Time Discounting:
Delay Effect and Procrastinating Behavior*

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Abstract

This paper pursues two aims by conducting economic experiments in Shanghai. One aim of this paper is to investigate the following three anomalies on time discounting: the delay, interval, and magnitude effects. We confirmed all the three anomalies. Particularly, by separating the delay effect from the interval effect, the delay effect is found when the delay is relatively short, which has seldom been reported in former studies. Another feature of our experiment is that it is immune to the criticism that the subjects recruited for the experiment did not have sufficient incentives to report their true preferences because the highest reward that was offered to the subjects was approximately equivalent to their monthly household incomes. The second aim of this paper is its explanation of the subjects' procrastinating behaviors by their time discount rates and the degrees of the delay effect. Our analysis suggested that higher time discounting always promotes procrastination; however, the delay effect is negatively associated with procrastination. An interpretation of the latter result can be that our subjects, i.e., the students of Fudan University, are *sophisticates* rather than *naïfs.*

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1. Introduction

This study examines an economic experiment that was conducted in China for exploring the manner in which people discount future values. Specifically, we focus on the following two topics: one is whether the existence of the delay effect is actually independent of the interval effect, and the other is whether procrastinating behavior can be explained with the time discount rate and delay effect.

Although traditional economics has relied on the assumption of "exponential discounting," i.e., the time discount rate is constant over the time horizon, numerous experimental studies have rejected the validity of the assumption (Ainslie 1975, Benzion et al. 1989, Kirby 1997, Kirby and Marakovic 1995, and Thaler 1981). This anomaly of discounting, i.e., the discount rate is not constant over the time horizon, is termed the delay effect, diminishing impatience, present bias, or hyperbolic discounting. In addition, it is a well-known fact that discount rates depend on the value to be discounted; the smaller the value, the more intensively it is discounted, and this is termed "the magnitude effect" (Benzion et al. 1989, Kirby and Marakovic 1995, Kirby 1997, and Thaler 1981).

However, most studies on delay effect encounter a problem. In experiments thus far, subjects were typically asked which of following two options they preferred: option A, wherein the subjects will receive a reward in the near future, or option B, wherein the subjects will receive a (usually larger) reward in the distant future. All options that were shown in the question could neatly be identified with the following four experimental conditions: date s and receipt of amount X in option A; and date t ($t > s$) and receipt of amount Y (usually larger than X) in option B. With respect to these conditions, the delay was termed s and the difference between the two points of time, $t - s$, was termed interval h. In what follows, we termed the phenomenon where discount rates depended on the delay, "the delay effect," on the interval, "the interval effect," and on the reward amount, "the magnitude effect."

Thus, the two concepts of time, delay s and interval h, must be distinguished as the factors that characterize intertemporal choices. Delay s is, among other things, the focal point because if time discounting depends on the delay, a plan made by such a person will be time-inconsistent. Nonetheless, most studies thus far have not separated the delay from the interval, and subjects have been asked to specify the amount of money that they would require, at some future date, in order to make them indifferent to receiving a certain amount *now*. In these studies, since the receipt time of the earlier option is fixed at *now*, their results must be interpreted as an investigation of the interval effect rather than the delay effect or, at least, as a combination of these two effects.

Read (2001) was the first to highlight this problem. He conducted an experiment that separated the delay from the interval. Although he observed a form of the interval effect, he did not confirm the delay effect.[1] However, although the delay effect exists even with a rather short delay (Frederick et al. 2002), the shortest delay used by Read was six

[1] Recently, Read and Roelofsma (2003) and Read et al. (2005) reported that the delay effect is found in experiments wherein subjects are asked questions in ways that differ from those in Read (2001). Read and Roelofsma (2003) utilized the matching method, which asks subjects regarding the amount at a specified date, which makes them indifferent to a specified option. This is different from the choice method used in Read (2001) and in this study, which asks subjects to select the better of two specified options. On the other hand, Read et al. (2005) focused on how the timings of the two options are described and specified the timing with respect to the calendar dates. This method is different from the method used in Read (2001) and this paper, which specified the length of the delay.

months. Thus, whether subjects show the delay effect within a six-month delay period remains an open question. Given these arguments, the primary aim of this study is to re-examine whether the delay effect is in fact found when the delay and the interval are explicitly distinguished. Our experiment differs from that of Read (2001) in that we investigated the delay effect using a much shorter delay than that used by Read (2001). [2]

The second aim of this study is to explain the subjects' procrastinating tendencies in performing onerous activities (e.g., doing homework assignments) using their time discount rates and degrees of their delay effects. Although correlation between the delay effect (or the present bias) and procrastination has often been predicted in literature (e.g., O'Donophue and Rabin, 1999), there is no empirical research on this important issue. This study attempts to fill this gap. In order to do so, we measure the subjects' degrees of procrastinating tendencies by asking them how often they procrastinated doing homework assignments in their childhood.

Intuitively, the delay effect is expected to lead to procrastinating behaviors because with delay effect people tend to always overweight immediate costs more than delayed costs. The prediction in fact holds for naïve people who do not expect the future incidence of preference reversal (see O'Donophue and Rabin, 1999). In contrast, in the case of sophisticated people, who make decisions by incorporating preference shifts of future selves, know that making future selves make decisions causes harmful procrastination and have incentives to do onerous jobs earlier. As indicated by O'Donophue and Rabin (1999),

[2] Kinari et al. (2009) examined the delay effect independent of the interval effect with Japanese subjects and reported that the delay effect is found for a short delay. The current paper differs from theirs with respect to the method of presenting options. We present pairs of options in sequential order of discount rates, whereas Kinari et al. (2009) presented them in random order.

if this incentive effect, called the sophistication effect, is sufficiently strong, then sophisticated people perform jobs earlier than exponential discounters would, and hence the delay effect can be negatively correlated with procrastination.

