



Present bias: Definition and measurement

Alexis Direr

► To cite this version:

| Alexis Direr. Present bias: Definition and measurement. 2019. hal-02133525v1

HAL Id: hal-02133525

<https://hal.science/hal-02133525v1>

Preprint submitted on 18 May 2019 (v1), last revised 24 Jun 2020 (v3)

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Present bias: Definition and measurement

Alexis Direr *

May 17, 2019

Abstract

A novel definition of present bias is proposed which takes preferences as primitives. A present biased individual over-weights immediate costs and benefits relative to those occurring at any point in the future. The definition allows to sort out previous confounds, such as decreasing impatience, choice reversal or short-term impatience. It intuitively connects to usual utility representations of present bias like the quasi-hyperbolic model of Laibson (1997) or the fixed cost model of Benhabib, Bisin and Schotter (2010). Drawing on the definition, we propose two experimental methods measuring present bias at the individual level which do not require assumptions about utility or discounting, one for daily trade-offs, the other for intra-daily trade-offs.

J.E.L. codes: D8, E21

Keywords : time preferences, decreasing impatience, present bias

*Univ. Orléans, CNRS, LEO, UMR 7322, F45067, and Paris School of Economics. E-mail: alexis.direr@univ-orleans.fr.

1 Introduction

The last two decades have witnessed a rapid growth of theoretical and empirical works on present bias. It is now considered an important determinant of many intertemporal decisions related to saving or borrowing (Meier and Sprenger, 2010), retirement timing (Diamond and Koszegi, 2003), addiction (Laibson, 2001, Bernheim et Rangel, 2004), health (Loewenstein et al. 2012), bargaining (Schweighofer-Kodritsch, 2018), or job search (DellaVigna and Paserman, 2005). It helps explain why individuals have self-control problems, procrastinate, or do not stick to the plans they have made earlier (O'Donoghue and Rabin, 2015, Bisin and Hyndman, 2014).

It is fair however to recognize that present bias still lacks a formal definition. It has been used so far as an evocative expression for addressing various behavioral properties like short-term impatience, decreasing impatience, choice reversal toward early outcomes, and more generally, procrastination, self-control problems, demand for commitment, high required rates of return and naiveté (when people underestimate their own procrastination or present bias). The profusion of concepts surrounding the term raise questions. Given the importance ascribed to the concept in the literature, a precise and well founded definition is of prime importance.

The aim of this article is to propose a simple and focused definition of present bias, which closely relates to, but remains distinct from choice reversal, decreasing or increasing impatience and short-term impatience. A present biased individual values more an immediate outcome than one postponed in the near future, where the near future can be arbitrarily soon. The definition makes a natural distinction between present bias, present neutrality and future bias. It takes a simple axiomatic form, which, once mixed with other axioms of time preference has the property of turning present neutral preferences into present or future bi-

ased ones. Two well known models of present bias, the quasi-hyperbolic model of Laibson (1997) and the fixed cost model of Benhabib, Bisin, and Schotter (2010) conforms in an intuitive way to the definition. Last, once the concept is cleared from unnecessary features, it can be used to design new and simple experimental protocols which allow measurement at the individual level of the bias, and provides information about its distribution in the population. Two novel estimation methods are proposed which do not make any assumptions about the shape of the utility function or the discount function.

The expression “present bias” is relatively recent. It can be traced back to the article by O’Donoghue and Rabin (1999) who present it as “a more descriptive term for the underlying human characteristic that hyperbolic discounting represents”. Hyperbolic discounting is taken as an equivalent expression for decreasing impatience, which means that when considering trade-offs between two future periods, individuals give stronger relative weight to the earlier moment as it gets closer. Decreasing impatience has since then served as a testable implication of present bias (e.g. Andreoni and Sprenger, 2012). Subsequent studies (Hayashi, 2003; Benhabib, Bisin and Schotter, 2010) have extended the meaning to the preference reversal property, which is the tendency of reversing one’s choice from late to early outcome once a trade-off is moved closer to the present (Thaler, 1981; Read and van Leeuwen, 1998). More recently, O’Donoghue and Rabin (2015) proposed as an alternative test of present bias the detection of non negligible impatience over short delays.

Experimental studies show that a significant fraction of subjects exhibit opposite tendencies, like increasing impatience (Attema et al., 2010) or choice reversals toward the late outcome (Read, Frederick and Airoldi, 2012; Sayman and Öncüler, 2009; Takeuchi, 2011), especially when the outcomes are money. While it seems natural to refer to those properties as future bias, the same remark about the need for a unified definition applies.

Many studies referring to present bias have worked with functional representations, usually the quasi-hyperbolic (or $(\beta - \delta)$) model of Laibson (1997) where, compared to the exponential model of Samuelson (1937), an extra weight $1/\beta$ on present utility is added. In his seminal article, Laibson did not propose a specific theory of present bias, whose very expression appeared later in his work (Laibson et al., 2003). His objective was rather to propose a time inconsistent discounting model which exhibits decreasing impatience while being closer to the canonical model of Samuelson (1937) than the hyperbolic formulation used by psychologists (Ainslie, 1992). Since then, the model has been widely used to investigate the consequences of many behaviors like decreasing impatience, choice reversal, naiveté or short-term impatience. Although functional forms offer tractable ways for analyzing a wide range of issues, they may lack scope and generality (Spiegler, 2019).

