The Psychology of Intertemporal Preferences

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Intertemporal decisions involve relative preferences and tradeoffs for costs and benefits that occur over time. These decisions are ubiquitous and have been extensively studied across multiple academic disciplines, including economics, psychology, business, and public policy. Common examples of such decisions include whether to consume today (i.e., borrow more and/or save less) but have less in your retirement fund; to purchase a cheaper refrigerator or air-conditioning unit, but forgo the ongoing energy savings; to hire an experienced employee who can start immediately instead of the brilliant but inexperienced recent graduate who needs more extensive training; or to eat that fatty chocolate cream dessert rather than the blueberry sorbet, increasing your current enjoyment while increasing the risk for your long-term health.

Research on this question has occupied the pages of many journals and produced multiple highly influential and widely cited papers (Fisher 1935; Ainslie 1975; Thaler 1981; Laibson 1997; Kirby et al 1999; Frederick et al 2002). The seminal paper on time discounting by Ainslie (1975), which drew a link between findings from the animal behavior literature and a detailed theory of shifting time preferences, self-control and precommitment, spurred a large and evolving research literature.

There have also been numerous chapters surveying the field. Loewenstein (1992) provides a detailed account of the development of thinking about intertemporal choice within economics. Frederick , Loewenstein and O'Donoghue (2002) present a detailed review and discussion of the development of the literature on time discounting in both psychology and economics. Baron (2007) offers a general review of decisions involving time, while Read (2004) and Killeen (2009) review alternative mathematical forms of discount functions. Recently, there have been reviews focusing on the neurological underpinning of intertemporal decisions (e.g., Kable, 2013).

The focus in this chapter is on the psychological foundation of intertemporal decisions and the consequences for people's decisions and behaviors. Much of the early research on the behavioral aspects of intertemporal preferences has compared observed behavior across different contexts to the normative standard--the discounted utility model, which assumes that the discounting rate of utility is constant over time. This research has demonstrated numerous violations of this normative model. While there is a great deal of heterogeneity in individuals' discounting, the literature has uncovered several robust empirical generalizations. These findings were instrumental in shaping our understanding of the psychology underlying intertemporal tradeoffs, but an explicit development of these psychological theories was generally not the center of the investigations.

More recently, however, research has shifted from identification of "anomalies" to uncovering the psychological determinants of intertemporal preferences. These theories

originally started with more emotional, visceral accounts and then developed to include more cognitive elements focusing on mental representations of outcomes and time.

Much of the broader interest in intertemporal choice has been spurred by the possibility that an understanding of how people make intertemporal tradeoffs might inform a wide range of behaviors, including seemingly non-normative behaviors such as undersaving for retirement, underinvesting in one's own education, overconsuming unhealthy foods, underexercising and abusing alcohol or drugs. However, while initial work discussed intertemporal choices (and particularly hyperbolic discounting) as an analogy for these behaviors, more recent work has explored the degree to which such behaviors are directly linked to intertemporal choice.

Rather than simply update the numerous excellent past reviews with a focus on the discounting phenomena, the emphasis in this chapter is on recent developments in uncovering the psychology underlying intertemporal preferences, understanding differences in discount rates across people and contexts, and using discounting to understand a broad range of intertemporal decisions and behaviors. The current chapter will therefore mainly focus on recent empirical findings with an emphasis on the psychological mechanisms underlying these findings. In particular, we examine the basic effects in the context of the different psychological mechanisms proposed in the literature. We conclude by pointing to open questions and the need to better map the match between the multiple psychological drivers and the types of intertemporal decisions they predominantly govern.

1. Discounting Behavior

Much of our initial understanding of intertemporal choice came from research comparing actual behavior across different contexts to the established normative standard -- the discounted utility model (Samuelson, 1937; described in the next section). Much was written about the development of the discounted utility model, and many have pointed out that it was never intended to serve as a descriptive model of behavior (Frederick et al 2002). Still, due to the clarity of its normative properties, it has been used as a metric against which actual behavior can be compared. Two underlying features of the model are most relevant for behavioral research: the source of utility should be irrelevant (since it is the utility that is being discounted), and that the rate of discounting should be constant over time. A great deal of evidence has been amassed showing that these assumptions are commonly violated. Because of the extensive literature on the issue, including comprehensive review papers cited above, we will be brief and highlight only relatively new findings.

Measuring and modeling intertemporal preferences

Measuring intertemporal preferences. The very basic effect of interest is the valuation of a given outcome at different points in time. To that end, two broad categories of measures are employed: matching-based and choice-based. The matching-based measures (e.g., Thaler 1981) provide participants an amount at a given point in time (e.g, $15 today) and ask for the monetary equivalent at another point in time (e.g., $X in 3 months). This basic task has been modified in different studies using different scenarios, and different framing (e.g., expedite a future receipt rather than delay a current receipt; Malkoc and Zauberman 2006). One main advantage of this approach is that it is flexible and requires only a single response to calculate a discount rate over a given time period.

The other commonly used measurement approach uses a series of binary choices to elicit discount rates; for example, $15 today or $16 in 3 months; $15 today or $18 in 3 months, etc. The researcher then identifies the point where a respondent switches from receiving an amount today to receiving a specified amount in the future, based on which they then calculate the discount rate. This binary choice measure has been implemented in a wide range of ways, from a simple paper-and-pencil series of static choices (e.g., Kirby and Markovic, 1996) to a more adaptive and iterative selection of the amounts and the times, allowing for more efficient and reliable measurement (e.g., Toubia, Johnson, Evgeniou, and Delquie, 2012). While this method usually involves incrementing the amounts, the time delay could be incremented instead.

When comparing the two most common measures, the matching task has the advantage of requiring only a single response to arrive at a discount rate. However, since it requires the respondent to generate an equivalence number, which could be more cognitively demanding, extreme responses may complicate the analysis. The binary choice task has the advantage of presenting a simple two alternative question which are easier for respondents to understand (Hardisty et al 2013) but requires a series of these questions to arrive at a discount rate. Fischer et al. (1999) argued that different measures can trigger different 'task goals,' such as goal to equate options versus differentiate between options. Specifically, while making separate choices leads to differentiating goal, making a series of iterative choices that identify an indifference point triggers a goal to equate options, more similar to matching.

The study of intertemporal choice using recent developments in neuroimaging data has been growing (for reviews see Barnes et al., 2007; Kable, 2013). While this new

methodology has already provided some interesting insights, we will mention relevant findings in the context of specific topics, but will not provide an in-depth discussion.

Modeling intertemporal preferences. The different theoretical models of discounting have been formalized using various mathematical models. We briefly describe the models most commonly used. Consider an outcome, such as receiving a sum of money *x* at some point in the future, *D* units of time from now. At the time of receipt, the outcome will be valued with some utility $V_D = U(x)$. The current valuation (V_0) of the outcome, given that it is delayed by D units of time, is computed by multiplying the delayed outcome by a *discount factor f,* which is often assumed to have values between 0 and 1:

$$V_0 = f(D)V_D$$

In most empirical work, a simplifying assumption of (local) linear utility is made, setting $V_D = x$, resulting in a model of the monetary discount rate (Noor 2009), rather than a utility-based discount rate.

In the standard economic model (Samuelson, 1937), the degree of discounting depends on an *exponential* discount factor f_E, defined by the delay D and *discount rate* r:

$$f_E(D) = \exp(-r_a * D) \text{ or } f_E(D) = 1 / (1 + r_b)^D$$

The instantaneous discount rate is defined as $-f'(D)/f(D)$, and as a result, the exponential discount rate is simply $r_E = r_a = \ln(1 + r_b)$, and is constant regardless of delay in the exponential model. Note, however, that the values of the discount rates are specific to the unit of time in which D is measured (e.g, days, weeks, years).

Alternatively, in the *hyperbolic* model (Mazur 1987), which allows for discount rates to continuously decline over time, discounting is defined by a *hyperbolic* discount factor:

$$f_H(D) = 1 / (1 + k*D)$$

While k is sometimes referred to as the hyperbolic discount rate, it is important to note that the instantaneous discount rate is actually $r_H = - k / (1 + k*D)$, which varies with the delay. In fact, the hyperbolic discount parameter *k* reflects not just the degree of change in the discount rate over time (e.g., the deviation from exponential discount) but also the average discount rate. For this reason, the widespread practice of correlating other variables to the *k* parameter (as discussed in subsequent sections) yields results that can be difficult to interpret. In particular, a high correlation should not be interpreted as evidence that high values of the other variable relates to "more hyperbolic" or "more time inconsistent" preferences.

The generalized hyperbola model (Harvey 1989) adds another parameter, which helps deal with this issue:

$$f_{GH}(D) = (1+\alpha D)^{-\beta/\alpha}$$

In this model, α is interpreted as the deviation from exponential. The instantaneous discount rate is $r_{GH} = \beta/(1 + \alpha*D)$,, and the model approaches the exponential model, $\exp(-\beta D)$, in the limit as α approaches 0 (Loewenstein and Prelec 1992).

Another widely used formulation, most popular in economics, is the quasi-hyperbolic discounting model (Laibson 1997) that distinguishes consistency of discounting from level of discounting by assuming a higher discount factor (β) in the first period, but a constant discount factor (δ) for subsequent periods:

$$f_{QH}(D) = \beta * \delta^{D}$$

In this model, β can be interpreted as a measure of present bias, while δ can be interpreted as determining the long-run discount factor, with an instantaneous discount rate after the first period of $r_{QH} = -\ln(\delta)$, which does not vary with time.