One merit of our study is that in our experiments, we give the Chinese subjects strong incentives, by offering high rewards to induce them to reveal their true preferences. This study examines whether real payments to all subjects is indispensable for eliciting the true preferences when some subjects are actually paid a larger reward.

The remainder of this paper is organized as follows. The subsequent section explains our experimental design. Section 3 reports the results of the experiment and examines whether the delay, interval, and magnitude effects are confirmed by using the test of the same mean, and a regression analysis. Section 4 examines whether the discount rate and the degree of the delay effect of the subjects can explain their procrastinating behaviors. Section 5 presents our conclusion.

2. Design of the experiment

We attempt to measure subjective time discounting by asking subjects to select one of the two options that they prefer: option A, to receive a reward X with a shorter delay s, and option B, to receive a (usually larger) reward Y with a longer delay t. On the basis of these conditions, the rate of compensation for postponement R is defined as $\frac{1}{X}\frac{Y-X}{t-s}$, and interval h is defined as $t-s$.

We specified four values for s (2 days, 1 month, 90 days, and 10 months), three values for h (7 days, 3 months, and 12 months), and three values for the reward amount (240, 2,800, and 800,000 yuan). We also controlled for whether the reward specified in the pay-off tables would be paid in reality, which was denoted as P = (YES, NO). Combining these four conditions, we specified twelve sets of conditions (s, h, X, *and* P), as shown in Table 1. Thus, the experiment consisted of twelve rounds, each of which corresponded to one set of conditions.

Each set of conditions comprised 32 pairs of options, each of which were specified with a value of the rate of compensation, R, by changing the value of the reward of the subsequent option, Y. Thirty-two pairs of options were arranged in ascending order of R, which varied from a rather low value of −20% to a rather high value of 300% (annual rate) in a table that we termed the "payoff table."[3] The subjects were expected to select the earlier receipt A when R is small and the subsequent receipt B when R becomes sufficiently large. Subsequently, we defined the time discount rate TD_{ij} for condition j = (s, h, X, P) and subject i with the value of R at which the subject switched from A to B.[4]

The experiment was conducted on March 11, 2005 at Fudan University, Shanghai.[5] The subjects were 29 undergraduate students recruited from the Department of World Economics at Fudan University. They were either 20 or 21 years old, and 25 of the 29 subjects (86%) were female. The reward was paid in the following manner: At the end of the experiment, we randomly selected one pair of options, starting from round one, to be paid from the payoff table. Subsequently, we randomly selected one subject as a recipient

[3] An example of the payoff table is presented in the Appendix.
[4] If a subject selects A (B) for all 32 pairs, then we regard the highest (lowest) value of R in the payoff table as TD_{ij}. If a subject switches multiple times, then we discard the data because the subject had probably misunderstood the question.
[5] Before conducting the experiment on the time discount rate, we conducted an experiment on risk aversion on the same day. For the experiment on risk aversion, see Sasaki et al. (2008).

of the reward amount on the date specified in the option that the subject had selected.[6] The highest reward presented in the payoff tables was 3,920 yuan (800,000 yuan would not be paid), which was a relatively large amount, considering that the annual household income of the subjects was 20,000−40,000 yuan. This enabled us to provide the subjects with an incentive to express their true preferences. Including a 120 yuan (approximately US$14) participation fee, the average payoff for both the experiments, on time discounting and risk aversion, was 788 yuan (approximately US$106). After we selected the winners, the subjects were required to complete a detailed questionnaire indicating their preferences, opinions, and attributes.

3. Results of the experiment

3.1 Time discount rates elicited by the experiment

The bottom row of Table 1 presents the averages and standard errors of the discount rates, which reveals that the discount rates changed substantially (from 1.0% to 44% in the annual rate) depending on the parameters of the experimental conditions. Since the discount rates would remain unchanged if all the subjects followed exponential discounting, then it would strongly suggest that the conventional assumption of exponential discounting is not supported by the data. In other words, there existed anomalies that were probably associated with the delay, interval, and reward amount. In this section, we have examined the delay, interval, and magnitude effects. We also investigated whether the results depended on the promise of the payment of a reward.

[6] Since this payment procedure was explained in the instructions and was rehearsed twice, the subjects were expected to clearly understand that what they would receive depended entirely on their choice.

3.2 Examination of the three anomalies in time discounting using tests of the same mean

In our framework, the discount rates probably depended on the following four experimental conditions: delay, s, interval, h, reward amount, X, and whether the payment is promised, P. In this subsection, each round held three of the four conditions constant and the fourth condition variable, and we tested whether the mean discount rate varied with the t-test of the same mean.

<u>The delay effect</u>

In order to test the delay effect, we compared the rounds wherein the interval and amount are the same but the delay differs.[7] The rounds are indicated as follows:

1) Round 2 (30 days, 90 days, 240 yuan) vs. Round 4 (10 months, 90 days, 240 yuan)
2) Round 5 (2 days, 7 days, 2,800 yuan) vs. Round 6 (90 days, 7 days, 2,800 yuan)
3) Round 7 (1 month, 3 months, 2,800 yuan) vs. Round 9 (10 months, 3 months, 2,800 yuan)
4) Round 10 (1 month, 3 months, 800000 yuan) vs. Round 12 (10 months, 3 months, 800,000 yuan)

Table 2 presents the P-values of the mean-difference tests. In all the combinations, the null hypothesis that the means are the same is not rejected. Thus, the delay effect is not observed by the mean difference test.