Only a few articles have attempted to give a conceptual or axiomatic definition of present bias. Chakraborty (2017) weakens the stationarity axiom to allow possible choice reversals in a way that does not contradict a preference for the present. Formally, if the late outcome is preferred in a trade-off where the early outcome is immediate, then the individual does not reverse her choice to the early option when the two outcomes are postponed by a common delay. Once added to basic postulates of rationality, the axiom yields a general class of utility representations, which allows several deviations from the stationary exponential model. Montiel Olea and Strzalecki (2014) provide an axiomatic characterization of quasi-hyperbolic discounting and a more general class of semi-hyperbolic preferences that suggests new experimental designs in which present bias is disentangled from the elasticity of intertemporal substitution. Both articles propose a full-fledged theory of intertemporal choices, while the present model concentrates on preferences over outcomes either delivered now or after a brief delay. The definition remains agnostic about time preferences beyond the near present.

The remainder of the paper is organized as follows. Section 2 lays out existing definitions of present bias and proposes a new definition. Section 3 presents axiomatic foundations of the definition. Section 4 draws on the definition to elaborate two new experimental designs measuring present bias at the individual level. Section 5 concludes.

2 Present bias: definitions

2.1 Common definitions of present bias

Present bias is loosely defined as the propensity of overvaluing immediate rewards at the expense of futures ones. The tendency is often phrased as an extreme form of impatience or a strong preference for early rather than late outcomes. A variety of psychological drivers have been mentioned, such as impulsivity, deprivation, addiction, or transient visceral factors such as hunger or thirst.

More formally, let us consider a decision maker (henceforth DM) whose time preferences are defined over the set of possible positive or negative outcomes $X \subseteq \mathbb{R} - \{0\}$. Let us denote by $T = \{0, 1, 2, \dots, \bar{t}\}$ the set of times at which an outcome may occur, with $t = 0$ the present. A time-dependent plan (x, t) delivers the outcome $x \in X$ at date $t \in T$. Let \succ and \sim be strict preference ordering and indifference relation respectively on $X \times T$ expressed at time 0. They are complete and transitive. Positive outcomes (consumption in a broad sense) are defined by $(x, t) \succ (y, t)$, $\forall x, y \in X$, $x > y$, and $\forall t \in T$, and negative outcomes (unpleasant experience or tasks) by the reverse preference. In the following, the set of dated outcomes is either restricted to positive outcomes or negative ones. Mixed domains with both positive and negative outcomes are not considered. Also, the issue of time-consistency is sidestepped by focusing on

time preferences from date 0 perspective, as if the DM could commit to them.

Before presenting an axiom-based definition of present bias, I first recall the definitions of impatience, decreasing impatience and choice reversal.

Definition 1 (*impatience*) *The DM is impatient if $\forall t, s \in T, t < s, (x, t) \succ (x, s), \forall x \in X$.*

The DM is impatient if early outcomes are always preferred to delayed identical ones. The definition applies to positive as well as negative outcomes. Patience, the opposite of impatience, holds if the preference relation is reversed. Impatience is generally observed for positive outcomes and patience for negative ones. Since impatience does not necessarily involve a present outcome, it cannot be confounded with present bias. A more compelling definition is related to decreasing impatience (or hyperbolic discounting), the propensity of being less impatient the further the trade-off away from the present (Prelec, 2004).

Definition 2 (*decreasing impatience*) *$\forall x, y \in X, \forall t, s \in T, t < s$, such that $(x, t) \sim (y, s)$, impatience is decreasing if $(y, s + \Delta) \succ (x, t + \Delta), \forall \Delta \in \{1, 2, \dots\}$ for all $s + \Delta \in T$.*

Impatience is decreasing if for any couple of dated outcomes such that the DM is indifferent between them, she prefers the delayed option when the two dates are shifted forward by the same time interval. Increasing impatience is defined the same way with a reversed preference relation between the early and late outcomes.

Most experimental studies have found decreasing impatience (Thaler, 1981; Benzion et al., 1989; Green et al., 1997; Kirby, 1997; Kirby, Petry, and Bickel, 1999; Kable and Glimcher, 2007; Benhabib, Bisin, and Schotter, 2010; Bleichrodt, Gao, and Rohde, 2016). Some studies have found increasing impatience

for money (Attema et al., 2010; Sayman and Öncüler, 2009; Scholten and Read 2006; Loewenstein, 1987 and Takeuchi, 2011).

Many articles assimilate present bias and decreasing impatience (O'Donoghue and Rabin, 1999; Halevy, 2008; Benhabib, Bisin, and Schotter, 2010; Andreoni and Sprenger, 2012). Present bias can be viewed as a particular instance of decreasing impatience in which the early date is the present one ($t = 0$). If the DM is indifferent between two delayed rewards (x, t) and (y, s) , $s > t > 0$, she strictly prefers the immediate reward $(x, 0)$ to the late one $(y, s - t)$. In definition 2, impatience is strongest when the early option is shifted backward to the present. However, decreasing impatience characterizes the evolution of impatience at every date, not necessarily the present one. It does not stress what is special about the present, which involves the strong appeal to consuming now against in any future dates.

Decreasing impatience, but not necessarily impatience, is a cause of time inconsistency and choice reversal. For this reason, present bias is also sometimes assimilated to choice reversal (Manzini and Mariotti, 2009; Chakraborty, 2017). Several experimental studies use it as a test of present bias (Read and van Leeuwen, 1998, Takeuchi, 2011, Andreoni and Sprenger, 2012, Augenblick et al., 2015). As a future trade-off gets closer to the present, preferences are increasingly biased toward the early option.

