) = 3.70$, $p < .001$, $\eta^2 = .16$). The results show that the participants' perception of temporal durations is not independent of the magnitudes of the outcomes, with larger monetary outcomes leading to shorter subjective time perceptions.

Prior literature suggests perception is a constructive process that can be influenced by attention (Brown, 1985). Larger outcomes may attract higher attention from consumers and thus lead to shorter subjective time perception of the same objective temporal distance. Furthermore, the contrast between the monetary outcome and the objective temporal distance may also lead people to perceive the larger outcomes as less distant (Hsee, 1998).

3. Experiment 2: Magnitude effect and perceived temporal distance

3.1. Procedure

Forty-four undergraduate students (mean age = 20.8; 58% female) at a university in the U.S. completed the study as a section of a series of unrelated tasks for course credit. This experiment employed a between-subject design with two randomly assigned groups. Participants were told that they had just won $20,000 (vs. $20) in a lottery, and told they could take the money now or wait until 3 months from now. They were then asked to state the minimum amount they would need to be paid to wait before receiving their winnings. Finally, participants were then given a 140-mm line with endpoints labeled "very short" on the left end and "very long" on the right end (similar to Zauberman et al., 2009), and were asked to place a mark on the line indicating their response to the following question: "If you wait, how long does this time period until you get the money seem to you?" The length from the left end to the participant's mark was measured as an indicator of subjective time perception.

3.2. Results

3.2.1. Subjective time perception

An independent samples t-test revealed that the mean marked length in the $20,000 payment condition was significantly shorter than the marked length in the $20 payment condition ($M_{\$20,000} = 68.74$ mm, $SD_{\$20,000} = 38.05$ mm, $M_{\$20} = 87.90$ mm, $SD_{\$20} = 24.99$ mm, $t(42) = 1.95$, $p = .03$, $\eta^2 = .083$). This confirmed our findings in experiment 1.

3.2.2. The magnitude effect

An independent samples t-test of the mean implicit annual discount rate over the *objective* time horizon showed results corresponding with the magnitude effect ($M_{\$20,000} = 134.07\%$, $SD_{\$20,000} = 100.92\%$, $M_{\$20} = 227.99\%$, $SD_{\$20} = 193.67\%$; $t(42) = 2.04$, $p = .02$, $\eta^2 = .09$).[1]

3.2.3. Discount over subjective time

An independent samples t-test on the discount rate over the *subjective* time revealed no reliable differences between conditions ($M_{\$20,000} = 381.17\%$, $SD_{\$20,000} = 877.67\%$, $M_{\$20} = 210.87\%$, $SD_{\$20} = 162.59\%$, $t(42) = 0.88$, $p = 0.19$).[2] In other words, when subjective time was used to compute the discount rate, the magnitude effect disappeared.

In this experiment, we replicated the magnitude effect when calculating the discount rate according to objective time. However, the data showed no statistically reliable difference and thus did not provide evidence of the magnitude effect when we adjusted the discount rate according to the subjective time.

4. Experiment 3: Multiple anomalies and perceived temporal distance

4.1. Procedure

One hundred and forty-four students recruited in a library from a university in China (mean age = 22.8; 42.2% female) completed the study with a small gift as an incentive. As we wanted to manipulate the magnitudes of the monetary outcomes, lengths of the time horizons, signs of the monetary outcomes, and presentation formats of the time delay, we employed a between-subject design with five conditions, shown in Table 2. We do not intend to examine interactions among anomalies, so pair-wise comparisons are enough to test the effects we are examining. The translated scenarios are given below:

Scenarios with gains: Imagine that you just won 20 RMB/2,000 RMB in a lottery. You can take the money now or wait for (3 months/2

[1] The familiar time value of money formula with annual compounding with annual discount rate δ and the change in objective time Δt uses the discount function $D(\Delta t,\delta) = 1/(1+\delta)^{\Delta t}$. Then for continuous compounding the corresponding discount function is $D(\Delta t,\delta) = e^{-\delta\Delta t}$. Assuming utility is linear in the monetary amount, we get $x_{t_0} = e^{-\delta\Delta t}x_{t_0+\Delta t}$. Rearranging the formula, we get $x_{t_0}/x_{t_0+\Delta t} = e^{-\delta\Delta t}$. Taking the natural logarithm of both sides of the equation and rearranging it yields the annual discount rate for each response $\delta = \ln(x_{t_0+\Delta t}/x_{t_0})/\Delta t$, where x_{t_0} is the given amount at the initial period and Δt is the given length of time delay expressed in terms of years (Thaler, 1981; Zauberman et al., 2009). The magnitudes of discount rates in our results are similar to Thaler (1981) and Zauberman et al. (2009).

[2] Consistent with the calculation method in Zauberman et al. (2009), the discount rate over subjective time for each response is calculated by using the formula: $\delta' = \ln(x_{t_0+\Delta t}/x_{t_0})/\Delta t'$, where $\Delta t'$ represents the subjective time length of the time delay. We set the overall mean marked length L across the two conditions equivalent to the objective temporal distance, then the subjective time perception for a specific participant should be $\Delta t' = (l/L)\Delta t$, where l is the length marked by the participant and Δt is the objective time.