[7] Whether the payment would be made or not is also controlled.

The interval effect

For the interval effect, three comparison tests, round 2 vs. 3, round 7 vs. 8, and round 10 vs. 11, are possible and Table 3 presents the test results. When the reward amount is set at 240 or 2,800 yuan, the discount rates were significantly higher in the shorter intervals than in the longer intervals, and this confirmed the interval effect. However, when the reward amount was set at 800,000 yuan, the null of the same mean was not rejected. This is probably because people select sufficiently low discount rates for an extremely large amount such as 800,000 yuan; therefore, the difference in the other conditions no longer changes the discount rates. The result of the interval effect is generally consistent with the subadditivity found by Read (2001).

The magnitude effect

Table 4 presents the results of the tests of the magnitude effect. The top panel shows three test results comparing the rewards of 240 and 2,800 yuan. The middle panel presents the results comparing the rewards of 2,800 and 800,000 yuan, and the bottom panel presents those comparing the rewards of 240 and 800,000 yuan. In all the combinations, the time discount rate was significantly higher for the smaller reward amount. Thus, the magnitude effect, wherein the discount rates were inversely related to the reward amount, was significantly observed. This is consistent with the results of previous studies (Benzion et al. 1989, Kirby 1997, Kirby and Marakovic 1997, and Thaler 1981).

The payment effect

Finally, we examined whether the promise of payment influences the discount rates.

Rounds 1 and 7 were designed to have the same condition (s, h, X), and they differed only in that the reward was actually paid in round 5 and not in round 1. Table 5 presents the test result of the same mean, which reveals that the null of the same mean is not rejected. As noted above, the reward of 2,800 yuan was relatively large in China; therefore, this result has a strong implication: as long as a few of the subjects will actually be paid a large reward for a few rounds that are selected randomly in the same experiment, whether the reward is actually paid to the subjects is unrelated to the time discount rates reported by them. This provides grounds for the validity of our experimental result with respect to the following: (1) although we did not pay rewards to all subjects except the winner of each round, the overall results are trustworthy, and (2) the results of rounds 10–12, where the reward of 800,000 yuan was only imaginary, are reliable.

3.3 Regression analysis for the investigation of the three anomalies

In the previous subsection, although we did not confirm the delay effect, we determined the interval and magnitude effects. This is consistent with Read's (2001) conclusion, and it creates uncertainty regarding the empirical validity of the delay effect reported by numerous previous studies because they did not separate the delay from the interval. However, we must be careful, because the comparison tests in the previous subsection may suffer from the problem of a small sample, and this may lead to a small power to reject the null of the same mean. A careful analysis of Table 2 indicates that the rounds of the 2-day delay report a discount rate of 30.6%, which is substantially higher than the discount rate of 22% for the 90-day delay in round 6. Although the P-value is only 32%, this may be a result of the small sample of 29. In order to avoid this weakness, we pool all the 348 samples, and conduct a regression analysis using these samples.

The regression equation essentially controlled all the experimental conditions: the delay, *s*, interval, *h*, reward amount, *X*, and whether the reward is actually paid, *P*. In particular, we adopted the following variables: For the variables standing for the delay, we used dummy variables $HOR2_j$, $HOR30_j$, and $HOR90_j$, which were equal to unity if the delay is 2 days, 1 month, and 3 months in round *j*, respectively, and 0 otherwise. The dummy variable representing 10 months was deleted for the benchmark. For the amount of the reward, we used dummy variables $AMT240_j$ and $AMT2800_j$, which were equal to unity for the reward amounts of 240 and 2,800 yuan, respectively, in round j, and 0 otherwise. The dummy variable representing 800,000 yuan was deleted for the benchmark. For the interval, we used a variable INT_j, which was equal to the length of the interval in round j. Since the interval dummies and delay dummies were perfectly collinear and not all the dummies could be included at once, we did not use the interval dummies. Finally, we used a dummy variable PAY_j, which was equal to unity if the reward would be paid in round j, and 0 otherwise. Thus, the regression equation is

$$\begin{aligned} LNTD_{ij} = {} & \alpha_0 + \alpha_1 HOR2_j + \alpha_2 HOR30_j + \alpha_3 HOR90_j + \alpha_4 INT_j + \alpha_5 AMT240_j \\ & + \alpha_6 AMT2800_j + \alpha_7 PAY_j + \varepsilon_{ij} \end{aligned}, \qquad (1)$$

where $LNTD_{ij}$ represents the logarithm of subject *i*'s time discount rate in round *j*. The logarithm of time discount rates were considered because the time discount rates were essentially positive, and therefore, the lognormal distribution was expected to fit better than normal distribution. It was probably owing to this fact that the fits of any estimation below became substantially worse when time discount rates were used instead of their logarithms.