Definition 3 (*choice reversal*) $\forall x, y \in X$ and $\forall s, t \in T$, $t < s$, such that $(x, t) \sim (y, s)$, there is choice reversal toward the early outcome if, t periods before $(x, 0) \succ (y, s - t)$, and toward the late outcome if $(x, s - t) \succ (y, 0)$.

Experiments usually find that the choice is reversed in favor of the present outcome when outcomes are positively valued by the DM.¹ Since choice reversal toward the present outcome often reveals self-control problems and toward

¹ Meier and Sprenger (2010) find choices reversed toward the late outcome.

the late outcome procrastination, present bias is also sometimes inferred from demand for precommitment devices that restricts the set of future consumption or actions (Bryan, Karlan and Nelson, 2010). The test relies on the joint assumption of sophistication where the DM is sufficiently aware of her self control problem. Decreasing impatience entails choice reversal towards the present outcome if preferences are stable across periods (Halevy, 2015).

Last, impatience over short-term trade-offs, a property commonly observed in experiments, is sometimes interpreted as signaling present bias (Rabin, 2002, Shapiro, 2005, O'Donoghue and Rabin, 2015). To see why, consider an exponential discounter whose discount rate over a short period of time is $\rho \geq 0$ and her short term discount factor is $d(1) = (1 + \rho)^{-1}$. Her utility in n years is discounted by $d(nm) = (1 + \rho)^{-nm}$, with m the number of short periods in a year. Her annualized discount factor ρ_a is equal to $1 + \rho_a = (1 + \rho)^{-m}$. A small degree of short-term impatience may translate into a potentially extreme degree of impatience once compounded over long periods of time. For instance, a discount rate of $\rho = 0.1$ percent over one day leads to a strong annualized discount rate of 44 percent. Such value may signal a bias toward the present as it seems incompatible with individuals engaging in profitable long-term investments like stopping smoking or saving for their long term standard of living.

The $(\beta - \delta)$ model of Laibson (1997) is a parsimonious way of breaking the link between short-term impatience and long-term impatience. An extra weight on present utility is given by $d(0) = 1/\beta > 1$, and the discount function for subsequent periods $t > 0$ is exponential: $d(t) = (1 + \rho)^{-t}$, with $\rho \in (0, 1)$ the subjective discount rate. The parameter $\beta > 0$ which measures short-term impatience captures the bias for the present, whereas long-term impatience is measured by the parameter δ . O'Donoghue and Rabin (2015) conclude that short-term discounting is a test of present bias, even better than choice reversal.

Although short-term impatience plausibly reveals a bias toward the present,

it is not a clear-cut criterion. In particular, the issue of what constitutes excessive impatience in a quantitative sense remains open. O'Donoghue and Rabin (2015) claim that any noticeable short-term discounting is evidence of present bias. It may be true for very short delays like a day or a week, but is less compelling for medium delays like a month. Also, the boundary between excessive and plausible short-term impatience is a moving one, as it depends on the time discounting model and the functional form at hand. For example, if exponential discounting is replaced by constant absolute decreasing impatience discounting (Bleichrodt, Rohde and Wakker, 2009): $d(t) = \exp(\exp(-ct) - 1)$, the same calibration exercise yields annualized long-term discount rates: 36, 30 and 18 percent at the horizons of 1, 2 and 5 years respectively, compared to the fixed annual discount rate of 44 percent in the exponential model. They are still high numbers, but less so than in the exponential case.

To sum up, short-term impatience, decreasing impatience and choice reversal are all intuitively related to the notion of present bias. The link is however informally established. The next subsection proposes a different approach based on a simple axiomatization of present bias.

2.2 Present bias: a definition

Let us include in the time set T an additional period of duration μ which takes place between date 0 (the present) and date 1.

Definition 4 (*present bias*) *Preferences are present biased if $\exists \epsilon > 0$ such that $\forall \mu \in (0, \epsilon] (x, 0) \succ (x, \mu), \forall x \in X$.*

A present biased DM value more an immediate outcome compared to one postponed in the near future, where the near future can be as soon as desired. The definition applies both to positive and negative outcomes, although it is

empirically relevant for positive outcomes. It provides a precise and natural meaning of the idea of “overvaluing immediate reward”. It is similar to Definition 1 of impatience, except that it is restricted to the temporal neighborhood of the present instead of being applied to the entire timeline. It is consistent with the claim that present bias “is about now” (O’Donoghue and Rabin, 2015). It does not necessarily imply a strong appeal toward the immediate outcome relative to a postponed outcome. The important ingredient is the temporal discontinuity between the present and the future.

Additionally, future bias can be symmetrically defined as a preference for the late outcome in the near future, a special case of patience.

Definition 5 (*future bias*) *Preferences are future biased if $\exists \epsilon > 0$ such that $\forall \mu \in (0, \epsilon] (x, \mu) \succ (x, 0), \forall x \in X$.*

Future bias may occur when the DM faces negatively valued outcomes like unpleasant tasks, or when individuals derive a positive utility of anticipating a pleasant consumption experience (Loewenstein, 1987, Shu and Gneezy, 2010). The DM may also be willing to postpone a positive outcome to create an improving sequence (Loewenstein and Prelec, 1991). The expression future bias has been used in the literature with a different meaning than the one in Definition 5. It stands either for increasing impatience (Attema et al., 2010) or choice reversals toward the late outcome (Read et al. 2012; Sayman and Öncüler, 2009; Takeuchi, 2011).

Last, a DM is present neutral if she is time neutral around the present moment.