Some more recent models (Benhabib et al 2007, Bleichrodt et al 2009, Ebert and Prelec 2007, Killeen 2009, Scholten and Read 2006, Scholten and Read 2010) provide alternative or extended specifications, generally to account for non-hyperbolic violations of time consistency. These models have been used to accommodate additional behavioral anomalies, including some of those described in this chapter.

Model-free estimates of discount rates. An alternative non-parametric approach is to estimate an aggregate degree of discounting without the use of a specific discounting function. Some researchers have simply computed estimated discount factors based on the amount of delayed outcome V_D judged to be equivalent to the immediate outcome V_0 as $f_{EST} = V_0/V_D$ (e.g., Bartels and Urminsky 2011). Importantly, when multiple estimated discount factors for a respondent are averaged, the result should be interpreted as an approximate overall discount factor that may depend on the range of delays used.

Another common approach, instead of averaging, is to use the estimated discount factor for each delay to calculate the "Area Under the Curve" (AUC; Myerson, Green and Warusawitharana 2001). The estimated discount factor (e.g., V_0/V_D) is plotted as a function of delay D, and the area under the curve is estimated, usually by discretizing the area into approximate trapezoids. On average, the lower the discount factors and the more rapid the decline in discount factors with longer delay, the lower the AUC measure will be. Therefore, AUC can be thought of as a non-parametric alternative to the hyperbolic *k* parameter, incorporating both overall discount rate and time inconsistency or present bias.

Reliability and consistency of estimated discount rates. Given the widespread use of elicited discount rates as a dependent variable or as a correlate in studies of intertemporal choices and behaviors, the reliability of the instruments used is an important consideration. Low reliability can frustrate attempts to study the effects of time discounting, leading to spurious null findings and low correlations. Furthermore, the reliability of a measure presents an upper bound for estimates of correlations between that measure and other constructs (e.g., Vul et al 2009), potentially casting doubt on high correlation findings, particularly for small samples.

Test-retest reliability has been assessed in multiple studies, over time periods ranging from one week to a year, generally with very positive results. A meta-analysis of 17 studies across 14 papers reveals a weighted average test-retest reliability of .78 (Urminsky 2014). Comparing across studies reveals a strong effect of time interval, with longer intervals between test and retest yielding lower reliabilities.

Methodological differences across elicitation instruments may also reduce the consistency of estimates. Common methodological differences in the literature include hypothetical vs. real outcomes, the order of multiple choice items, the reward magnitudes and time lengths, and even the nature of the outcome (monetary vs. other items). Similar discount rates have been found when elicited via hypothetical questions compared to identical paid (or probabilistically paid) choices (Frederick et al 2002; Johnson and Bickel 2002), and a high correlation between hypothetical and real choices has been documented (r=.83, Johnson and Bickel 2002), albeit with a small sample. Correlations between different elicitation methods (e.g., titrated vs. randomized stimuli, computerized vs. on paper) using similar monetary gains have generally been high, but sometimes led to different estimates of discount rates, due to systematic differences in average scores (see Urminsky 2014). In particular, while average discount rates differ based on the magnitude of gains used, as discussed below, discount rates elicited using different magnitudes are strongly correlated (meta-analysis average r=.77 based on eight studies, Urminsky 2014).

Order effects seem more problematic. When eliciting a series of choices, discount rates are higher when the magnitude of the immediate option (sooner-smaller) is titrated in descending (vs. ascending order), and rates from different orders are only moderately correlated (descending vs. ascending, r=.44, Robles et al 2009; descending vs. random, r=.38, and ascending vs. random, r=.59, Robles and Vargas 2007).

The correlations between instruments based on fundamentally different choices can be very low. Researchers have found very low correlations between discount rates using hypothetical monetary choices and in-lab behavioral impulsivity,[1] such as discount rates of thirsty participants based on tradeoffs between drink rewards and short experienced delays (Jimura et al 2011, Lane et al 2003, Smits et al 2013). Likewise, averaging across five studies, there is very little correlation between discount rates from monetary gains and losses (meta-analysis average r=.13, Urminsky 2014).

[1] Sometimes labeled as “delay of reward” or “experiential discounting” paradigms.

High discount rates

The literature on intertemporal choices has been characterized by a willingness to forego much larger future rewards in order to receive smaller rewards sooner, which can be characterized as *high discount rates* (or, equivalently, low discount factors). Numerous studies have attempted to estimate discount rates, using field and experimental studies, real and hypothetical outcomes, and a range of elicitation methods. Frederick et al. (2002) characterize the findings as a "predominance of high discount rates – discount rates well above market interest rates," although they note that many potential confounds may inflate estimates of the discount rate. While it is difficult to specify an objective normative rate, the reasonableness of a discount rate can be thought of as shaped by economic considerations, such as how much interest could be earned in the intervening time (Fisher 1930), liquidity constraints (Meyer 1976; Fuchs 1982), inflation (Frederick et al 2002), uncertainty (Dasgupta and Maskin 2005), among other factors. A large literature (reviewed in Frederick et al 2002), using lab studies with either hypothetical outcomes or small-stakes real outcomes, has attempted to control for these other factors and has found generally high discount rates.

One limitation of discount rates elicited in the lab is that they tend to be based on either hypothetical choices or real choice with low stakes, due to cost limitations. However, discounting is of interest primarily for the insight that can be generated into people's real consequential behavior, which could be different. Some field studies have attempted to estimate discount rates from consequential high-stakes decisions. In an early attempt to quantify the discount rates implied by choices in the field, Hausman (1979) estimated a private annualized discount rate of 25%, based on the differential costs savings from different air conditioners. Laibson (1997) has found evidence that actual savings behavior is generally more impatient than what would be predicted by economic factors alone. Warner and Pleeter (2001) document military employees' preferences for a large lump-sum payment over a higher-yield long-term annuity, and estimate an average inflation-adjusted discount rate of between 16 and 23 percent. Tanaka, Camerer and Nguyen (2010) estimated discount rates from high-stakes real monetary choices with rural villagers in Vietnam, and find both substantial present bias and extremely high average annualized discount rates (>1600%) when looking at delays ranging from three days to three months. Kirby et al (2002) also finds median annualized discount rates (> 4000%), over shorter time intervals for real choices with Bolivian villagers.

Heterogeneity in discount rates.

A large literature has studied the ways in which discount rates vary across individuals. Some researchers have proposed that discount rates should differ by demographic factors. Fisher (1930) predicted that people should have lower discount rates if they have higher current or future expected income. Bjorklund & Kipp (1996) proposed, based on an evolutionary argument, that women may be better able to delay gratification than men, potentially resulting in lower discount rates. Building on prior research suggesting that delay of gratification is a learnable skill that increases as children age (Mischel et al 1989), Green, Fry and Myerson (1994) proposed that discount rates would decline with age.

Differences in discount rates based on demographics have been documented in many studies, but results often conflict from one study to another, largely due to small sample sizes and low statistical power. However, several factors seem to consistently replicate across large-sample studies. In a particularly large scale study (N=42,863), Reimers et al (2009) find that choices of a single hypothetical sooner-smaller option (vs. later-larger) are weakly but significantly higher for younger (r=.05), less educated (r=.13) and lower-income (r=.09) respondents. Warner and Pleeter (2001) analyze severance payment decisions of 11,000 military officers and 55,000 enlisted personnel, and similarly find significantly more choices of a sooner-smaller lump-sum payment among those who are younger, less educated, African-American, or have more dependents. Lastly, using a panel data set of consumption in over 1,500 households, Lawrence (1991) finds evidence of higher discount rates for lower income, lower education and non-white families. In these studies, the reported effects remained significant when controlling for the other factors measured, which addresses potential confounds, such as intercorrelations between age, income, and education.

Shamosh and Gray (2007) conducted a meta-analysis on the correlation between intelligence test scores and discounting. They find a significant negative relationship (r = -.25), such that those with lower intelligence (IQ) scores have higher discount rates. Similarly, Frederick (2005) finds higher impatience among people with lower "cognitive reflection," that is, those who are more likely to choose mistaken but seemingly correct responses to test questions. Consistent findings have been documented in multiple studies for highest level of education achieved (de Wit et al 2007, Warner and Pleeter 2001 , Reemers et al, 2009). Furthermore, there is some research suggesting that higher delay of gratification predicts future scores on standardized achievement tests (Mischel et al 1989), and that lower discount rates predict grades (Duckworth and Seligman 2005; Kirby et al 2005, Lee et al 2012; Silva and Gross 2004) and standardized test scores (Benjamin et al 2013).

Most papers that correlate discount rates with either demographics or behaviors (discussed in section 3) either use a single intertemporal choice as a proxy for discounting or, in most lab

studies, estimate a single discount parameter (e.g., the hyperbolic *k* parameter, or "area under the curve"). It is important to note that choices of the sooner-smaller option, or larger values of the hyperbolic discount parameter, are influenced both by how hyperbolic (e.g. present-biased) the discounting is and the average (or long-term) discount rate. To the degree that present bias and long-term discount rates are conceptually and psychologically distinct, quantifying discounting with a single parameter (e.g., as opposed to using a two-parameter model, such as Laibson's β-δ model) confounds the two and makes accurate interpretation of the results difficult. Tanaka, Camerer and Nguyen (2010) provide an important exception, which illustrates the potential problem. They find that older people and those with more income and education have lower average discount rates, but they find no effect of these factors on present bias. In contrast, in a repeated-measures study of changes in discount rates over time, Green et al (1999) find that as people age, their discount rates decline and they also become less present-biased.