Table 6 presents the results of the random effect model. For the variables of the delay dummies, although the estimated coefficient of $HOR2_j$ was significantly positive, those of $HOR30_j$ and $HOR90_j$ were insignificant, thereby indicating that the delay effect operates only in 2-day delays, but not in the rounds where the delay is over 30 days. This implies that the delay effect is found between delays of two days and 30 days (approximately four weeks). This non-linear property of the delay effect is close to that of the quasi-hyperbolic discount model, wherein people discount much of the future value between the present and the very near future, whereas they discount it only moderately after that period (Laibson 1997). The result does not contradict Read (2001), who reported that the delay effect is not observed in the case of 6-month and 8-month delays, which are both substantially longer periods of delay than that considered in our study. It is also consistent with Kinari et al. (2009), who reported the delay effect between two and four weeks (when interval is set at four weeks) or zero and two weeks (when interval is set at two weeks).

Let us briefly examine other anomalies. The estimated coefficients of $AMT240_j$ and $AMT2800_j$ were significantly positive, and that of INT_j were significantly negative. These results confirm the magnitude and interval effects, which have already been confirmed by us using the test of the same mean. The estimated coefficient of PAY_j was insignificant, which is also consistent with the results in the previous subsection. Thus, when a part of the subjects are randomly selected, and are actually paid a large reward amount for certain rounds, the subjects honestly answer the questions even when the reward is imaginary.

Subsequently, we considered the attributes of the subjects, i.e., gender, and household income. In particular, we added a dummy variable, *MALE*, which was equal to unity for male subjects and zero otherwise, and a dummy variable *HINCOME*, which was equal to unity if the subject's annual household income was over 14,000 yuan and zero otherwise. Four subjects were classified as high income and 20 as low income. Since five subjects who did not report household income were excluded, there were 24 observations for this regression. The right column of Table 6 indicate the estimates. Both coefficients of *MALE* and *HINCOME* were not significant at the 5% level. Thus, for our subjects, the discount rates were independent of these attributes. On the other hand, the three anomalies were clearly confirmed with this specification. The result that *PAY* had no effect also remains unchanged.[8]

4. Time discounting and procrastinating behavior

4.1 Analytical framework

It is not common to behave as we had originally planned: we tend to postpone experiencing discomfort and enjoy pleasure earlier. In this section, we investigate whether the subjects'

[8] The questions that were included in the questionnaire, which the subjects were asked to complete at the end of the experiment, were similar to those in the experiment. Thus, we computed the discount rates from these questions in order to compare them with those in experiment. Although the discount rates elicited by the questionnaire and the experiment were not exactly the same, they were rather close in numerous cases. This also supports the conclusion regarding the effect of the payment of the rewards.

time preference and the delay effect, as revealed in the experiment, can explain their procrastinating behavior.

As an example of an unpleasant task that people tend to procrastinate, we adopted homework assignments in childhood. In the questionnaire that was distributed at the end of the experiment, we asked the respondents the following question in order to determine when they did their assignments:

"Thinking about the time when you were a child and were given an assignment in school, when did you usually do the assignment?" (Circle ONE number)

1. Got it done right away
2. Tended to get it done early, before the due date
3. Worked on it daily up until the due date
4. Tended to get it done toward the end
5. Got it done at the last minute

On the basis of their answers, we defined HWK_i as the number that was chosen by subject i. This is a proxy for procrastinating behavior, a larger value of HWK_i implies a stronger propensity to procrastinate.

Our interest was to empirically examine the manner in which the subjects' procrastinating propensities, measured by HWK_i, related to their following two attributes regarding time discounting: the degree of impatience, measured by the mean discount rate, and the degree of the delay effect. Since lesser patient subjects would select the performance of onerous activities at a subsequent stage, we hypothesized that the time discount rate is positively correlated to procrastinating propensity.

The impact of the delay effect on when to perform onerous tasks depends on whether the decision maker is naïve or sophisticated.[9] With the delay effect, naïve people, who do not expect a future upward shift of impatience, repeatedly procrastinate the performance of costly jobs. Therefore, in this case, procrastination is expected to be positively correlated with the delay effect.

In contrast, sophisticated people, who make decisions by incorporating preference shifts of future selves, understand that making future selves make decisions leads to harmful procrastination and have incentives to perform onerous tasks earlier. The incentive effect, termed the sophistication effect, mitigates procrastination. In particular, as shown by O'Donophue and Rabin (Proposition 2, 1999), if the sophistication effect is sufficiently strong, sophisticated people perform tasks earlier than exponential discounters would. In such an extreme case, the delay effect is negatively correlated with procrastination.

Overall, these arguments may be summarized in the following manner: (i) if the subjects are *naïfs*, the delay effect will enhance their procrastination; however, (ii) if the subjects are *sophisticates*, the delay effect may not evidently promote procrastination; it may even suppress procrastination. Here, it must be noted that although theory does not predict any signs of correlation between the delay effect and procrastination, a negative correlation between them implies that the subjects are sophisticated.

We regressed procrastination (*HWK*) over the time discount rate and the degree of the delay effect. The coefficient of the discount rate is expected to be positive regardless of *naïfs* or *sophisticates*. If most of the subjects are *naïfs*, the coefficient of delay effect must

[9] See O'Donophue and Rabin (1999).

be positive. However, if they are *sophisticates*, it can take any sign.

