Discounting Time and Time Discounting:

Subjective Time Perception and Intertemporal Preferences

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WEB APPENDIX

SECTION 1

This experiment replicates the findings of Experiment 1 in a within-subjects setting. Although hyperbolic discounting has been observed in between-subjects and within-subjects experiments, one could argue that if different time horizons were evaluated jointly, consumers would show more sensitivity to changes in time horizon. Instead, we hypothesize that insensitivity to time horizon is a more perceptual effect and should impact hyperbolic discounting regardless of experimental modes and thus prevail even in within-subjects designs.

This study also addressed some other limitations of Experiment 1. In Experiment 1, time horizon confounded the length of duration and the description of duration: "3 months" time horizon was compared to "1 year" time horizon (instead of 12 months), which leaves open the possibility that participants underestimated duration of the 1 year horizon because it has a smaller numerical value. To control for the effect of time horizon description, in this study we described time horizon only in units of months. In addition, in Experiment 1, subjective time perception was measured after completing the intertemporal preference task. To avoid any influence of the intertemporal preference task on subjective estimates of time horizon, in this study we switched the order of the tasks.

Method

Participants and Design. Thirty six undergraduate students participated in this study as part of an hour long session and were paid $10 for their participation. Time horizon (3 months and 12 months) and the two types of measures (intertemporal preference and subjective time) were manipulated within-subjects.

Stimuli and Procedure. Stimuli and procedure were similar to those used in Experiment 1. The first part included subjective assessments of time horizon. Participants were given a 180*mm* line with end-points labeled as '*Very Short*' on the left end and '*Very Long*' on the right end and asked to mark the duration between today and a day 3 months later. On the next page, as in Experiment 1, participants were presented with a scenario of receiving a $75 gift certificate and indicated how much they would have to be paid in order to wait for 3 months. After completing these two tasks, participants repeated this procedure for a 12 months time horizon.

Results

Subjective Time horizon. The mean distance from the left end of the 180*mm* scale was 85.20*mm* (SD = 39.35) for the 3 months time horizon and 129.73*mm* (SD = 35.41) for the 12 months, which are significantly different ($t(36) = -7.38$, $p < .0001$). As in Experiment 1, the mean value of the distance for 3 months time horizon (M = 85.20*mm*) was set equivalent to 3 months and the mean subjective estimate for 12 months was 135.37*mm*, which corresponds to 4.57 months. That is, whereas the objective time

horizon grows 300% from the 3 months to 12 months, the subjective time horizon grows only 52.33% for the same duration, replicating the results of Experiment 1.

Discount rates. We first calculated compound annual discount rates based on objective time. As expected, the objective discount rate for the 3 months (M = 104.26%) was significantly higher than the discount rate for 12 months (M = 47.83%, $t(35) = 4.90$, $p < .0001$), implying a hyperbolic pattern of discounting. Next, adjusted discount rates were calculated based on individual subjective estimates of time horizon. For these adjusted discount rates, there was no reliable difference between 3 months and 12 months (M_{3m} = 119.80% vs. M_{12m} = 137.88%, $t(35) = -1.09$, $p = .28$), showing that participants' implied discount rates do not decrease over time after taking subjective time perception into account.

A 2 (time horizon: 3 months vs. 12 months) x 2 (time horizon measure: objective vs. subjective) fully within-subjects ANOVA revealed a significant interaction of time horizon by time horizon measure ($F(1,35) = 20.57$, $p < .0001$), indicating differences in the level of discounting as a function of the measure used, replicating our Experiment 1 results (see figure 2).

Discussion

This experiment replicates Experiment 1's findings with within-subjects measures of time horizon sensitivity. As before, we find that consumers' subjective duration perceptions are relatively insensitive to the objective changes in time horizon and that accounting for this insensitivity significantly reduces the extent of hyperbolic discounting. These results from a within-subjects design rule out the alternative explanation that the

insensitivity to time horizon is an artifact of eliciting separate evaluations of time horizons (Hsee 1998). In this study, each participant estimated multiple time horizons and still showed lack of sensitivity to time. This experiment also demonstrated that this phenomenon is robust to different descriptions of time horizon (months versus years) and to time perception measurement being the first task.

SECTION 2

In Experiment 1 and 2 we measured time perception and intertemporal preferences separately, providing a strong, conservative test of our theory. In doing so, we demonstrated across multiple experimental conditions that subjective estimates of time horizon measured independently from the focal preference task drive the pattern of participants' intertemporal preferences. To further show the robustness of our results, in this section we replicate our findings when subjective estimates are directly linked to the focal intertemporal decision. This is potentially important, because our day-to-day utilization of such time estimations is likely to be in the context of the transaction in question. We also manipulate in a single experiment whether the measurement of subjective time occurs before or after the preference task. Thus, in this experiment, we examine our hypotheses with participants estimating subjective time in terms of the distance to the transaction and manipulate whether the estimate comes before or after the preference task.