Another important concern is that the link between demographics and discounting (as well as between behaviors and discounting, Section 3) has been substantiated primarily through correlational evidence. This makes it particularly problematic to draw causal conclusions. As an illustration, consider the relationship between higher education and lower discount rates. In a developmental account of the relationship, education is the cause and training in gratification deferral would, directly and indirectly, presumably lower discount rates. In an investment account, however, time preferences are the cause, such that people with lower discount rates are less willing to bear the near-term direct costs and opportunity costs of getting more education. Alternatively, other factors (such as socio-economic status in childhood or cultural norms) may shape both the level of educational attainment and discount rates, even without the existence of a direct causal relationship between education and discounting.

The recent interest in the psychological determinants of time preference, discussed in Section 2, has motivated research on interventions that shift intertemporal choices. This approach has the potential to resolve some of the causal ambiguity. For example, several papers have noted differences in discount rates across countries, cultures and ethnicities (Castillo et al 2011, Poulos and Whittington 2000). Chen, Ng and Rao (2005) and Benjamin, Choi and Strickland (2010) investigate the causal basis of one such difference by manipulating the salience of national or cultural identity in order to isolate the effect of culture-specific norms on discount rates.

Context dependent discounting.

The rate at which people discount the future depends strongly on the context in which they are elicited. For example, discounting is higher for short delays than longer delays, higher for smaller amounts than larger amounts, higher for gains than for losses, higher when delaying a current amount than when expediting a future amount, and is often different for different resources (higher for time than money). Because these features of discounting behavior have been widely reviewed, we will only briefly mention them with a focus on recent new findings.

Temporal inconsistency. The behavioral regularity that has probably received more attention than any other is temporal inconsistency, also often referred to as 'hyperbolic discounting', 'declining impatience,' or 'present bias.' This refers to the basic phenomenon where discounting over a given time delay changes with the time horizon over which it is measured. More specifically, revealed discount rates decline with the length of the duration (e.g., Benzion, Rappoport, and Yagil, 1989; Chapman; 1996; Thaler, 1981). Thaler (1981) found median responses over a set of values to be 345% over one month delay, 120% over one-year delay, and only 19% over ten year delay.

Beyond showing the sensitivity of unit discounting to time horizons, the key implication of hyperbolic discounting is time inconsistent preferences which yield a preference reversal as the time to both outcomes diminishes (Ainslie 1975). For example, a person would prefer $10 today over $12 in a week but prefer $12 in a year and one week over $10 in a year. Note, however, that the set of findings about declining discount rates, for which we have a great deal of evidence, often comes from matching tasks over different time horizons (Thaler, 1981). Direct evidence for intertemporal preference reversal, for which we have far less evidence, generally comes from studies in which people make prospective choices (Green, Fristoe, and Meyerson, 1994; Kirby and Herrnstein, 1995). Recently, there has been accumulating evidence that the process of actually waiting for the outcome may affect preferences, such that actual preference reversals may be unlikely (Harrison et al 2005; Luhmann 2013; Read et al 2012) or may even occur in the opposite direction, with increasing patience (Dai and Fishbach 2013; Sayman and Öncüler 2009).

Still, taking the accumulated evidence on this question, the data supports the conclusion that intertemporal preferences are sensitive to the time horizons being considered, with greater weight on departure from the immediate present than any other period. The underlying psychology is less understood. As discussed later, the phenomenon of hyperbolic discounting provided a foundational finding for the development of psychological theories, ranging from affective to cognitive processes.

Magnitude and sign effects. Thaler (1981) noted that the magnitude of the outcomes being considered also affects the level of discounting. This gave rise to the idea that we cannot think of the decision process as a simple consideration (and discounting) of present utility regardless of its source. In particular, the paper established that small amounts are discounted more steeply than large amounts. For example, over a one year delay, $15 yielded a median annual discount rate of 139%, $250 yielded 34%, and $3000 yielded 29%. In addition, Thaler (1981) reported that gains are discounted more than the monetary equivalent loss.

Temporal framing effects. There are two aspects of temporal framing effects that have been documented. One pertains to the direction: whether the situation involves delaying a current outcome or expediting a future one. Loewenstein (1988) demonstrated that for a given time horizon, delaying a present outcome results in steeper discounting than when expediting a future outcome to the present. This effect was further established for losses as well as gains (Benzion, Rappoport, and Yagil, 1989; Shelly, 1993), and for the degree of hyperbolic discounting rather than just overall discount rates (Malkoc and Zauberman, 2006).

The other facet concerns the manner by which the time horizon is being expressed, whether making the length of delay explicit or just providing the date, often referred to as the date-delay effect (LeBoeuf, 2006; Read et al., 2005). The two forms yield different elicited discount rates, indicating that the framing of the temporal context plays an important role in the decision process. This effect demonstrates higher discounting when a given future time horizon is framed as a delay (e.g., one month) versus a date marking the identical duration (June 27), as well as greater hyperbolic discounting. This shows that merely altering the way in which a time horizon is represented changes the valuation of outcomes over that duration.

Resource specific discount rates.

While the elicitation of discount rates has primarily focused on monetary tradeoffs, many decisions that researchers have tried to explain in terms of discounting involve non-monetary tradeoffs, such as time, health, or environmental impact. If people make tradeoffs purely based on utility and timing, consistent with the normative discounting model, then the source of utility should not matter and discounting in one domain should explain behavior across other domains. However, people may either have different relative valuations of sooner vs. later outcomes in different domains or may just have different heuristics for making intertemporal choices in different contexts. In either case, people would have effectively different discount rates for different items or benefits (Winer 1987).

This possibility has been incorporated into economic models of intertemporal choice as related to poverty (Banerjee and Mullainathan 2010) and taxation (Futagami and Hori 2010). In particular, the "affective discounting" hypothesis (Vallacher 1993, Loewenstein 1996) suggests that people will have higher discount rates (or exhibit more present bias) when making tradeoffs involving more affectively rich outcomes. Zauberman and Lynch (2005) demonstrated that when considering discounting of time and money, two fundamental economic resources, people consistently showed both greater discounting and more hyperbolic discounting for time than for money, and show that this difference is due to greater relative growth in the perceived availability of time then money. Still, to date, the evidence for cross-resource discounting stability is mixed.

The largest literature comparing discount rates across domains has been between discounting money and health outcomes, such as trading off between a partial reduction in symptoms soon vs. a more complete reduction that begins later (Chapman, Nelson and Hier 1999). These studies have generally replicated present bias consistent with hyperbolic discounting (e.g., higher discount rates for a shorter delay, Bleichrodt and Johannesson 2001; Cairns and van der Pol 1997; Chapman and Elstein 1995), as well as other findings, such as magnitude effects and higher discounting for gains than losses (Chapman 1996).

A central question is whether discount rates are higher for money or health. The results are somewhat inconsistent, with most studies finding higher discount rates for health than money, but some studies finding the opposite (see Urminsky 2014 for a review). In particular, in order to rule out magnitude effect confounds, Chapman (1996) calibrates equal-utility health and monetary outcomes and finds a higher discount rate for health than money.

Other researchers have used the same methodology to compare how smaller-sooner vs. later-larger tradeoffs are made for amounts of money and for amounts of other consumable products. Across twenty papers, higher discount rates are consistently found for money than for drugs, cigarettes, alcohol and food, and somewhat weaker differences have also been reported for non-consumable products such as books, DVDs and music, laptops and TVs (see Urminsky 2014 for a review). However, these studies do not control for differences in the utility or value of the products.

Despite the intuitive appeal of the idea that differences in discount rates underlie differences in decision-making for hedonic vs. non-hedonic outcomes, the large literature on hedonic consumption (see Alba and Williams 2013 for a review) has not shown a link between individual differences in elicited discounting and hedonic consumption. There are several difficulties with comparing item-specific discount rates, which present impediments to linking these two areas. First, the stimuli must be equalized so that

differences in discounting cannot be due to differences in magnitude (Chapman 1996). Second, when discount rates are elicited by trading off smaller or larger amounts of the same item, item-specific differences in discount rates are confounded with item-specific differences in the shape of the utility function, such as diminishing marginal utility (Andersen et al 2008; Gafni and Torrance 1984).

However, it seems unlikely that this confound completely explains the existing findings. In a large-scale field study in Uganda, Ubfal (2013) finds significantly higher discount rates for staple foods (meat, sugar, plantains) than for money and some consumer products (lotion and perfume) and lower rates for other products (clothes, shoes, school supplies, meals outside, soda, airtime, saloon, entertainment and snacks), controlling for overall (but not good-specific) diminishing marginal utility.

Given that much of the literature documents differences in average discount rates, it may be that a person's discount rate in one domain is largely unrelated to their discount rate in another domain. However, some researchers have suggested that discounting for money or goods both draw on the same mental processes (McClure et al 1997). In the health domain, a meta-analysis of eight papers (Urminsky 2014) reveals a moderate but robust weighted-average correlation of r=.23 between discount rates elicited from health versus monetary outcomes. Similarly, a review by Odum (2011) found generally strong intercorrelations between discounting of money, alcohol, cigarettes and food, ranging from .18 to .90. Similarly, moderate correlations (averaging approximately r=.35) have been found between discounting of money, alcohol, cigarettes, food and entertainment products (meta-analysis of four papers, Urminsky 2014). These results, particularly given the high short-term test-retest reliabilities typically observed, suggest that discounting, while a stable trait, can be moderated by state factors, including the type of good being discounted.

2. Psychological Determinants

This section reviews several psychological mechanisms that have been shown to drive intertemporal preferences. These mechanisms range from the "hot" (emotion based) to "cold" (cognitive based), and focus on the outcomes relevant to the choice, the self in the context of the choice, and the perception of the time horizon relevant to the choice. It is important to note that intertemporal preferences are inherently multiply determined, and no one psychological mechanism can explain all situations. Yet, thinking about the psychological underpinning of this behavior will lead to a better understanding and the ability to better predict these choices and, therefore, the ability to design behavioral interventions that will shift preferences. Moreover, these various mechanism, whether hot or cold, all tend to result in a heightened motivation for the immediate outcome compared

to the distant one. We first discuss determinants related to affect, motivation and tradeoff conflict and then discuss cognitive determinants, including processing, memory and time perception.