4.2 Definition of variables used in the regression

For the time discount rate of subject *i*, we used the standardized average $AVSTDTD_i$ of the logarithmic discount rates in all rounds $LNTD_{ij}$ (j = 1, …, 12) such that

$$AVSTDTD_i = \sum_{j=1}^{12} STDTD_{ij} / 12 , \tag{2}$$

where $STDTD_{ij}$ represents the standardized value of TD_{ij}, which is calculated as $STDTD_{ij} = (\frac{LNTD_{ij} - \mu_j}{\sigma_j})$, where μ_j and σ_j are the means and standard deviations of logarithmic time discount rates, respectively, in round j over the subjects. It must be noted that the standardization was necessary for ruling out biases owing to the cross-round differences in the averages of the discount rate.[10]

In the same token, we define the degree of the delay effect of subject *i*, $STDDLY_i$, as the average of the differences in standardized time discount rates among the cases where all the conditions other than the delay are the same (see Table 2), i.e.,

$$\begin{aligned} STDDLY_i = [&(STDTD_{i2} - STDTD_{i4}) + (STDTD_{i5} - STDTD_{i6}) \\ &+ (STDTD_{i7} - STDTD_{i9}) + (STDTD_{i10} - STDTD_{i12})] / 4. \end{aligned} \tag{3}$$

4.3 Estimation results on procrastination

[10] For example, a simple average would underestimate the contribution of the discount rates in case of the larger reward amount, wherein the discount rates are rather small. However, the conclusions essentially remain unchanged when we use non-standardized discount rates and delay effects.

We estimated the relationship using ordered probit because the dependent variable HWK_i takes on integers from one to five, and a larger value represents stronger procrastination.[11] In the left column of Table 7, HWK_i is regressed only over the time discount rate, *AVSTDTD*, which reveals that higher discount rates enhance procrastination. In the right column of Table 7, we indicate the results including both *AVSTDTD* and *STDDLY*. Although the time discount rates have a positive coefficient, the coefficient of *STDDLY* is significantly negative. The result that the coefficient of the delay effect is not positive contradicts that the subjects are *naïfs,* thereby suggesting that our subjects may be *sophisticates*. This is an intuitively natural result since the students of Fudan University are undoubtedly the top elite in China.[12]

4.4 Further examination of the *naïfs-sophisticates* model

It may be suspected, however, that our results were merely obtained by chance and are thus not reliable. In order to address this concern, we conducted an additional analysis on the relationship between the delay effect and procrastination. If all the subjects are *naïfs*, larger delay effects result in greater procrastination. On the other hand, if all the subjects are essentially sophisticates, then what can be expected? The correlation between the delay effect and procrastination may depend on the size of the delay effects displayed by the subjects: The regret experienced by those whose delay effect is weak is not strong enough

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[11] It must be noted that the estimated coefficients do not represent the marginal effect on the value of *HWK*. They represent the effect on the continuous latent variable corresponding to the *HWK*.

[12] It was reported in the media that "according to the results of a respected exam, the students in Shanghai have surprised experts by outscoring their counterparts in dozens of other countries in reading as well as in math and science" (New York Times, December 7, 2010). The news offers evidence that education level in Shanghai is generally rather high.

to prevent further procrastination, whereas those who have strong delay effects will stop procrastinating because of a strong sophistication effect.

In order to substantiate our hypothesis, we divided the subjects into two groups, high and low degrees of delay effects. Subsequently, we defined a variable representing the degree of the delay effect of the higher group, $HSTDDLY_i$, and a variable representing that of the lower group, $LSTDDLY_i$, in the following manner:

$$HSTDDLY_i \equiv \begin{cases} STDDLY_i & if \quad STDDLY_i \geq \overline{STDDLY} \\ 0 & otherwise \end{cases}, \tag{4}$$

$$LSTDDLY_i \equiv \begin{cases} STDDLY_i & if \quad STDDLY_i < \overline{STDDLY} \\ 0 & otherwise \end{cases}, \tag{5}$$

where $\overline{STDDLY}$ denotes a critical value dividing the subjects into two groups that are specified below. The regression equation now becomes

$$HWK_i = \beta + \gamma AVSTDTD_i + \delta_H HSTDDLY_i + \delta_L LSTDDLY_i + v_i, \quad i = 1, \ldots, 29. \tag{6}$$

If our subjects are *naïfs*, then $\delta_H = \delta_L \geq 0$ will be obtained. On the contrary, if the subjects are *sophisticates*, δ_H and δ_L can take any sign. However, the following may be a probable case: when the critical value $\overline{STDDLY}$ is set at an adequately low level, *sophisticates* who have weaker delay effects do not regret that they are procrastinating; therefore, they behave as if they are *naïfs*. On the other hand, those who have stronger delay effects attempt to stop procrastination; therefore, their increase in the level of procrastination is lesser than proportional to their degree of delay effect. Therefore, the sensitivity to the delay effect, δ_H, becomes smaller than δ_L. In this case, $\delta_H < \delta_L \geq 0$ is expected. This does not necessarily mean that procrastination is weaker for the higher delay effect group. However, in case it is weaker for the higher delay effect group, then δ_H is negative.

In order to determine the critical value, $\overline{STDDLY}$, let us study the histogram of *STDDLY* in Figure 1. It reveals that 17 out of 29 subjects do not report the delay effect. Thus, we first stratify all the subjects who report negative *STDDLY* as the low-delay-effect group and all others as the high-delay-effect group. The left column of Table 8 presents the estimates in this case, which reveal that the high group (*HSTDDLY*) has a significant negative coefficient and the low group (*LSTDDLY*) has an insignificant coefficient. Thus, we obtain $\delta_H < 0$ and $\delta_L = 0$.