Definition 6 (*present neutrality*) *Preferences are present neutral if $\exists \epsilon > 0$ such that $\forall \mu \in (0, \epsilon], (x, 0) \sim (x, \mu), \forall x \in X$.*

All individuals are characterized by one of the three attitudes toward immediate outcomes. The definitions may also receive an axiomatic form.

3 Axiomatic foundations

3.1 Axioms

Let us turn Definitions 4, 5 and 6 into axioms by asymptotically shortening the present period.

Axiom 1 (*present bias*) $(x, 0) \succ (x, 0^+), \forall x \in X$.

with the short notation $0^+ = \lim_{\mu \rightarrow 0^+} \mu$. Axiom 1 is a limit case of Definition 4. The passage to the limit stresses the specificity of present utility, an instantaneous flow over a timeline. It is close to the description of Volpp and Loewenstein (2015) as the “tendency to over-weight immediate costs and benefits relative to those occurring at any point in the future”.

The axioms of future bias and present neutrality are defined the same way:

Axiom 2 (*future bias*) $(x, 0^+) \succ (x, 0), \forall x \in X$.

Axiom 3 (*present neutrality*) $(x, 0) \sim (x, 0^+), \forall x \in X$.

They can be used to classify usual models of discounting as present biased or neutral, and to provide axiomatic foundations to present biased models.

The delivery date when $x = 0$ is meaningless, but the comparison of arbitrarily small quantities remains an issue. There are two competing possibilities. Either individuals become asymptotically present neutral: $(0^+, 0) \sim (0^+, 0^+)$.

Or they are still present (or future) neutral: $(0^+, 0) \succ (0^+, 0^+)$. In the first case, the attraction of the immediacy vanishes with the value of the outcome. In the second case, a psychological process associated with the immediate outcome, like impulsivity, persists. This issue has not been empirically addressed to the best of our knowledge. Its welfare implications are far from benign, as many bad habits take the form of repeated small-stake decisions over long periods of time, like adding sugar in one's coffee or delaying small tasks.

3.2 Utility representation

Present bias has been defined in a narrow sense by focusing on some minimal necessary ingredients. Consequently, it does not impose a complete preference ordering of intertemporal plans. One may wonder how the definition fits with full-fledged models of intertemporal choices. We have first to express Axiom 1 as a condition on discounted utilities. Let $u(x, t)$ be the utility of x in t periods. The DM is present biased if

$$u(x, 0) > u(x, 0^+) \tag{1}$$

where $u(x, 0^+)$ stands for $\lim_{\mu \rightarrow 0^+} u(x, \mu)$. The DM is future biased if the inequality is reversed, and present neutral if the condition is an equality.

All discounting models which do not give extra weight to the immediate outcome are present neutral. To illustrate, the exponential discount function (Samuelson, 1937) $d(t) = (1 + \rho)^{-t}$ with $\rho \in (0, 1)$ a subjective discount rate defined over a unit period of time, is present neutral:

$$u(x, 0) - u(x, 0^+) = u(x) \left(1 - \lim_{\mu \rightarrow 0^+} (1 + \mu\rho)^{-1} \right) = 0$$

While the result is well known in the literature, the interpretation is novel. Exponential discounting is present neutral because it is continuous in the neighborhood of the present. The same analysis applies to the generalized model of

hyperbolic discounting of Loewenstein and Prelec (1992), which nests as special cases the models of Harvey (1986) and Mazur (1987).² Although those models satisfy the property of decreasing impatience, they are present neutral since the discounting functions are smooth around the present. Discount functions in Bleichrodt, Rohde and Wakker (2009) and Ebert and Prelec (2007) are also present neutral for the same reason.

There are several manners to model the discontinuity between the present and the future in Condition (1). It can take an additive form:

$$u(x, 0^+) = u(x, 0) - \tau(x)$$

with $0 < \tau(x) < u(x, 0)$, $\forall x \in X$, or a multiplicative form:

$$u(x, 0^+) = \beta(x)u(x, 0)$$

with $0 < \beta(x) < 1$, $\forall x \in X$. The higher $\tau(x)$ or the lower $\beta(x)$, the stronger the bias toward present utility. If discounted utility is time-separable: $u(x, t) = d(t)u(x)$, and given the normalization $d(0^+) = 1$, the weight $d(0)$ on present utility can be interpreted as a present bias parameter. It is with the additive form:

$$d(0) = \frac{u(x)}{\tau(x)}$$

and the multiplicative form:

$$d(0) = \frac{1}{\beta}$$

A weight above 1 reflects a bias toward the present, below 1 toward the future and equal to 1 present neutrality.

The additive formulation is a key ingredient in Benhabib, Bisin, and Schotter (2010) whose discounting model is $u(x, 0) = u(x)$ and $u(x, t) = \exp\{-rt\}u(x) -$

²The discounting function of Loewenstein and Prelec (1992) is $d(t) = (1 + ht)^{-r/h}$ with $h \geq 0$ and $r > 0$. The model nests two special cases: proportional discounting (Mazur, 1987) with $h = r$ and power discounting (Harvey, 1986) with $h = 1$.

$\tau, t > 0$. A bias toward the present is generated by a fixed utility cost $\tau > 0$ interpreted as the “psychological restraint from the impulse of choosing the immediate reward”. The model has a jump discontinuity at date 0:

$$u(x, 0) - u(x, 0^+) = u(x) - \lim_{\mu \rightarrow 0^+} \exp\{-r\mu\}u(x) + \tau = \tau > 0$$

which makes it present biased according to Condition (1).