Affective determinants

Freud is famous for using a horse and a rider as an analogy to describe the *id* as providing power and the *ego* controlling it. This dual system analogy has been used by George Ainslie and others (e.g., "planner" and "doer", Thaler and Shefrin 1981) to describe the mechanism underlying impulsivity in intertemporal decisions, both high overall discount rates and hyperbolic discounting (e.g., Soman et al. 2005). In a decision that involves intertemporal tradeoffs, the basic drive (the horse) is for the immediate reward, whereas self-control comes from an overriding deliberate process (the rider) that takes future consequences into consideration. It is this tension between the desire for the immediate and understanding that long term consequences need to be taken into account that characterizes the process of intertemporal choice.

In one of the most often cited arguments for an affect-based process, Loewenstein (1996) argued that visceral factors have a significant influence on intertemporal decisions, in particular because people have a hard time anticipating these factors. Visceral factors are emotions (e.g., anger) and drive states (e.g., hunger, thirst) that motivate people to consume. As such, stimuli that are linked to these factors and can thereby satisfy the state of deprivation (such as food, drugs, sex, etc) are then most likely to display impulsive preferences that are difficult to anticipate when not in this 'hot state'. This idea is consistent with the horse and rider analogy above, and has provided an intuitively appealing rationale for two-system models of interetemporal preferences, such as the beta-delta model (Laibson 1997).

In support of the role of affective influence, Shiv and Fedorikhin (1999) present evidence that the preference for an affect rich chocolate cake compared to the relatively affect poor fruit salad increases when cognitive resources are low (e.g., using a cognitive load manipulation). These results are often cited to make the point that the reference for the option with the immediate benefit (taste) but long term costs (health) is determined by an affective mechanism, that is controlled (to various extents) by cognitive resources. McClure et al. (2004) use evidence from a brain imaging study to propose the existence of two distinct brain regions, one that correspond to the response to immediate rewards and the other to delayed rewards, although the evidence for two separate neural systems has been challenged (e.g., Glimcher, Kable, and Louie, 2007). Regardless of the exact neurological

underpinning, emotions play a clear role in the heighted motivation toward immediate rewards, and represent an important mechanism in intertemporal choice.

Mental representation and concreteness of outcomes

One important determinant for the weight given to present versus future outcomes is the different way in which they are mentally represented: more concrete evaluations of the near future and abstract evaluations of future outcomes. The most relevant theoretical framework for this process is Construal Level Theory (see chapter XX), and temporal construal in particular (e.g., Liberman and Trope, 1998). The basic notion underlying this mechanism is that people naturally tend to construe immediate or near future outcomes concretely, while naturally construing the more distant events in more abstract terms. The implications of changes in mental representations over time, and the changes in the degree of concreteness have been shown to mediate several established effects (Fujita, et al., 2006; Liberman and Trope, 1998, Malkoc , Ulu and Zauberman, 2005; Malkoc and Zauberman, 2006).

Linking level of representation and impatience, abstract mental construal has been shown to lead to more self-control (Fujita, et al., 2006) and less present-bias or hyperbolic discounting (Malkoc and Zauberman, 2006; Malkoc Zauberman, and Bettman, 2010). Examining the role of the representation of outcomes in the temporal framing effect, Malkoc and Zauberman (2006,) demonstrated that the greater concreteness of the near future compared to the distant future outcome is one factor that leads to higher discounting in delay versus expedite decisions. Delay decisions start with more concrete immediate outcome, while expedite decisions start with the more abstract distant future outcome. This effect of the initial mental representation then affects the level of discounting. The lingering effects of the initial mental representation were also demonstrated by triggering initial abstract mindsets that had an effect on subsequent intertemporal preferences (Malkoc et al, 2010). Asking participants to elaborate on the outcomes before making their decision attenuated the delay-expedite effect (Malkoc and Zauberman, 2006). Further supporting the effect of mental representation, Zhao, Hoeffler, and Zauberman (2007) showed that mentally simulating the future outcome changes the weight of different attributes, moderating the standard temporal construal effects. This suggests that mental representation is a cognitive mechanism that drives overall levels of discounting, as well as related intertemporal effects, such as present-bias and delay-expedite framing effects.

Goal-based determinants

The basic psychological idea in time discounting is that outcomes closer in time are more valued in the present. This parallels the notion of a goal gradient, in which nearer outcomes are more motivating, which had been widely studied and documented in the animal behavior literature (Hull 1932), and proposed to explain differences in motivation over time in human behavior as well (Gjesme 1974). One interpretation is that more temporally distant rewards are less motivating specifically because delayed rewards are discounted (and potentially also riskier). In this view, goal-gradient behavior (exerting more effort for sooner rewards) is another source of evidence for time discounting.

While much of the recent research on goals does not account for the potential time discounting confound, some papers have documented goal-gradient differences in behavior by manipulating perceived proximity to the goal, holding actual timing constant (Kivetz, Urminsky and Zheng 2006; Nunes and Dreze 2006). Urminsky, Goswami and Lewis (2014) independently manipulate goal timing (i.e. when a lottery is drawn, an airline voucher is received or an assignment is due) from outcome timing (when the winnings are received, the airline voucher is redeemed or the assignment grade is posted). They find separate disassociated larger goal gradient and smaller time discounting effects and report estimated discount rates which are substantially lower when separately accounting for goal gradient effects. These findings suggest that goal gradient effects may contribute to elicited time discounting.

Connectedness of current and future self

One view of how valuation of future benefits vary across people and change over time has to do with the way that people think about themselves changing over time (Parfit 1984). Recent empirical research suggests that the motivation to sacrifice consumption on behalf of future selves often depends on the degree of psychological "connectedness" people have with their future self, where connectedness is defined by the degree of overlap in beliefs, values, goals, and other defining features of personal identity (Bartels and Rips 2010). In this view, the more people feel that their future selves are different in the defining aspects of personal identity, the less they value the outcomes that befall the future self.

Although an initial exploration by Frederick (2002) did not find a correlation between measured connectedness and discount rates, recent research has provided evidence that discount rates are lower when people are experimentally made to feel more connected to their future selves (Bartels and Urminsky 2011) and that rates correlate with neural-activation approximations of connectedness (Ersner-Hershfield, Wimmer, and Knutson 2009; Mitchell et al 2011). In addition, variation over time in the degree of connectedness

to one's present self can help explain hyperbolic discounting (Bartels and Rips 2010). During intervals when connectedness to the present self declines more rapidly, future outcomes are discounted more steeply, compared to time intervals when there is less change in connectedness.

Less is known about what causes differences in connectedness to the future self. Joshi and Fast (2013) find that when people recall a prior experience of social power, they discount less, and the relationship is mediated by measured connectedness to the future self. Some research has also looked at differences in how people think about their future self as a potential influence on connectedness. Hershfield et al (2011) find that visualizing one's future self increases connectedness and savings behaviors. However, Urminsky and Bartels (2014) find a more complex pattern, where viewing a similar-looking aged future self reduces discount rates (compared to a dissimilar-looking aged future self), but only when people are prompted to consider the gradual change between present and future self.

Opportunity cost considerations and resource slack theory

When discount rates inferred from decisions (either explicitly stated choices in the lab or real-world behaviors) are interpreted as representing time preferences, an under-appreciated assumption is generally being made that both immediate and delayed consequences are equally salient and receive equal consideration over the specified time horizon. Most laboratory or survey-based research on time discounting measures intertemporal preferences using explicit tradeoffs between smaller-sooner and larger-later rewards. However, in practice, this assumption may not hold, because of a limited planning horizon, or limits in the degree to which people either spontaneously consider opportunity costs (Frederick et al., 2009; Spiller 2010), have biased perceptions of these opportunity costs over time (Zauberman and Lynch, 2005), or fail to plan for future financial decisions (Lynch, Netemeyer, Spiller, and Zammit, 2010). Thus, a person who consistently over-consumes in the present and under-saves for the future is seen as having a high discount rate, reflecting a deliberate preference for the present over the future. However, this pattern of behavior could also arise for a person who makes far-sighted choices when facing explicit intertemporal tradeoffs, but who fails to consider the opportunity costs of current spending and to plan for future financial needs.

Across individuals, a greater propensity to consider the long-term implications of current choices correlates with more engagement in a range of behaviors that yield primarily future benefits, and that have been linked to low discount rates (Lynch, Netemeyer, Spiller and Zammit 2010, coupon use and credit score; Nenkov, Inman and Hulland 2008, intended retirement savings; Strathman et al 1994, health behaviors; Shell and Husman 2001, academic

achievement). Furthermore, experimental manipulations that explicitly direct attention to the future consequences (Hershfield et al. 2011; Magen et al. 2008, Malkoc and Zauberman, 2006; Zhao et al. 2007), such as reminding people about the low level of future resources if current consumption is chosen, or asking them to elaborate on costs and benefits at different points in time has been shown to increase preferences for larger-later rewards.

To date, there has been relatively little overlap between the literature investigating the consideration of future consequences and that investigating the valuation of future consequences. In fact, most research on intertemporal preferences does not discuss the distinction and has not provided a generally accepted theoretical integration of the two.