When the critical value is increased to 0.2, it is confirmed that we obtain the same results, i.e., $\delta_H < 0$ and $\delta_L = 0$. The results in Table 8 contradict the notion that the subjects are *naïfs*; however, it is consistent with the hypothesis considered for *sophisticates*.[13]

5. Conclusion

This study used an economic experiment in order to investigate the time discounting of human beings. Economic experiments are often termed unreliable because the subjects that are recruited do not have sufficient incentives to report their true preferences. Our experiment is immune to such criticism because in our study, the highest reward that was

[13] When the non-standardized time discount rate and delay effect were used, we obtained the same results, wherein δ_H is significantly negative and δ_L is insignificant.

indicated to the subjects was close to their monthly household incomes.

This study achieved two goals. First, the delay effect owing to which people discount the near future more than the remote future was substantiated by explicitly separating the delay from the interval.[14] A majority of the previous studies have not separated these two experimental conditions; however, Read (2001) identified these two conditions and reported that the delay effect was not found. By setting shorter delays than that set by Read (2001), we substantiated the delay effect for a delay of less than 90 days. This finding is important because the delay effect induces people to make time-inconsistent plans and subsequently regret their decision.

Another contribution of this study is its explanation of the subjects' procrastinating behavior on the basis of their time discount rates and the degree of the delay effect. Higher time discounting always promotes procrastination; however, the impact of the delay effect depends on whether the subjects are *naïfs* or *sophisticates*. If they are *naïfs*, a higher delay effect promotes procrastination. However, if they are *sophisticates,* it involves two competing effects on procrastination, i.e., the positive present-bias effect and the negative sophistication effect, so that the direction of the effect is not known a priori. We hypothesized that the effect of the delay effect is weaker when the delay effect is strong than when it is not strong. Our results contradicted the notion that our subjects are *naïfs* and are consistent with our hypothesis on *sophisticates*.

However, we must note that this study found that the *naïfs-sophisticates* model holds

[14] Simultaneously, we confirmed the interval effect, wherein subjects discount the future more in shorter intervals than in longer intervals, and the magnitude effect, wherein subjects discount the future more for smaller amounts of money than larger amounts of money.

for a specific sample of the students at Fudan University. On the other hand, Hiruma and Ikeda (2007) and Tsutsui et al. (2007) had found a positive correlation between the degree of the delay effect and the loan amount. Considering that the loan amount is a good proxy for the behavior of the procrastination of unpleasant things, their results contradict those of this paper. The *naïfs-sophisticates* model interprets the results of our study for *sophisticates* and *naïfs*; however, this interpretation may seem arbitrary. Determining more direct evidences for identifying *sophisticates* and *naïfs* is a potential area for future research.

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Table 1. Twelve sets of experimental conditions and their mean discount rates

Round	1	2	3	4	5	6
Delay (*s*)	1 month	1 month	1 month	10 months	2 days	90 days
Interval (*h*)	3 months	3 months	1 year	3 months	7 days	7 days
Rewards (*X*)	2,800	240	240	240	2,800	2,800
Payment (*P*)	No	Yes	Yes	Yes	Yes	Yes
Mean discount rate	9.586	40.034	23.793	43.828	30.638	22.121
Standard error	2.085	7.520	3.770	8.630	9.160	7.027

Round	7	8	9	10	11	12
Delay (*s*)	1 month	1 month	10 months	1 month	1 month	10 months
Interval (*h*)	3 months	1 year	3 months	3 months	1 year	3 months
Rewards (*X*)	2,800	2,800	2,800	800,000	800,000	800,000
Pay (*P*)	Yes	Yes	Yes	No	No	No
Mean discount rate	8.276	5.819	9.034	1.103	1.491	0.959
Standard error	1.275	0.948	2.040	0.378	0.655	0.299

Note: This table shows the experimental conditions of twelve rounds and the mean and standard errors of the discount rate of each round.

Table 2. Results of the t-test of the same mean in the case that delays are different

Round	2	4	5	6	7	9	10	12
Delay (s)	1 month	10 months	2 days	90 days	1 month	300	1 month	10 months
Interval (h)	3 months	3 months	7 days	7 days	3 months	3 months	3 months	3 months
Rewards (X)	240	240	2,800	2,800	2,800	2,800	800,000	800,000
Payment (P)	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Observations	29	29	29	29	29	29	29	29
Mean discount rate	40.034	43.828	30.638	22.121	8.276	9.034	1.103	0.959
95% upper bound	24.630	26.149	11.875	7.727	5.664	4.855	0.329	0.346
95% lower bound	55.439	61.506	49.401	36.514	10.887	13.214	1.876	1.573
P-value	0.617		0.317		0.455		0.638	

Note: P-values indicate the probability with which the null of the same mean is rejected.