The multiplicative formulation is exemplified by the $(\beta - \delta)$ model of Laibson (1997), which is also present biased according to Condition (1):

$$u(x, 0) - u(x, 0^+) = u(x) \left(1/\beta - \lim_{\mu \rightarrow 0^+} (1 + \mu\rho)^{-1} \right) = (1/\beta - 1)u(x) > 0$$

with $1/\beta - 1$ a measure of the bias. The $(\beta - \delta)$ model is a workhorse framework for studying and testing various behavioral properties associated with present bias like decreasing impatience, preference reversal, or short-term impatience (see Section 2.1 for definitions).

3.3 Axiomatic inclusion

Axiom 1 of present bias and Axiom 2 of future bias can mix with consistent sets of axioms, changing present neutral preferences into present biased or future biased preferences. The analysis focuses on present bias, but a symmetric reasoning would apply to the case of future bias. Any axiom-based preference relations become present biased once Axiom 1 is added to the set of axioms:

Proposition 1 *Let us consider a preference relation (\succ_A, \sim_A) over $X \times \{0, 1, \dots, \bar{t}\}$, complete, transitive and present neutral satisfying a set A of axioms.*

1. *There exists a preference relation (\succ_B, \sim_B) , complete and transitive, over $X \times \{0, 0^+, 1, \dots, \bar{t}\}$ satisfying all axioms in A over $X \times \{0^+, 1, \dots, \bar{t}\}$ and Axiom 1 over $X \times \{0, 0^+\}$.*

2. $(x, t) \sim_A (y, s) \forall x, y \in X \text{ and } t, s > 0 \Rightarrow (x, t) \sim_B (y, s)$
3. $(x, 0) \sim_A (y, s) \forall x, y \in X \text{ and } s > 0 \Rightarrow (x, 0) \succ_B (y, s)$

Proof 1. Since (\succ_A, \sim_A) is complete and transitive over $X \times \{0, 1, \dots, \bar{t}\}$, so it is over the modified time set $\{0^+, 1, \dots, \bar{t}\}$, where immediate outcomes are replaced by asymptotically immediate outcomes. Present neutrality preserves all orderings of outcomes: $(x, 0) \sim (y, s) \iff (x, 0^+) \sim (y, s)$. The relation (\succ_B, \sim_B) is complete over $X \times \{0, 0^+, 1, \dots, \bar{t}\}$ as (\succ_A, \sim_A) is complete over $X \times \{0^+, 1, \dots, \bar{t}\}$ and Axiom 1 implies $(x, 0) \succ_B (x, 0^+)$ and therefore $(x, 0) \succ_B (x, s) \forall s > 0$. It is transitive over $X \times \{0, 0^+, 1, \dots, \bar{t}\}$ since (\succ_A, \sim_A) is transitive over $X \times \{0^+, 1, \dots, \bar{t}\}$ and $(x, 0) \succ_B (x, 0^+)$ plus $(x, 0^+) \succ_B (x, s), \forall s > 0$, implies $(x, 0) \succ_B (x, s)$.

2. Straightforward since (\succ_B, \sim_B) satisfies all axioms in A over $\{0^+, 1, \dots, \bar{t}\}$.

3. $(x, 0) \sim_A (y, s)$ over $X \times \{0, 1, \dots, \bar{t}\}$ implies $(x, 0^+) \sim_A (y, s)$ over $X \times \{0^+, 1, \dots, \bar{t}\}$ due to present neutrality. Since (\succ_B, \sim_B) ranks dated outcomes over $X \times \{0^+, 1, \dots, \bar{t}\}$ the same way than (\succ_A, \sim_A) , this implies $(x, 0^+) \sim_B (y, s)$ over the same domain. Axiom 1 implies in turn $(x, 0) \succ_B (y, s)$. \square

The relation (\succ_B, \sim_B) replicates the ordering of (\succ_A, \sim_A) except when one of the two compared outcomes is obtained immediately. Since a present neutral DM identically values an immediate outcome and an asymptotically immediate one, the axioms in A equivalently apply on a modified time set where “now” is replaced by “next moment”. Present outcomes are then ordered relative to other dated outcomes thanks to Axiom 1.

Proposition 1 implies that any axiom-based preference relations can display present bias once Axiom 1 is included. Furthermore, if all future outcomes are

identically valued under the relations (\succ_A, \sim_A) and (\succ_B, \sim_B) , then a present outcome is more valued with Axiom 1 than without:

Proposition 2 *Let us assume that the complete, transitive and present neutral preference relation (\succ_A, \sim_A) over $X \times \{0, 1, \dots, \bar{t}\}$ is represented by a continuous real-valued function $u(x, t)$ such that $(x, t) \succ_A (y, s) \Leftrightarrow u(x, t) > u(y, s)$. There exists a continuous real-valued function $v(x, t)$ on $X \times \{0, 0^+, 1, \dots, \bar{t}\}$ representing the relation (\succ_B, \sim_B) and characterized by:*

1. $v(x, t) = u(x, t), \forall x \in X \text{ and } t \in \{0^+, 1, \dots, \bar{t}\},$
2. $v(x, 0) > u(x, 0) \forall x \in X.$

Proof 1. Straightforward, since the preference relation (\succ_B, \sim_B) ranks dated outcomes over $T - \{0\} + \{0^+\}$ the same way than (\succ_A, \sim_A) .