One possibility is that, for all practical purposes, the consideration of future consequences and valuing those consequences are highly related or even equivalent. Thinking more about future consequences may induce people to place a higher value on future outcomes (Logue 1988). Conversely, discount rates have also been proposed as underlying inattention to future outcomes (Ainslie 1992), as people with lower discount rates may be more likely to investigate the future consequences of a present action (Hershfield, Cohen and Thompson, 2012; Strathman et al., 1994). Consistent with this view, some recent research has provided evidence that the salience of outcomes can moderate elicited discount rates. Specifically, emphasizing the null outcomes (i.e., reframing the sooner-smaller outcome as "something now and nothing later" and the later-larger outcomes as "nothing now but more later") increases choices of later-larger outcomes (Magen and Gross 2008), due to a difference in the attention paid to the delayed outcome (Radu et al 2011).

An alternative possibility is that the consideration of future outcomes and true discount rates may be completely distinct, and both factors may independently influence intertemporal decisions. One common interpretation of seemingly high discount rates is that people have considered future outcomes but undervalued or underweighted them (e.g., see the discussion of Hausman's (1979) findings for choices between more and less energy efficient appliances in Loewenstein and Prelec 1992). Adams and Nettle (2009) examine the antecedents of smoking, by separately correlating measured discount rates and the propensity to consider future consequences.

A third possibility is that when people make choices with intertemporal consequences, the combination of both consideration of future consequences and concern for future outcomes (e.g., a low discount rate) are needed for far-sighted options to be chosen. Bartels, Urminsky and Frederick (2013) provide evidence for this account in the context of consumer spending decisions, by manipulating the salience of opportunity costs and discount rates (via connectedness). They find that spending is reduced primarily when people are both considering opportunity costs and have low discount rates, but not when only one or the

other condition holds. This possibility is reflected in some quantitative models of dynamic decision making (e.g., Winer 1997).

Slack Theory (Lynch, Spiller, and Zauberman, 2014; Zauberman and Lynch, 2005) provides another approach that centers on the level of available resources and explains intertemporal preference using the concept of slack. Slack is defined "as the perceived surplus of a given resource available to complete a focal task without causing failure to achieve goals associated with competing uses of the same resource" (Zauberman and Lynch, 2005, p. 23). This theory states that discounting, both the overall rate, as well as the extent of hyperbolic discounting and differences between resources, such as time and money, can be explained by different patterns of how much slack is perceived over time. That is, when people perceive much more slack in the future than the present, they will tend to devalue the resource over time; for example, a person's tendency to take the sooner-smaller ($50 today) over the later-larger reward ($75 in 3 months) will increase the more they think that they will have more money available in the future compared to now. Consequently, because people generally believe that their growth in slack in the future is greater for time than for money, they also then tend to discount time more than money. It also predicts situations in which people do not display discounting at all, and even cases where they will appear to show negative discounting, preferring to complete a task or take on an expense now rather than later.

Slack theory therefore provides another mechanism by which the perception of future resources can motivate people to discount the future (e.g., consuming an immediate over a distant reward), by highlighting which goal they will need to give up if they take on another immediate task or expense. The main idea in this theory is that when an individual perceives that in order to take on another task they have to give up a current active goal (for example, saving for retirement will result in not replacing your current car), people will be more likely to prefer delaying that new task.

Tradeoffs and constructed time preferences

The time discounting literature generally treats intertemporal choices as its own domain of study, distinct from other decision processes. In particular, intertemporal choices are often treated as revealing a stable discount rate, corresponding to a true time preference, although this is often a problematic assumption (Cubitt and Read 2007) that falls short of much of the accumulated empirical evidence. An alternative view is that decision-makers reason through the tradeoff between sooner-smaller and later-larger options in much the same way they reason through other attribute tradeoffs, by systematically comparing attribute values (Arieli, Ben-Ami, and Rubinstein 2011). A large literature on tradeoffs in choice has concluded that, in general, choices are often constructed (Payne, Bettman and

Schkade 1999), reflecting some stable preferences but resulting in decisions that can be malleable (Simonson 2008). Intertemporal choices can be approached in the same way, as another form of choice that may also be subject to unique or common heuristics and biases, resulting in patterns of choice that are incompatible with both exponential and hyperbolic discounting.

A person choosing between a sooner-smaller or later-larger outcome may experience this as a potentially difficult conflict between the desire for immediacy and the desire for magnitude. Urminsky and Kivetz (2011) document a resulting "mere token" effect, in which adding a small immediate amount to both the sooner-smaller and later-larger options increases the choice proportion of the later-larger option, particularly when choice conflict is high. These findings are incompatible with simple models of exponential or hyperbolic discounting.

Tradeoff reasoning also differs from the application of a stable discounting rule in that the way specific comparisons are perceived and processed may influence the choice. In particular, people's intertemporal choices are inconsistent between whether a given delay is one interval or multiple periods (Read 2001, Roelofsma and Read 2000), potentially due to similarity relations (Rubinstein 2003). Scholten and Read (2006) develop an "interval discounting" model to account for some of these findings, in which discounting is defined by the difference in delays, rather than the absolute values of the delays. More recently, Scholten and Read (2010) extended this approach to a full tradeoff model, in which people make intertemporal choices by comparing the differential reward to the differential delay when waiting. Scholten, Read and Bartels (2014) use this model to predict and document context effects in multi-option intertemporal choices, while Scholten, Read and Sanborn (2014) implement the model in a general Bayesian framework.

These findings suggest that people making intertemporal tradeoffs may lack a stable frame of reference. Consistent with this view, intertemporal choices are affected by reference points, such that discount rates are higher for otherwise equivalent choices framed as whether or not to expedite rather than whether or not to delay rewards (Loewenstein 1988, Weber et al 2007). Even more problematic for assuming the generalizability of findings in time discounting, Read, Frederick and Scholten (2012) replicate standard findings for tradeoffs between amounts but find lower discount rates, a reduced magnitude effect and non-hyperbolic discounting when the same choice options are instead presented using equivalent interest rates.

Anchoring effects have also been documented, such that a series of intertemporal choices are affected by which choice in a sequence is presented initially (Robles and Vargas 2007, Robles et al 2009). More generally, both present bias (preference for no delay) and

discounting (delay aversion) are stronger when a single option is valued (e.g. by generating willingness-to-pay for sooner or later outcomes), compared to when multiple such valuations of outcome timing differences are considered simultaneously (Hsee et al 2013). These findings point to the important potential for specific discounting findings to be "constructed" and moderated by the specific context in which they are observed.

Memory queries and intertemporal decisions

Consideration of reasons and events stored in memory could be important factors that could affect the generation of intertemporal preferences. Two theories that center on such effects are query theory (Weber et al., 2007) and decision by sampling. (Stewart, Chater, and Brown, 2006). Query theory (Weber et al., 2007) posits that decisions are constructed in a given context and their evaluations are determined by a set of queries, or questions. In the context of intertemporal decisions, people ask themselves what are the benefits of consuming now versus later. Weber et al. (2007) show that the queries' content can explain the delay versus expedite framing effect, because the relevant reference differs in each of these decision frames (immediate consumption when delaying a current option; future consumption when expediting a future option). They further show that reversing the order in which reasons were listed attenuates the effect.

Another mechanism based on judging information generated from memory is decision by sampling (Stewart, Chater, and Brown, 2006). Under this account, people judge time delays via ordinal comparisons to the distribution of time delays sampled from memory (as opposed to using a stable underlying psychometric scale). Because short delays are more frequent than long delays, differences between short delays are given more weight than equivalent differences in long delays (which can be modeled with a power function). This distribution and random sampling from memory account can explain some of the key temporal anomalies in the literature, such as hyperbolic discounting, the magnitude effect and gain-loss asymmetry.

Superficial or impaired processing

A basic general account for seemingly non-normative behavior, including high or time-inconsistent discount rates, is that the findings are due to insufficient mental processing. When people think superficially (for example because they are not taking enough time, because they are confused by the mathematics of the tradeoffs or because they are distracted when making choices) their choices may be more prone to bias and error. This may be because superficial thinking is more associative and heuristics-based than driven by

calculation and optimization (Sloman 1996) or because superficial thinking is more driven by affective cues, such as impulsivity and impatience (Hoch and Loewenstein 1991). Frederick's (2005) finding of a correlation between cognitive reflection (which he interprets as more deliberative thinking) and lower discount rates is consistent with this view.

The most direct test of this hypothesis was conducted by Hinson, Jameson and Whitney (2003), who found that taxing participants' working memory (either via a second concurrent task or by making the discounting task more complex) resulted in higher elicited discount rates. They concluded that temporarily reduced cognitive capacity yielded impulsivity in decisions. However, subsequent research suggests that this finding is attributable to more error and lower reliability in responses under working memory load (Franco-Watkins, Pashler and Rickard, 2006). Consequently, superficial thinking favors moderate estimated discount rates, and the opposite finding can also be shown, with cognitive load leading to reduced discount rates, depending on the stimuli used (Franco-Watkins, Rickard and Pashler 2010).

This debate highlights the value of attending to inconsistent or seemingly nonsensical responses in discounting tasks, and in particular, of testing whether inconsistent responses correlate with experimental manipulations or presumed drivers or outcomes. While most research on discounting has not leveraged inconsistent responses in this way, an exception is Bettinger and Slonim (2007), who find that inconsistent responses relate to mathematical achievement among school children, but that degree of discounting and mathematical achievement do not correlate.

Another potential test of this account is provided by research on how intoxication affects decisions. De Wit and Mitchell (2010) review research on the effects of drug consumption and drug withdrawal on discounting for human and animal subjects. The more extensive animal literature documents higher discount rates under intoxication for most substances tested. Fewer studies have been done with humans, and these studies find little effect on time preferences for immediate vs. delayed rewards. The only study that finds an effect of alcohol increasing discounting uses very short delays (0-60s, Reynolds et al 2006), similar to the animal-behavior studies. Somewhat related, one study has found that lower glucose levels lead to higher elicited discount rates (Wang and Dvorak 2010).