Table 3. Results of the t-test of the same mean in the case that the intervals are different

Round	2	3	7	8	10	11
Delay (s)	1 month	1 month	1 month	1 month	1 month	1 month
Interval (h)	3 months	1 year	3 months	1 year	3 months	1 year
Rewards (X)	240	240	2,800	2,800	800,000	800,000
Payment (P)	Yes	Yes	Yes	Yes	No	No
Observations	29	29	29	29	29	29
Mean discount rate	40.034	23.793	8.276	5.819	1.103	1.491
95% upper bound	24.630	16.070	5.664	3.877	0.329	0.151
95% lower bound	55.439	31.516	10.887	7.761	1.876	2.832
P-value	0.003		0.003		0.538	

Table 4. Results of the t-test of the same mean in the case that reward amounts are different

Round	2	7	3	8	4	9
Delay (*s*)	30	30	30	30	300	300
Interval (*h*)	90	90	365	365	90	90
Rewards (*X*)	240	2,800	240	2,800	240	2,800
Payment (*P*)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29	29	29	29	29	29
Mean discount rate	40.034	8.276	23.793	5.819	43.828	9.034
95% upper bound	24.63	5.664	16.07	3.877	26.149	4.855
95% lower bound	55.439	10.887	31.516	7.761	61.506	13.214
P-value	0.000		0.000		0.000	

Round	7	10	8	11	9	12
Delay (*s*)	30	30	30	30	300	300
Interval (*h*)	90	90	365	365	90	90
Rewards (*X*)	2,800	800,000	2,800	800,000	2,800	800,000
Payment (*P*)	Yes	No	Yes	No	Yes	No
Observations	29	29	29	29	29	29
Mean discount rate	8.276	1.103	5.819	1.491	9.034	0.959
95% upper bound	5.664	0.329	3.877	0.151	4.855	0.346
95% lower bound	10.887	1.876	7.761	2.832	13.214	1.573
P-value	0.000		0.001		0.001	

Round	2	10	3	11	4	12
Delay (*s*)	30	30	30	30	300	300
Interval (*h*)	90	90	365	365	90	90
Rewards (*X*)	240	800,000	240	800,000	240	800,000
Payment (*P*)	Yes	No	Yes	No	Yes	No
Observations	29	29	29	29	29	29
Mean discount rate	40.034	1.103	23.793	1.491	43.828	0.959
95% upper bound	24.63	0.329	16.07	0.151	26.149	0.346
95% lower bound	55.439	1.876	31.516	2.832	61.506	1.573
P-value	0.000		0.000		0.000	

Table 5. Results of the t-test of the same mean for the cases that the reward is paid or not

Round	1	7
Delay (*s*)	30	30
Interval (*h*)	90	90
Rewards (*X*)	2,800	2,800
Payment (*P*)	No	Yes
Observations	29	29
Mean discount rate	9.586	8.276
95% upper bound	5.315	5.664
95% lower bound	13.857	10.887
P-value	0.461	

Table 6. Result of the regression analysis on three anomalies

	Estimated coefficient	P-value	Estimated coefficient	P-value
Constant	−1.074	0.000	-1.140	0.000
HOR2	0.765	0.004	0.822	0.004
HOR30	0.077	0.651	0.160	0.382
HOR90	0.336	0.203	0.342	0.230
AMT240	4.413	0.000	4.485	0.000
AMT2800	2.941	0.000	2.957	0.000
INT	−0.001	0.018	-0.002	0.016
PAY	0.001	0.997	0.028	0.920
MALE			-0.304	0.491
HINCOME			0.817	0.064
Number of observations	348		288	
Number of subjects	29		24	
R^2	0.6284		0.6581	

Note: The regression equation is given by

$$LNTD_{ij} = \alpha_0 + \alpha_1 HOR2_j + \alpha_2 HOR30_j + \alpha_3 HOR90_j + \alpha_4 INT_j + \alpha_5 AMT240_j + \alpha_6 AMT2800_j + \alpha_7 PAY_j + \varepsilon_{i,j}$$

Results are presented according to the random effect model.

Table 7. How procrastination depends on time discount rate and delay effect

	Estimated coefficient	P-value	Estimated coefficient	P-value
AVSTDTD	0.855	0.014	1.147	0.003
STDDLY			-1.362	0.015
Cut1	-1.434		-1.362	
Cut2	-0.054		0.012	
Cut3	0.577		0.699	
Cut4	1.669		1.815	
Log likelihood	-39.138		-35.986	
Pseudo R^2	0.073		0.148	
Number of observations	29		29	