2. $u(x, 0^+) = v(x, 0^+) \forall x \in X$ (claim 1). Since $u(x, 0^+) = u(x, 0)$ due to present neutrality and $v(x, 0^+) < v(x, 0)$ due to present bias, claim 2. obtains. \square

Present bias has the flexibility of accommodating axiom-based discount functions. It makes possible a simple and transparent axiomatization of present biased preferences. As an illustration, let us start from the set of axioms posed in Fishburn and Rubinstein (1982) which utility representation is consistent with exponential discounting. They demonstrate that a real scalar δ exists such that $u(x, t) = \delta^t u(x)$. Proposition 2 can be applied on top of this result. The time set is expanded by the inclusion of the date 0^+ . The axioms of Fishburn and Rubinstein and the resulting present neutral functional form u hold for the modified time set $\{0^+, 1, 2, \dots, \bar{t}\}$. The addition of Axiom 1 in the set of axioms changes the utility representation from the present neutral u to the present biased v : $v(x, t) = u(x, t) = \delta^t u(x) \forall t \in \{0^+, 1, 2, \dots, \bar{t}\}$ and $v(x, 0) > v(x, 0^+) = u(x)$.

3.4 Implications

A separate axiomatization of present bias allows a sharp distinction between several behavioral properties often interpreted as a unique phenomenon in the literature: present bias, decreasing impatience and choice reversal.

We saw that any consistent set of axioms defining a weak order are compatible with Axiom 1, once defined over the expanded time set $\{0, 0^+, 1, 2, \dots, \bar{t}\}$ (Proposition 1). Those preferences may be characterized either by decreasing, constant or increasing impatience, regardless of the presence of present or future bias over the time set $\{0, 0^+\}$. Experimental studies which test whether subjects are increasingly or decreasingly impatient (e.g. Attema et al. 2016) do not test present bias according to Definition 4.

Likewise, present bias does not necessarily imply choice reversal toward the immediate outcome, even if preferences are stationary (Halevy, 2015). Following Definition 3 of choice reversal, suppose the outcomes (x, t) and (y, s) , $t < s$, are equivalent from date 0 perspective, or $u(x, t) = u(y, s)$. t periods later, when the early outcome is now available, the DM choice is tilted toward the immediate option if $u(x, 0) - u(y, s - t) > 0$ or if:

$$\left(u(x, 0) - u(x, 0^+)\right) + \left(u(x, 0^+) - u(y, s - t)\right) > 0$$

The choice is reversed if the DM preferences satisfy both present bias (the first difference is positive) and decreasing impatience (the second difference is positive). Yet, if time preferences are characterized by increasing impatience (the second difference is negative), present bias could well be associated with preference reversal toward the late outcome. A corollary is that the definition of present bias is insensitive to the delicate issue of whether individuals choose naively (they do not foresee their self control problems) or in a more sophisticated way (they foresee them, at least partially).

4 Measuring present bias

Propositions 1 and 2 imply that present bias can be studied regardless of DM's preferences beyond the near present. An experimental protocol designed to test the bias does not need the backing of a full-fledged theory of intertemporal preferences. Definitions 4, 5 and 6 only require to focus on whether respondents prefer consuming now or after a brief delay.

The definition makes important that the immediate reward is really immediate, and not in a few hours or at the end of the day. Evidence suggests an extremely quick fall in value with delay, on the order of minutes (Ericson and Laibson, 2018). McClure et al. (2007) use neuroimaging of the brain and show that limbic reward-related areas is sensitive to present primary rewards (fruit juice or water) but only for delays up to ten minutes. Several experimental studies fail to evidence present bias for monetary options (Andreoni and Sprenger, 2012; Augenblick et al., 2015; Andersen et al., 2014). In those studies however, the sooner payment has a non trivial delay. Balakrishnan et al. (2016) make the soonest available payment truly immediate and find a substantial degree of present bias over money. Imai, Rutter and Camerer (2019) show, based on a meta-analysis of present-bias estimations, that experimental studies that delivered the “immediate” rewards by the end of the experiment, as opposed to only by the end of the day, tended to find greater levels of present bias.

We would like not only to test the presence, but also to measure the strength of the bias at the individual level. A simple measure consists in estimating the discount rate over a very short period of time. A popular elicitation method is the multiple price list (MPL) design (Andersen et al., 2008). Subjects are given a series of decisions which consist in choosing between a unit quantity now or a compounded quantity $(1 + r)$ later with varying r . By gradually increasing the interest rate r , the design detects the interest rate for which the subject switches

from preferring the smaller sooner reward to the larger, later reward. The method has been used for primary rewards by Reuben, Sapienza and Zingales (2010) to estimate short-run discount rates over one week.

Applied to the present bias definition, the MPL design elicits the instantaneous rate r over a brief delay μ : $u(1, 0) = u(1 + r, \mu)$. Under time-separability and with the normalization, $u(1) = 1$, the condition becomes $d(0) = d(\mu)u(1+r)$. The discount $d(0)$ on immediate utility is the present bias parameter. If the delay μ is short enough, the second period utility is not discounted: $d(\mu) = 1$. A first-order approximation yields $d(0) \simeq 1 + ru'(1)$. The present bias parameter is approximately equal to the subjective rate $1 + r$ if marginal utility is constant. The return rate r overestimates the present bias parameter $d(0)$ if marginal utility is decreasing ($u'(1) < 1$).³

The linearity assumption is particularly hard to justify for primary goods and brief delays. First, individuals differ by their taste for the good. Consuming a little bit more of them could be more valued by subjects who like them. A taste for the good could be confounded with present bias. Second, subject's marginal utility depends on previous consumption and satiation. Hungry or thirsty subjects may value immediate consumption more than satiated subjects because their marginal utility of the good is higher, not because they are more present biased. Consistent with those pitfalls, Reuben, Sapienza and Zingales (2010) show that their discount rate estimations are less reliable for subjects who do not like much chocolate or are not hungry.