Method

Participants and Design. One hundred and thirty three undergraduate students completed the study as part of an hour long session and were paid $10 for their participation. The experimental design was a 2 (time horizon: 3 month vs. 12 months) x 2 (position of time perception measure: before vs. after) between-subjects design.

Stimuli and Procedure. Stimuli are similar to those used in previous experiments. Unlike prior experiments, however, the time perception task and the intertemporal preferences measure were implemented on the same page. All participants were first asked to imagine receiving a gift certificate worth $75 and delaying the use of it by 3 months (or 12 months). Next, half of the participants were asked to indicate their subjective estimates of this time horizon and then to complete the intertemporal task, reporting the amount they would need to be paid to accept delay of the $75 gift certificate by 3 months (or 12 months). The other half of the participants completed the two tasks in the reverse order. Consistent with our prior studies, the findings replicate for both orders.

Results and Discussion

Subjective time horizon and discount rate. To replicate our previous findings, we first separately analyzed the data from the before (c.f., Experiments 2) and after (c.f., Experiment 1) time perception measurement conditions and then the combined data. For the before condition, the mean distance was 88.15*mm* (SD = 38.02) for the 3 months condition and 126.67*mm* (SD = 36.08) for the 12 months condition. When the mean value of the distance for the 3 months condition was set equivalent to 3 months time horizon, the mean of the 12 months condition was equal to 4.31 months, showing only 44% growth. Next discount rates were calculated using both objective time horizon and

subjective estimates of the time horizon. With respect to objective time horizon, the annual compound discount rate for the 3 months condition (M = 116.75%) was higher than the discount rate for the 12 months condition (M = 36.10%), indicating a hyperbolic pattern of discounting ($t(64) = 4.09$, $p < .001$). With respect to subjective time estimates, however, the adjusted discount rate for the 3 months condition (M = 146%) was not statistically different from the discount rate for the 12 months condition (M = 104.107%, $t(64) = 1.26$, $p > .21$).

A 2 (time horizon: 3 months vs. 12 months) x 2 (time horizon measure: objective vs. subjective) mixed ANOVA with time horizon as the between-subjects factor and time horizon measure as a within-subjects factor revealed a significant interaction of time horizon by time horizon measure ($F(1, 64) = 4.19$, $p < .05$), indicating differences in the extent of hyperbolic discounting as a function of the measure used.

These results replicated for those in the after condition. When the mean value of the distance for the 3 months condition (87.26*mm*, SD = 34.71) was set equivalent to 3 months time horizon, the mean of the 12 months condition (135.06*mm*, SD = 32.41) is equal to 4.64 months, showing only 55% growth. The objective discount rate for the 3 months condition (M = 126.98%) was higher than the discount rate for the 12 months condition (M = 44.44%, $t(65) = 3.46$, $p < .001$), and the adjusted discount rate for the 3 months condition (M = 143.39%) was not statistically different from the discount rate for the 12 months condition (M = 113.94%, $t(65) = .93$, $p > .35$). A significant interaction of time horizon by time horizon measure was also revealed ($F(1, 65) = 4.43$, $p < .05$).

Finally, we collapsed the data from both measurement position conditions and examined subjective estimates of time horizon and intertemporal preferences.

Measurement position had neither a main effect ($F(1, 129) < 1$) nor an interaction ($F(1, 129) < 1$) for subjective estimates of time horizon or discount rates. The overall mean of the 3 months condition (87.70*mm*, SD = 36.10) was set equal to 3 months, implying that the overall mean of the 12 months condition (130.86*mm*, SD = 34.29) was equal to 4.48 months (49% growth). The objective discount rate for the 3 months condition (M = 121.94%) was higher than the discount rate for the 12 months condition (M = 40.27%, $t(131) = 5.30$, $p < .0001$), and the adjusted discount rate for the 3 months condition (M = 144.68%) was not statistically different from the discount rate for the 12 months condition (M = 109.04%, $t(131) = 1.57$, $p = .12$). An interaction of time horizon by time horizon measure was also significant ($F(1, 131) = 8.60$, $p < .05$).

In sum, this study replicates and extends our prior findings by demonstrating that consumers' relative insensitivity to changes in the time horizon persists when the subjective time estimation is measured within the context of the transaction, and is robust to when the time perception measure is carried out relative to the intertemporal preference measure. These findings provide further support for our hypothesis that time perception is a significant robust driver of hyperbolic discounting.