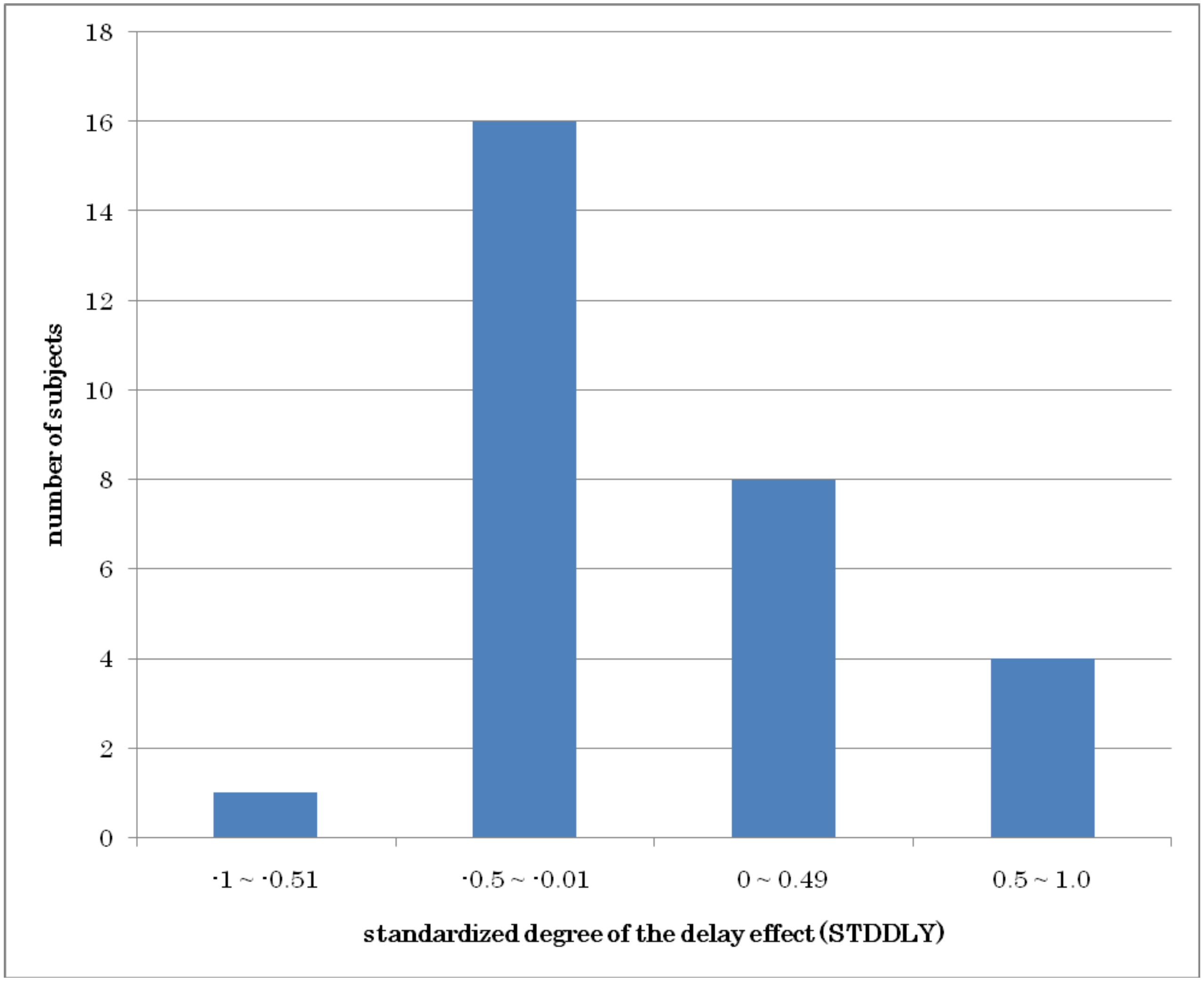
Note: This table presents the estimates by ordered probit. It must be noted that the estimated coefficients are not for the marginal effect. Cut 1 to Cut 4 are estimated cutpoints on the latent variable for classifying HWK_i into values from 1 to 5, which represent the propensity of procrastination.

Table 8. Analysis on *Naïfs-Sophisticates* model

	Estimated coefficient	P-value	Estimated coefficient	P-value
AVSTDTD	1.059	0.007	1.049	0.008
HSTDDLY	-2.856	0.008	-2.233	0.016
LSTDDLY	0.672	0.607	-0.196	0.858
Cut1	-2.4		-2.06	
Cut2	-0.544		-0.273	
Cut3	0.131		0.401	
Cut4	1.311		1.55	
Log likelihood	-34.485		-35.218	
Pseudo R2	0.1832		0.1659	
Number of observations	29		29	
Critical value of STDDLY	0		0.2	
(High group, Low group)	(12, 17)		(8, 21)	

Note: Refer to Table 7's footnote.

Figure 1. Histogram of the standardized degree of the delay effect, *STDDLY*



Appendix: An example of Payoff table used in the experiment (Round 1)

① Payoff table (2,800.00 yuan, 1 month vs. 4 months, reward is not actually paid)

Number of the option pair	Option A (yuan) (receipt at 1 month later)	Option B (yuan) (receipt at 4 month later)	Rate of return (annual rate)	Answers	
1	2,800.00	2,730.00	−10%	A	B
2	2,800.00	2,765.04	−5%	A	B
3	2,800.00	2,772.00	−4%	A	B
4	2,800.00	2,779.04	−3%	A	B
5	2,800.00	2,786.00	−2%	A	B
6	2,800.00	2,793.04	−1%	A	B
7	2,800.00	2,800.00	0%	A	B
8	2,800.00	2,807.04	1%	A	B
9	2,800.00	2,814.00	2%	A	B
10	2,800.00	2,821.04	3%	A	B
11	2,800.00	2,828.00	4%	A	B
12	2,800.00	2,835.04	5%	A	B
13	2,800.00	2,842.00	6%	A	B
14	2,800.00	2,849.04	7%	A	B
15	2,800.00	2,856.00	8%	A	B
16	2,800.00	2,863.04	9%	A	B
17	2,800.00	2,870.00	10%	A	B
18	2,800.00	2,877.04	11%	A	B
19	2,800.00	2,884.00	12%	A	B
20	2,800.00	2,891.04	13%	A	B
21	2,800.00	2,898.00	14%	A	B
22	2,800.00	2,905.04	15%	A	B
23	2,800.00	2,912.00	16%	A	B
24	2,800.00	2,919.04	17%	A	B
25	2,800.00	2,926.00	18%	A	B
26	2,800.00	2,933.04	19%	A	B
27	2,800.00	2,940.00	20%	A	B
28	2,800.00	2,975.04	25%	A	B
29	2,800.00	3,010.00	30%	A	B
30	2,800.00	3,080.00	40%	A	B
31	2,800.00	3,150.00	50%	A	B
32	2,800.00	3,220.00	60%	A	B

Notes: 1. Please circle A or B, whichever you prefer.
2. If you circled a wrong option, correct the answer with a double line.