I propose two estimation methods of present bias which disentangle pure attitude toward immediate outcomes from marginal utility. Both are based on simple intertemporal trade-offs with convex time budgets (Andreoni and Sprenger, 2012) and offer the advantage of not relying on particular assumptions about the utility function. The first design elicits short-run discount rates for money or

³ Some overestimation is found e.g. by Andersen et al. (2008) for longer horizons.

primary goods for delays longer or equal to one day. The second one is dedicated to the measurement of present bias over extremely short periods of time, like a few minutes or a few hours.

4.1 Eliciting daily short-run discount rate

The first elicitation method is based on a simple optimization problem with an intertemporal resource constraint. The model is akin to the popular convex time budget protocol (Imai, Rutter and Camerer, 2019) but adapted to the definition (4) of present bias. In a convex time budget experiment, subjects are asked to choose a basket of consumption (x_t, x_{t+k}) delivered at two points in time $(t, t+k)$, under an intertemporal budget constraint with a k -period gross interest rate of $1 + r$. Allocations over varying horizons k span a large set of periods so as to estimate a complete temporal sequence of discount rates and utilities. Here, subjects solve a two-period consumption saving problem with w the initial endowment, x the first period consumption and y the second period consumption:

$$\begin{cases} \max_{x,y} u(x, 0) + u(y, \mu) \\ (1 + r)(w - x) = y \end{cases}$$

with μ a 'brief' time interval. A present biased DM tends to concentrate consumption in the present, the same way as an impatient DM would do for longer time intervals. $r(x)$ is defined as the interest rate for which the DM equalizes consumption across the two periods:

$$r(x) = \frac{u'_1(x, 0)}{u'_1(x, \mu)} - 1 \quad (2)$$

The more present biased the DM, the higher the delay premium necessary to equalize consumptions. If discounted utility is time-separable, $u(x, t) = d(t)u(x)$, and if the delay μ is brief enough so that $d(\mu) = 1$, the index simplifies to:

$$r = d(0) - 1 \quad (3)$$

The rate r is an intuitive index of present or future bias. A negative r denotes future bias, a zero r present neutrality. The higher r , the more present biased the DM. Under the mild assumption of time-separability, the index has the nice property of being independent of the utility function. This is contrary to most empirical tests which either do not distinguish time preference from concavity of utility or rely on the accuracy of a structural estimation of the utility function to estimate the discount function (e.g. Andreoni and Sprenger, 2012 or Andersen et al., 2014).⁴

The measure is axiomatically founded, related in a meaningful way to the discounted utility representation, and intuitively connected to usual models of intertemporal choice. Framed into the $(\beta - \delta)$ model, the present bias index in Eq. 2 when μ is converging to zero is:

$$r = \frac{1}{\beta} - 1$$

where $1/\beta$ is the present bias coefficient.

In practice, the delay μ cannot be too close to zero for several reasons. In case of monetary rewards, the delay between the early option and the late one must be minimal so that the subjects are given enough time to spend their money if they wish. If the delay is too short, receiving money early is of little use compared to receiving it a few hours later if it cannot be spent in the meantime. In case of primary rewards, like squirts of fruit juice (McClure et al., 2007) or chocolate (Reuben, Sapienza and Zingales, 2010), marginal utility of consumption depends on how much has been consumed in the few hours preceding the trial. Eating chocolate or drinking beverage cause satiation with the effect of reducing marginal utility of the late reward.⁵ Furthermore, the propensity to

⁴Attema et al. (2016) propose a method of measurement of the discount function without the need of a utility function. Their method based on choices over temporal sequences of consumption cannot be applied here.

⁵ If the dates are too close, the intertemporal utility function takes the form $u(x, 0) +$

consume may systematically vary over the day. Marginal utility at 8:00 am may be different from marginal utility at 12:00 am or 6:00 pm.

For all those reasons, the minimal delay which minimizes the risk of confounding present bias and marginal utility fluctuations is 24 hours. This gives enough opportunities to subjects to spend the money obtained in the first round of the trade-off. In case of primary rewards, marginal utilities separated by a full day are relatively independent of each other and intra-day variations of marginal utility are less an issue.

Conversely, longer delays entail the risk of confounding present bias and impatience. The scope of the problem can be analyzed in the $(\beta - \delta)$ model with

$$d(t) = \beta_i \delta_i^t = \beta_i \left(\frac{1}{1 + \rho_i} \right)^t \quad t = 1, 2, \dots$$

and ρ the subjective discount rate for a unit period of time. Assuming that the discount rates are not compounded for delays shorter than a unit period, the present bias index (3) over a short period μ expresses as:

$$r = \frac{1 + \mu\rho}{\beta} - 1 \tag{4}$$

For non trivial delays μ , the index not only measures present bias (the coefficient $1/\beta$) but possibly also impatience (the discount rate ρ). To get a quantitative flavor of the bias, let us assume a present bias coefficient equal to $\beta \simeq 1/3$ (Laibson et al., 2015). The present bias index in (4) is

$$r = 3(1 + \mu\rho) - 1$$

which is different from the true index equal to 2, with $\mu = 0$. At a monthly frequency, a delay of 24 hours implies $\mu = 1/30$, of 48 hours $\mu = 1/15$ and of a full week $\mu = 0.233$. Table 1 indicates the size of the discrepancy for various degrees of impatience.