SECTION 3

In this section we address the issue of the scale that we used to measure time perception. We used the same procedure to measure time perception as in Experiment 1, but systematically manipulated the scale anchors. We chose several pairs of words indicating subjective feelings of a short and long time horizon to use as anchors: 1) very short – very long, 2) instant – distant, 3) near – far, 4) now – forever, or 5) now – eternity.

Participants indicated the subjective feeling of duration between today and a day in 1 month or 3 months and their estimated growth from 1 month to 3 months were compared.

Method

Participants and Design. Ninety six undergraduate students participated in this study as part of an hour long session and were paid $10 for their participation. Time horizon (1 month and 3 months) were manipulated within-subjects and the five wordings of anchors were manipulated between-subjects.

Stimuli and Procedure. As in previous studies, participants were given a 180*mm* line and indicated the subjective feeling of duration between today and a day in 1 month or 3 months. Participants were randomly assigned to one of five conditions. In one condition, the end-points of the line were labeled as '*Very Short*' on the left end and '*Very Long*' on the right end as in other experiments in the paper. In the other conditions, the end-points were labeled as "*Instant*" on the left end and "*Distant*" on the right end, "*Near*" on the left end and "*Far*" on the right end, "*Now*" on the left end and "*Forever*" on the right end, or "*Now*" on the left end and "*Eternity*" on the right end.

Results and Discussion

For very short – very long anchor, the mean distance was 76.84*mm* (SD = 41.52) for the 1 month time horizon and 120.37*mm* (SD = 36.25) for the 3 months, which are significantly different ($t(18) = -5.87$, $p < .001$). For instant – distant anchor, the mean was 90.05*mm* (SD = 45.24) for the 1 month and 127.20*mm* (SD = 46.89) for the 3 months ($t(20) = -4.82$, $p < .001$). For near – far anchor, the mean was 70.53*mm* (SD = 44.72) for

the 1 month and 100.68*mm* (SD = 46.67) for the 3 months ($t(19) = -3.46$, $p < .01$). For now – forever anchor, the mean was 62.68*mm* (SD = 51.71) for the 1 month and 90.37*mm* (SD = 54.44) for the 3 months ($t(18) = -4.30$, $p < .001$). For now – forever anchor, the mean was 58.68*mm* (SD = 46.85) for the 1 month and 97.21*mm* (SD = 53.92) for the 3 months ($t(18) = -5.54$, $p < .001$).

One-way ANOVA revealed no difference for the mean distances for 1 month time horizon among the five conditions ($F(4,91) = 1.41$, $p = .24$). Thus, we normalized the subjective time estimate for each individual based on the mean distance for 1 month time horizon as in Experiment 1 and 2 to compare the growth of time perception from 1 month to 3 months. Based on the 1 month time horizon, the mean subjective time estimate for 3 months were 1.57 months, 1.41 months, 1.43 months, 1.44 months, and 1.66 months separately for each anchors. Repeated measures ANOVA revealed only a significant main effect of time horizon ($F(1,91) = 112$, $p < .0001$), but no significant main effect of anchor ($F(4,91) < 1$) and no significant time horizon by anchor interaction ($F(4,91) = 1$, $p = .41$).

These results replicate the findings of contracted time perception in Experiment 1 regardless of the labels used for scale anchors. In addition, we found no evidence of systematic impact of scales anchors on subjective time perception. It implies that the our continuous line scale captures participants' subjective estimates of time horizon consistently regardless of the specific anchors, as long as one anchor indicates the feeling of short time horizon and the other indicates the feeling of long time horizon.

SECTION 4

Priming tasks used in Experiment 3: Control (Student Diet) and Duration (Student Activities)

Student Diet		**Student Activities**	
In this task, we ask you to consider the typical food items you would consume and estimate how many calories each of the items would contain. Please think about each food item below and provide your most accurate estimate of the total number of calories each would contain.		In this task, we ask you to consider several activities and estimate how long each of these activities would take you to complete. Please think about each activity below and provide your most accurate estimate of the total time required to complete each of the following activities.	
One slice of a large one-topping pizza:	_____ calories	**Graduating from college (undergraduate):**	_____ hours / days / weeks / months / years
A bowl of salad:	_____ calories	**Learning a new language:**	_____ hours / days / weeks / months / years
A Whooper with cheese:	_____ calories	**Finding a job (once started searching):**	_____ hours / days / weeks / months / years
One serving of chicken wings:	_____ calories	**Studying for a difficult final exam:**	_____ hours / days / weeks / months / years
A 6-inch Turkey sandwich with cheese:	_____ calories	**Planning for a Spring Break vacation:**	_____ hours / days / weeks / months / years
6 pieces of California roll Sushi:	_____ calories	**Painting the exterior of a 2 story house:**	_____ hours / days / weeks / months / years
One beef burrito:	_____ calories	**Driving from NC to California:**	_____ hours / days / weeks / months / years