Finally, as mentioned earlier, it is important to note that there is little evidence for systematic differences between discount rates elicited via hypothetical questions versus paid (or probabilistically paid) choices (Frederick et al 2002; Johnson and Bickel 2002), which might be assumed to receive deeper consideration. Likewise, the basic discounting findings have been replicated with real high stakes choices (Warner and Pleeter 2001; Tanaka, Camerer and

Nguyen 2010), which is inconsistent with an easily corrected bias that only arises when people fail to deliberate.

Time Perception

A particular cognitive determinant is the perception of the relevant future anticipated time horizon. Unlike the mostly value-based mechanism mentioned above, this cognitive process is not centered directly on the weight given to the outcomes at different points in time, but rather to the perception of the time horizon itself. Indeed, several researchers have recently suggested the importance of the *perception* of delays (versus the actual delay) in temporal discounting (e.g., Ebert and Prelec, 2007; Killeen, 2009; Zauberman, Kim, Malkoc, and Bettman, 2009).

The role of time in intertemporal decisions is reflected in the weight given to the time delay versus the value being delayed (e.g., Ebert and Prelec, 2007; Scholten and Read, 2010). However, in addition to the decision weight of the time delay attribute, the way in which time is actually being perceived can affect decisions (e.g., Kim and Zauberman, 2009, 2013; Kim, Zauberman and Bettman, 2012; Takahashi, 2005; Zauberman et al., 2009). In the first empirical demonstration of this effect, Zauberman et al. (2009), measured people's perception of future time durations and discovered that it follows a standard non-linear psychophysical function rather than an objective linear mapping to calendar time. Specifically, one year is perceived to be less than four times as long as 3 months. They further showed that this non-linear time perception can account for much of hyperbolic discounting phenomena, including sub-additivity effects (Read, 2001). Moreover, those individuals who perceived a given future duration as longer, discounted outcomes over that duration more steeply than did those who perceived it as shorter (Kim and Zauberman, 2009; Wittmann, 2009).

Furthermore, several papers have demonstrated that factors which change the perceived length of a given duration, will also change the level of discounting over that duration. Zauberman et al., (2009) found that asking people to judge expected durations of various tasks (e.g., learning a new language, painting a house, etc.; versus judging the calories in food), makes people more sensitive to time (and more linear in their perceptions) and thus reducing the extent of hyperbolic discounting. Kim et al. (2012) leveraged the effect of spatial distance on temporal distance, where a given duration is judged to be longer when it is associated with greater spatial distance versus less distance. For example, when a month is embedded in spatial locations (e.g., today in Philadelphia and next month in Tel-Aviv vs. today in Philadelphia and next month in Chicago) it is perceived to be temporally longer when associated with the greater geographical distance. They then showed that the

resulting longer time judgments are associated with more discounting. That is, when time delay was perceived to be longer due to the longer spatial distance, participants required more money to delay receiving a reward.

Following a similar logic, Kim and Zauberman (2013) showed that changes in time perception when people are exposed to sexual cues also yield changes in discounting. Specifically, individuals perceive the same future time duration to be longer when they are exposed to sexual cues, and then also showed greater impatience for immediate monetary rewards because delayed rewards seem further away and therefore less attractive. In sum, these recent findings establish that the way that people perceive future time itself is an important factor in their revealed intertemporal preferences (for recent brain imaging findings see Cooper, Kable, Kim, and Zauberman, 2013).

3. Applications of discounting to decision making

Understanding how people make intertemporal tradeoffs, and quantifying their discount rates, is primarily of interest because of the potential to explain a wide range of seemingly "short-sighted" real-world behaviors. Ainslie (1975) first presented discounting, particularly hyperbolic discounting, as a compelling model to account for such behaviors. However, investigations of the empirical link between discounting and "prudent" decision-making has relied primarily on correlational evidence, and the evidence has been somewhat mixed. In part, this may be because discount rates should only predict choices that are treated as intertemporal tradeoffs at the time of decision (Bartels, Urminsky and Frederick 2013), which may not be the case in some decisions that researchers have labeled intertemporal tradeoffs (Rick and Loewenstein, 2008). In addition, people may use other context-specific cues to make decisions, instead of or in addition to their discount rates.

One limitation to keep in mind in interpreting specifically the correlational results summarized below is the potential role of discounting as a surrogate variable in predicting outcomes, particularly given the relationships described earlier between discounting and education and income. Studies vary widely in how they address this issue. Many papers merely report correlations, without conclusively addressing the potential for confounds. Papers in economics are more likely to measure and control for demographic factors and papers studying clinical populations (e.g., recovering drug addicts) are more likely to recruit demographically matched control populations.

Savings

Perhaps the clearest prediction of discounting theories is for savings and spending behaviors, where anomalous behavior consistent with hyperbolic discounting or high discount rates has been observed in the field. Laibson (1997) argues that hyperbolic discounting is consistent with both self-reported under-saving and with government interventions such as penalties for early withdrawal from retirement accounts. Angeletos et al (2001) argue that people with non-exponential discounting (e.g., hyperbolic or quasi-hyperbolic) will have more of their long-term assets in illiquid form, while also borrowing more and more often on credit cards.

Similarly, Bernheim et al (2001) argue that consumption patterns over time cannot be explained by stable time preferences and other normative factors. They find a lack of correlation between wealth and consumption growth patterns, as well as a correlation between consumption decline at retirement and low financial resources (wealth and retirement benefits). They argue that these results indicate time preferences that are inconsistent with far-sighted rational optimization. Hurst (2004) identifies a subset of consumers whose consumption closely tracks predictable changes in their income. He finds that these consumers, who demonstrate a lack of voluntary savings in order to smooth consumption, had low pre-retirement wealth. These papers document patterns of financial behavior that are difficult to reconcile with far-sighted exponential discounting. Bernheim and Rangel (2007) provide a review of savings behaviors incompatible with normative assumptions and survey models of saving using behavioral assumptions, including quasi-hyperbolic discounting.

Ainslie (1975) outlined strategies that hyperbolic decision makers could use to prevent future preference reversal (e.g. preferring to save in the future but choosing to spend when the times comes). These strategies largely assume that people know they are hyperbolic and prone to reversals (e.g. sophisticated rather than naïve, in O'Donoghue and Rabin's 1999 model). Perhaps the most cited example of behavioral economic interventions is the 'Save More Tomorrow' savings plan (Thaler and Benartzi, 2004). The plan leverages people's present bias and optimistic slack perceptions and asks employees to pre-commit to increase the percentage of their salary saved for retirement when they get raises in the future. The pre-commitment to boost savings can be reversed at a later point in time, but once it is set, people tend to follow through. In one example, Thaler and Benartzi report that Save More Tomorrow led employees to increase their annual savings rate for retirement from 3.5% to 13.6% over the course of 40 months.

While certainly not the norm, research documenting people's adoption of other such strategies (Wertenbroch, 1998), including different pre-commitment devices for saving, suggests that some people hold a partly sophisticated belief about future inconsistency.

Houser et al (2010) document the use of costly pre-commitment devices in a lab setting. Beshears et al (2011) find that people put money in a savings account with penalties for early withdrawal even when a no-penalty alternative is available, as long as the interest rates match. Ashraf, Karlan and Yin (2005) find more take-up of a pre-commitment savings plan among women with more hyperbolic time preferences (e.g., more present-bias or preference reversals), leading to increased savings. Schwartz et al (2014) found that over a third of participants in a wellness program were willing to pre-commit to an increase in healthy food purchases, risking their discount if they failed to do so, thus yielding a significant increase in healthy food purchases.

Other research has more directly linked differences in elicited discounting tasks with some of these predicted differences in savings behaviors, sometimes attempting to distinguish between factors that relate to generally high discount rates vs. present-bias (higher discount rates specifically for tradeoffs involving the present). Meier and Sprenger (2009) found that individuals with lower discount rates had both higher financial literacy and were more likely to accept an offer of a free credit counseling session, controlling for other demographic factors. People with more present-bias have less credit card debt, but credit card debt does not vary with individual discount rate (Meier and Sprenger 2010; Harrison, Lau, and Williams 2002). Lower discounting has also been linked to people being more likely to pay their bills in full (Chabris et al 2008) as well as homeowners being less likely to owe more on their homes than the market value (Johnson, Atlas and Payne 2011). However, discounting has not been found to correlate with the proportion of income saved (Chabris et al 2008) or voluntary retirement account contributions (Chapman et al 2001).

One corrective action to under-saving for people near retirement age is continuing to work, which represents a tradeoff between present leisure consumption and future total retirement savings. Bidewell, Griffin and Hesketh (2006) find that people with lower discount rates make hypothetical choices to delay retirement later. Appelt et al (2011) find that present bias (but not long-term discount rate) predicts early-retirement preferences at eligibility, but not before.

Some research has begun to look at how factors implicated in discounting might impact savings decisions. Ersner-Hershfield et al. (2009) also present evidence that people who report having accrued greater total assets—more money invested in a home, in securities, in other material goods, and in the bank—tended to rate themselves as more similar to who they would be in 10 years than people who had fewer assets. Bryan and Hershfield (2011) find that an appeal focusing on the person's responsibility to their own future self increased savings among those high in connectedness to the future self.

Overall, the tendency to focus on the present and under-weigh the future naturally leads to difficulty to save, especially for the long term. Many of the ways to counter this tendency are based on making the future more salient or alternatively, using our discounting to facilitate future commitment to increase savings. The main idea is to either try to counter discounting or when possible leverage it by getting people to pre commit.

