# Easy time: How difficulty of comparisons leads to different choices about time.

## Introduction

A large portion of our daily decisions involve making decisions involving time in some respect. A sizeable percentage of these decisions involve the tradeoff between receiving something of smaller value now and receiving something of larger value in the future. For instance when a consumer selects a shipping speed on Amazon they are making an intertemporal choice. These decisions require consumers to, perhaps implicitly, calculate how much waiting for the slower shipping speed is worth.

Multiple studies have shown that how an intertemporal choice is framed has consequences on how patient consumers are (Lowenstein and Prelec; Weber 2007, etc.). Firms could have differing preferences on whether a consumer is impatient or patient when choosing a shipping speed. If a firm’s inventory is low on a particular item they may not profit from the extra cost that it takes to expedite shipping, however if their inventory is high they may want to nudge consumers to ship their items faster. It is important to understand what variables consumers are using and how they are comparting these variables in order to create robust and adaptive choice environments.

A number of empirical regularities are found when intertemporal choice is studied in the lab; one of the most robust is that people value the present more than the future – Present Bias (e.g., O’Donoghue and Rabin 1999; Thaler 1981; Zauberman 2003, Zauberman et al. 2009). People will be more impatient when deciding between 1) $10 today vs 2) $11 in one week, than when they are deciding between 3) $10 in one week vs. 4) $11 in two weeks.

Various explanations of Present Bias discounting have been marshalled (Andreoni and Sprenger 2012; Scholten and Read 2013; Zauberman et al. 2009, Marzilli Ericson, White, Laibson, & Cohen, 2015). These can generally be split into two different types: models that try to account for present bias via psychophysical functions of discounting, and models that look at the heuristics – shortcuts that yield quicker, non-optimal solutions to a problem – as explanations.

A psychophysical account of present bias is given by Zauberman, Kim, Malkoc, and Bettman (2009). They find that people’s subjective representations of time to not map onto objective time. Concretely, subjective duration is nonlinear and insensitive to changes in duration. Zauberman et al. show that taking into the psychophysical account of duration can map onto the degree of present bias.

In contrast, Marzilli and colleages (2015) use a heuristic model named the intertemporal choice heuristic (ITCH) model which is closely related to the DRIFT and Tradeoff models (Read, Frederick, & Scholten, 2013; Scholten, Read, & Sanborn, 2014). ITCH accounts for present bias but does not assume an underlying psychophysical discount function; it accounts for present bias by hypothesizing that people compare the monetary amounts and the time amounts. These comparisons take the form of calculating a difference and a ratio of the dollar amounts and a difference and a ratio of the monetary amounts. The ITCH model can predict out of sample choice better than the other models of intertemporal choice. In this paper we focus on how people compare times

## A conceptual cognitive model for intertemporal choices

We argue that a combination of the heuristic model with a psychophysical model we can better account for present-biased preferences. Specifically if people are comparing times by calculating differences and ratios we would expect that we need to investigate their psychophysical function for both 1) differences in times and 2) ratios in times. Because if people calculate both ratios and differences, the psychophysical function of time suggested by Zauberman (2009) may not account for all of these differences. Additionally we suggest that the decision weight the participant puts on these psychophysical functions is dependent on the presentation of the times. For instance, by making the computation of ratios more difficult, we would expect participants to put a small decision weight on the ratio psychophysical function. The formula below is our specification of how various decision weights affect patience:

Where P\_ll is the probability of choosing the larger later outcome, D\_xD is the decision weight put on the difference in amounts, D\_xR is the decision weight put on the ratio of amounts, D\_tD is the decision weight put on the difference in times and D\_xR is the decision weight put on the ratio of times. For instance the day date effect may make ratios difficult to calculate yielding a higher decision weight on the time difference decision weight (D\_tD).

These decision weights are subject to the following model outlined below. The model suggests that when people are making choices involving time that they only calculate ratios and differences if they are easily calculated. This means that how intertemporal choices are framed can lead to different strategies.

Are the amounts easy to compare

Calculate Ratio and Difference and whichever is “higher”put more weight on

Yes

No

Make general comparison and put lower weights on both

Are the times easy to compare on difference and ratio?

Calculate difference and ratio. Decision weights depend on the size of the ratio and difference

Yes

Was the ratio or difference hard?

No

Calculate difference and put a low decision weight on ratio

Difficult ratio

Calculate ratio and put a low decision weight difference and a high weight on difference

Difficult difference

We propose that the properties of numbers have an effect on the difficulty of calculating differences and ratios. This difficulty of comparison could be a mediating effect of altering units on intertemporal choice. For instance changing $10 in 1 day vs $11 in 7 days to $10 in 24 hours to $11 in 168 hours has been shown to make people more impatient (Li, Wall, Toubia, Johnson, *in preparation*). This descriptive variance may be due to people using differences and not considering ratios and solely comparing differences, leading to them making more impatient choices because the psychophysical difference seems quite large whereas the ratio is difficult to calculate and its psychophysical function is not considered.

Another important implication of this model is that the relative sizes of the ratio and difference lead to varying decision weights. For instance if the participant can calculate the ratio and their psychophysical ratio function is high, they consider this to be a large ratio then their decision weight on that attribute will be high.

Another implication of this model is that when time has a large magnitude the psychophysical difference and ratio functions may seem small; leading to a smaller decision weight on both the ratio of time and difference of time.

We restrict our current paper to investigating how our model performs when people are making comparisons between times, and specifically about present bias. Present bias is usually studied by adding a constant amount to both the smaller sooner and larger later options. However, often this additional time is added at easily ratio-able and difference-able amounts (e.g. 6 months). For instance when people are given $10 in today vs $12 in 30 days and 30 days are added to both they are faced with $10 in 30 days vs $12 in 60 days; both of which are easily ratio-able and difference-able. However if 17 days were added to both options we would have $10 in 17 days vs $12 in 47 days, making the difficulty of calculating a ratio more difficult, and in our model making the decision weight on the psychophysical ratio smaller.

However these lead to the following predictions.

1. When items have easily ratio-able times and the ratio is large the importance of the ratio goes up, meaning that the probability of choosing the smaller sooner option goes up.
2. When items have uneasily ratio-able times the decision weight on the ratio is small, meaning that the difference in times receives more weight meaning that if the difference is perceived as small people will be more patient, but if it is perceived as large people will be more impatient.

This model makes the prediction that if you add an easily ratioable difference to the times that the decision weight on the ratio will remain the same but the ratio itself will be smaller leading to more patient choices. However if you add an uneasily ratioable difference to the times the decision weight on the ratio will be zero and the decision weight on the difference will be high meaning that people will be more impatient by adding the same time to both options – a reversal of present bias.