Employment decisions

Employment decisions often involve trading off efforts and revenues over time and give rise to multiple intertemporal tradeoffs. The investment in education, discussed above, can also be seen as a tradeoff between short-term concerns (the effort to do well, the increase in current revenue from ending schooling and beginning work) and potential long-term career benefits of longer schooling.

As people enter the workforce, the job search process can be seen as an intertemporal tradeoff. Hesketh et al (1998) find hyperbolic discounting in hypothetical choices between a less enjoyable immediate job and a more enjoyable job available later. Schoenfelder and Hantula (2003) find both present-bias and magnitude effects in people's tradeoffs between jobs with different profiles of wages and enjoyment over time. In addition, they find that discount rates over wages correlate only weakly with discount rates for favorability of job duties (r=.19).

There is also supporting evidence for these findings in workers' actual behavior. Lee and Ohtake (2012) look at the decision to take a temporary work position, which they argue provides short-term financial rewards potentially at the cost of longer-term career advancement. They find that people who have taken temp work have higher elicited discount rates and more inconsistent time preferences. Saunders and Fogarty (2001), in a three year longitudinal study with a small sample of employees, found reversals of preference, from an initial preference for a future higher-paid senior manager position to an ultimate choice of a lower-paid manager role available immediately.

Other researchers have found additional evidence, by linking panel data on employment history and behaviors to proxies for impatience. Della Vigna and Paserman (2005) find that people with higher impatience (as measured by multiple proxy variables, such as smoking) have lower search intensity and therefore remain unemployed for longer. They argue that the pattern of results they observe are consistent with hyperbolic but not with exponential discounting. Using cigarette smoking as a proxy, Munasinghe and Sicherman (2000) find that more impatient workers have lower initial wages and slower wage growth. Drago (2006) finds that workers with lower proxied short-run impatience are more likely to

invest in their current jobs and less likely to engage in on-the-job search. Likewise, Van Huizen (2010) finds that workers with lower proxied short-run impatience are more likely to invest in their current job, but contrary to Drago (2006), that they are also more likely to search for a new job. However, these findings have not been tested with elicited discount rates, and smoking may proxy for other relevant factors besides discounting.

Employment decisions can have a major effect on long-term financial resources, and are a primary contributor to savings outcomes. As such, discounting may be central to how these decisions are made. The causal link between discounting and employment behaviors are difficult to assess, however. In particular, unobserved differences in present resources and beliefs about future resources may affect both discounting and employment behaviors. More research on this important question is needed.

Educational achievement

As noted earlier, there is an intriguing correlational relationship between level of educational attainment (e.g., years of schooling) and measures of impatience, including both discount rates and delay of gratification (Mischel et al., 1989). While causality is difficult to determine in this context, and most studies do not control for income and other demographic factors, perseverance in education can be seen as arising from either intrinsic motivation or from an intertemporal tradeoff between current effort and the potential future financial rewards of higher educational achievement. Consistent with the latter view, some research has suggested that low discount rates may be related to behaviors that facilitate educational attainment.

Lee et al (2012) find that the relationship between discount rates and grades is partially mediated by a self-reported "school attitude", which includes measures of motivation and effort investment. Silva and Gross (2004) find a parallel correlation between grades and time discounting as well as between grades and effort discounting (willingness to do more extra credit work even when rewards decrease), although the relationship between time discounting and effort investment is not tested.

Discounting may also be related to students' focus and non-disruptive behavior. Castillo et al (2011) find that high discounting predicts disciplinary referrals in middle school, even controlling for demographics, suggesting another causal path via which discount rates might influence educational achievement. Teens with a learning disability (ADHD) have also been found to have higher discount rates (Barkley et al 2001). However, Wilson and Daly (2006) find no difference in discounting between juvenile offenders and a control group of high school students.

Finally, Duckworth and Seligman (2005) show that a composite measure of self-discipline (which includes discount rate) predicts not only educational outcomes (grades, test scores and high school placement) but also other relevant behaviors, such as students with lower discount rates having fewer absences, spending less time watching television, starting their homework earlier and spending more time doing homework. Consistent with these results, Reed and Martens (2011) find that elementary school students with lower discount rates were more likely to remain on-task when completing work in the classroom. However, focused interventions are needed to determine the direction of the causal link between discount rates and education-related motivation and outcomes.

Consumer behavior and self-control

Research on consumption and purchase decisions has documented findings that are consistent with time discounting, in particular with treating choices between "virtues" and "vices" (or, alternatively, since most lack a clear moral component, utilitarian vs. hedonic options) as choices between larger-later vs. sooner-small rewards (Bazerman et al 1998, Hoch and Loewenstein 1991, Thaler and Shefrin 1981). However, there exists remarkably little research documenting a direct link between differences in either discount rate or present-bias and consumption or purchase decisions.

Some consumer behaviors may be explained by present-biased time preferences (Lynch and Zauberman 2006). These include failure to file for mail-in-rebates (Soman 1998) and to return undesired purchases (Wood 2001), as well as differential willingness to expedite vs. delay consumption (Malkoc and Zauberman 2006). Preference reversals, such as preferring healthy foods or high-brow movies in advance but then switching to unhealthy foods or lowbrow movies at the time of consumption (Milkman, Rogers and Bazerman 2009; Read and van Leeuwen 1998; Read, Loewenstein and Kalyanaraman 1999), are consistent with either hyperbolic discounting or errors in affective forecasting (Loewenstein 1996). Likewise, the tendency to overpay in advance for flat-fee gym contracts (vs. per visit, Della Vigna and Mallmendier 2006), to favor non-leisure magazines when subscribing (vs. at the newsstand, Oster and Scott-Morton 2005) and to choose healthier groceries when ordering farther in advance (Milkman, Rogers and Bazerman 2010) can be interpreted as driven by unanticipated intertemporal preference reversals, potentially due to hyperbolic discounting. In contrast, Chevalier and Goolsbee (2005) do not find support for high discount rates, based on textbook purchase and resale decisions.

Some of the above results, however, can also be interpreted as a temporal inconsistency due to different items potentially having different discount rates. A key implication of item-

specific discount rates is that people should be willing to forego money to get more steeply discounted goods sooner. The notion of affect-driven time discounting (Loewenstein 1996; Metcalfe & Mischel 1999; Mischel, Shoda and Rodriguez 1989; Vallacher 1993) suggests that goods higher in affective (i.e. hedonic) dimensions will be discounted more steeply over time than goods higher in cognitive (i.e. utilitarian) dimensions. Urminsky and Kivetz (2013) compare intertemporal tradeoffs between expensive-sooner and cheaper-later options (e.g. due to shipping costs, expected price declines) for different kinds of consumer goods. While they find results consistent with affective discounting in scheduling decisions (e.g., which of two goods to receive first) they find less willingness to spend to expedite purchases for more affective goods, contrary to the prediction of affective discounting. They argue that choices between hedonic items and money induce guilt, countering hedonic discounting, more so than for choices between practical items and money.

Other consumer behaviors can be explained as an attempt to compensate for or circumvent time-inconsistent preferences. Wertenbroch (1998) showed that people will pay a premium for smaller packages of vice (but not virtue) foods, presumably to prevent a reversal of preference and future over-consumption. Similarly, Gine, Karlan and Zinman (2008) show that people are willing to enroll in costly pre-commitment contracts to prevent future behaviors (e.g., smoking) and such a program can be effective.

However, the potential for guilt to over-ride intertemporal preferences suggests that some consumers may in fact face the opposite self-control problem, deferring hedonic consumption more than they would like. Consistent with this view, people do pre-commit to hedonic consumption (Kivetz and Simonson 2002) and focusing consumers on the long-term regrets of hedonic under-consumption increases their consumption (Keinan and Kivetz 2008).

Though the above mentioned papers seem to document patterns of behavior associated with intertemporal preferences, they are not directly linked to differences in elicited discount rates. To a large degree, research on discounting and research on self-control have evolved in parallel, with the two areas mutually influencing each other, but with very little direct integration. In part, this may be because the behaviors studied, such as self-control, may be jointly determined by the interaction of discount rates with other factors. Consistent with this view, Bartels, Urminsky and Frederick (2013) find that restrained spending (foregoing purchases or choosing a less expensive option) is motivated by lower discount rates and lower connectedness to the future self, but only when tradeoffs and opportunity costs are salient to consumers.

There has been increasing interest in incorporating and testing discounting using dynamic choice models applied to observed consumer choices. One major difficulty (summarized in

Dube, Hitsch and Jindal 2013) is that consumers' utility function, discount function, and beliefs about the future are not separately identifiable from panel data. This makes it challenging (and at time impossible) to identify specific intertemporal effects in real world observed data. One common approach is to fix certain parameters by assumption, in order to be able to estimate others. For example, the discount factor may be set to a normatively-suggested level (e.g., $\delta = .995$) and consumers are then assumed to be fully forward-looking, in that they accurately take into account all future outcomes (Erdem and Keane 1996). A better understanding of planning horizons, differential discounting of different kinds of benefits and the relative discounting of payments and goods received will be important for progress in this area.

Energy conservation

Energy conservation involves two kinds of intertemporal choices, as future energy savings can be achieved by either foregoing current benefits of energy consumption or by paying more now for efficient equipment. One of the first and most influential demonstrations of high revealed discount rates (Hausman 1979) was in this context, estimating a private discount rate of 25% based on the upfront cost and energy savings from actual air conditioner purchases. Other papers have found similar discount rates for appliances (Gately 1980), heating systems (Dubin and McFadden 1984) and for auto purchases (Dreyfus and Viscusi 1995). However, the implied discount rates can also be affected by other factors, including high inflation, anticipated duration of use, risk from changes in energy prices in the future and beliefs about those prices, as well as differences in actual or perceived product benefits that are confounded with energy efficiency. Consequently, the actual discount rates may be lower and more reasonable (see Allcott and Greenstone 2012 for a review and discussion).

High (and potentially hyperbolic) discounting is consistent with requiring a rapid recoup of investment in more efficient technology, and an informal 2-year cutoff for payback in capital budgeting has been proposed as a major barrier to commercial adoption of energy efficient equipment (Bressand et al, 2007). If this is in fact a bias, there may be a profitable opportunity to lease rather than sell such equipment, a shift in business model that has arguably been successful in solar energy provision to both commercial and residential consumers in the U.S. (Himmelman 2012).

Health behaviors

Managing one's health often involves a trade-off, between either present rewards (e.g. consuming unhealthy foods, smoking) or present costs (immunizations) and longer-term health benefits. While it is important to note that long-term health benefits are often more uncertain than the present consequences (i.e. a smoker generally faces only a higher risk of lung cancer), health behaviors can be thought of as an intertemporal choice between present resources and investment in future human capital (Becker 1964; Grossman 1972).

The relationships between discounting and addictive behaviors have been the most thoroughly researched. MacKillop et al (2011) provide a meta-analysis of 46 studies, and find an overall significant relationship between addictive behaviors and higher discount rates (d=.15). This relationship is significant separately for alcohol, tobacco, stimulants, opiates and clinical pathological gambling. Yi, Mitchell and Bickel (2010) review this literature and note that the evidence for a predictive relationship between prior discounting and severity of relapse, while preliminary, is stronger than the link between prior discounting and drug use initiation.

Multiple papers have found that financial proxies indicative of higher discount rates correlate with a measure of obesity, Body Mass Index (BMI): Smith, Bogin and Bishai (2005), reported savings; Ikeda et al (2009), debtors; Komlos, Smith and Bogin (2003) average savings rates across countries and debt-to-income ratio over time in the US. Furthermore, multiple papers have now documented a small but robust correlation between higher elicited discount rates and BMI. In particular, the Reimers et al (2009) large-scale survey finds a correlation of r=.05. A meta-analysis of nine other studies (Urminsky 2014) likewise finds positive correlations in all but one and an estimated average r=.07. However, Borghans and Golsteyn (2006) argue that changes in discount rate over time do not account for increases in obesity.

The literature has not been able to conclusively identify the means by which BMI and discount rates are related. Adams and Nettle (2009) find a marginally significant correlation between moderate exercise and lower discount rates, while Chabris et al (2008) find mixed results for exercise across three studies and Melanko and Larkin (2013) find no relationship. Cabris et al (2008) also find no relationship between discount rates and self-reported over-eating or eating healthy foods, while Melanko and Larkin (2013) find a positive relationship between discount rates using experienced delays and self-reported nutrition behaviors.

The evidence for a relationship between discounting and long-term preventative health behaviors and health outcomes is mixed as well. A review of six papers looking at the

relationship between discounting and health promotion behaviors finds mixed results for exercise, consuming healthy foods, prescription compliance and a range of preventative health behaviors (Urminsky 2014), suggesting a potential but weak relationship. The strongest evidence is for the correlation between getting a flu shot and low discount rates for monetary losses (Chapman and Coups 1999; Chapman et al 2001). Of course, actual health behaviors are affected by many other factors, and there may be a stronger relationship between discounting and behavioral intentions. Consistent with this possibility, Urminsky et al (2013) find a relationship between higher connectedness to the future self and willingness to undergo painful or uncomfortable medical procedures that promise long-term health benefits.

The link between discounting and health behaviors has arguably been more thoroughly studied than any other behavior. The most reliable relationships (although modest in magnitude) have been the links between discounting and both addictive behaviors and BMI. This research, as well as studies using pre-commitment, suggests that interventions targeting discounting may be effective, albeit limited, as one component in treating these problems, which is an interesting opportunity for future research.

Public policy

The literature on intertemporal choice has several major implications for public policy. Most directly, cost-benefit analysis of potential policies that differ in the timing of their costs and benefits requires specification of a social discount rate (or social time preference), as well as making assumptions about the discount function (Sugden and Williams 1978). The standard approach is to assume exponential discounting with a finite time horizon and a market-estimated rate. However, there have been some arguments for why social time preference should be modeled using hyperbolic or declining (Henderson and Bateman 1995; Weitzman 1998) discount rates.

More generally, making the assumption that people have exponential discounting with near-market rates may lead to ineffective policies, because it may not reflects people's actual behavior. For example, Shapiro (2005) documents high start-of-month food consumption among food stamp recipients, consistent with present bias or high daily discount rates, which suggests that moving from monthly to bi-monthly payments might be beneficial. In a broader context, even small upfront costs (of time, money or inconvenience) may have a seemingly disproportionate impact, reducing adoption of otherwise beneficial policy interventions (Bertrand et al 2006; Zauberman, 2003). For example, Bhargava and Manoli (2013) find that, relative to other interventions, merely simplifying program information so that it is quicker and easier for people to fill out is the

most effective in increasing take-up of the Earned Income Tax Credit. Conversely, policy makers may find it surprisingly costly to incentivize homeowners to spend money on energy conversion home upgrades. In contrast, programs that provide immediate benefits and potentially deferred costs (e.g. "Cash for Clunkers", Busse et al 2013) may be more readily adopted. Lastly, providing steeply discounted "cash-out" opportunities, such as lump-sum severance or foregoing some benefits in order to receive Social Security earlier may be surprisingly cost-effective. However, some people's choices when given such opportunities may reflect their impatience and discounting tendencies (Appelt et al., 2013) more than their actual future needs, resulting in negative long-term consequences.

A better understanding of people's time preferences may provide policy makers additional insight into the source of problems they are concerned with. Research described in this review points to the potential role of discounting in under-saving, over-spending, non-compliance with health care regimens, substance abuse, poor nutrition, and under-investment in education and career outcomes.

To the degree that discounting contributes to these problems, understanding either how to change people's discount rates or how to structure choices so as to subvert the impact of time preferences will be a necessary component of solving them. As mentioned earlier, Thaler and Benartzi (2004) have demonstrated the impact of one such approach in their "Save More Tomorrow" program, by having people commit in advance to future increases in their automatic savings rate.

4. Conclusions

Understanding how people form their intertemporal preferences, and quantifying their discount rates, is primarily of interest across multiple theoretical and applied areas because of the potential to explain a wide range of real-world behaviors. This chapter presented a review of the main current findings on intertemporal choice. However, given the focus of past reviews, we only provided a descriptive account of discounting behavior as a way to set up the main discussion of the psychological mechanisms that have been shown to drive intertemporal preferences. We have also reviewed the studies that investigate links between key real world decision domains and intertemporal choice.

The mechanisms we covered in this chapter range from emotion based to various cognitive based accounts, and focus on the outcomes relevant to the choice, the future self in the context of the choice, the perception of resources and opportunity costs, and the perception of the time horizon relevant to the choice. Examining the vast research, both conceptual and applied, in psychology, decision research, economics, business, and policy, our view is that intertemporal preferences are inherently multiply determined, and no one specific

mechanism can explain all situations. What is common across all these mechanisms, however, is that they work on the relative attractiveness of achieving a present goal compare to a later more distant one. It is then the salience and importance of their goals, and the possibility to failing attaining them, that determines the attractiveness of the present verses the future outcome, and thus the extent of time discounting.

Our review highlights several important understudied areas and much-needed directions for future research.

1. *Reconciling multiple determinants*. We have a better understanding now that time preferences are determined by multiple psychological factors. Less is understood about how these factors interact in jointly shaping both elicited time preferences and behavioral outcomes.

2. *Separating elicitation factors from time preference*. Many studies have identified contextual factors that affect elicited time preferences. However, for the most part, we don't know which of these factors are central to actual time related preferences and which factors represent biases that distort the link between actual preferences and elicited measures. We also don't know enough yet about the stability of time preferences over longer periods of time, which is important to understand the predictive usefulness of elicited time preferences.

3. *Moving beyond single-parameter time discounting*. Research on modeling time preferences, which has developed sophisticated multi-parameter models, has not been well-linked to research on the relationship between discounting and other behaviors. As a result, much remains to be done to understand how multi-dimensional time preferences are, how reliable each parameter is, and which behaviors are systematically related to which aspects of time preference. Early work has provided evidence that β and δ in quasi-hyperbolic discounting may differentially correlate to specific behaviors, but much remains to be done in understanding what these aspects capture and what behaviors each predicts.

4. *Incorporation of time preference into general decision models*. Time discounting has largely developed in isolation from other decision models, using simple elicitation tasks. Much remains to be done to incorporate time discounting into models of multi-alternative multi-attribute choice. Doing so can both help us understand a broader range of decisions and also refine our understanding of time discounting in complex decision settings.

5. *Causal interventions*. The empirical links between discounting and time-related behaviors have largely been established using correlational methods. At the same time, some researchers have begun to develop interventions that manipulate time preferences. This provides an opportunity to test whether time-preference interventions will causally impact the correlated behaviors that have been identified. The opportunity is both to potentially establish causality, which is largely lacking in this area, and to develop effective interventions that are useful for policy.

We hope that this review highlights both the wealth of data we now have on intertemporal choice as well as the key unresolved questions and opportunities for future research. While a single unified theory of intertemporal is probably unattainable, we do believe that better understanding the relationship between the various affective and cognitive mechanism can provide useful insight. We further believe that thinking about how the psychological underpinnings of intertemporal choice relate to people's time-relevant decisions and behaviors will lead to better understanding of and to better ability to predict these choices and will enable the design of interventions that will change behavior.

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