$u(y, \mu; x)$ with marginal utility $u'(y, \mu; x)$ decreasing with previous consumption x . Under mild assumptions, the optimal consumption plan is decreasing with time, even if the DM is present neutral.

Table 1: Long-run discount rates and estimation bias for various delays

ρ (annual)	ρ (monthly)	r (one day)	r (two days)	r (one week)
0.01	0.00083	2.00008	2.00017	2.00058
0.05	0.00407	2.00041	2.00081	2.00284
0.10	0.00797	2.00080	2.00159	2.00557
0.20	0.01531	2.00153	2.00306	2.01070
0.30	0.02210	2.00221	2.00442	2.01545
0.40	0.02844	2.00284	2.00569	2.01988
0.50	0.03437	2.00344	2.00687	2.02402

For annual subjective rates ranging from 1% to 50%, the equivalent monthly rate varies from 0.83% to 3.44%. The estimation bias with regard to the length of the delay is the estimated subjective rate r indicated in the three last columns minus the true one which is equal to 2 in the calibration. Although impatience tends to bias the present bias index upwards, the error remains within an acceptable interval whatever the subject’s degree of impatience for delays of one or two days. For longer delays like a week, the error term is more significant. Overall, a delay of one day between the two consumptions seems therefore a good compromise between the risks of a too short and a too long delay.

4.2 Eliciting intra-daily discounting rates

It has been argued that the previous design cannot elicit discount rates for delays shorter than a full day. Measuring present bias over extremely short horizons like minutes or hours could be interesting, especially when the choices involve primary rewards, gratifications or addictive substances. We need a design which

controls for dispersion of marginal utility and avoids consumption dates too close in time. The set of decisions now includes choices between (i) now and a long delay and (ii) a brief delay and a long delay. The first trade-off allocates the resource w between immediate consumption x and consumption y postponed to a remote date T (for example several months later):

$$\begin{cases} \max_{x,y} d(0)u(x) + d(T)u(y) \\ (1 + r_0)(w - x) = y \end{cases}$$

with $d(T)$ the long-run discount rate. As previously, r_0 is defined as the interest rate for which the DM equalizes consumption across the two periods:

$$r_0 = \frac{d(0)}{d(T)} - 1$$

The second trade-off allocates the good between a briefly delayed consumption and date T consumption:

$$\begin{cases} \max_{x,y} d(\mu)u(x) + d(T)u(y) \\ (1 + r_1)(w - x) = y \end{cases}$$

Since the early consumption is slightly delayed, the utility flow is not discounted: $d(\mu) = 1$. It is not subject to a present bias as it is close to but distinct from the present. It is not sufficiently postponed in the future to be discounted at a non-negligible rate by an impatient DM. The utility function may vary across subjects but is assumed to be the same in the three dates: the present, the briefly delayed date and the remote date. This is plausible if the short delay is brief enough and the good in the long delay is delivered the same day in the week and at the same hour than the good delivered in the present. The rate of return r_1 also equalizes consumption at both dates:

$$r_1 = \frac{1}{d(T)} - 1$$

The present bias parameter is retrieved by taking the ratio of the rates of return:

$$d(0) = \frac{1 + r_0}{1 + r_1}$$

The method estimates the discount rate between two successive consumption dates separated by a short delay, while maintaining the independence of marginal utilities at the two dates. As in the first elicitation method, the present bias estimation does not rest on assumptions about utility aside from time-separability. It necessitates the mediation of a long-run discounted utility but does not make any assumptions on the shape of the long-run discount function $d(T)$ neither. Compared to the first method, two rates instead of one have to be estimated by a convex time budget method.

Disentangling pure attitude toward the present from marginal utility is of prime importance for trade-offs involving short delays and primary goods like food or beverage. Hunger, thirst or a special taste for the good proposed in the trial are not stable preference parameters but transient factors which varies across goods and fluctuates over time. They should be distinguished conceptually and in experiments from present bias.

5 Conclusion

How concepts are defined influences the way researchers frame their reasonings and build new knowledge. Sound and operational definitions facilitate scientific progress and open new directions for research. This article has argued that a focused definition of present bias is missing in the literature. The concept is either confounded with its behavioral implications or identified to functional forms, principally the $(\beta - \delta)$ model of Laibson (1997).

The definition of present bias, a strict preference for immediate outcomes

over outcomes postponed in the arbitrarily near future, has affinities with, yet is distinct from behaviors previously associated with the concept. An individual may be present biased and not decreasingly impatient with regards to future trade-offs. In addition, she may not necessarily reverse her choice toward the immediate outcome, even if her preferences are stationary. The definition takes a simple axiomatic form and discriminates between models commonly associated with present bias. The $(\beta-\delta)$ model of Laibson (1997) and the fixed cost model of Benhabib, Bisin, and Schotter (2010) satisfy the definition, while the generalized model of hyperbolic discounting of Loewenstein and Prelec (1992) or the discount functions of Bleichrodt, Rohde and Wakker (2009) and Ebert and Prelec (2007) do not.

The paper proposes an intuitive axiomatic framework in which the elicitation of present bias is agnostic about preferences over delayed trade-offs, and as a result not tied to a specific functional form. The definition suggests new ways of measuring present bias. Two experimental designs are proposed, which allow measurement at the individual level of present or future bias in a symmetric way, do not require any knowledge or previous measurement of utility, are easy to implement, may provide information about the distribution of the bias among subjects for varying delays or types of goods.

References

Ainslie G. (1992) *Picoeconomics: The Strategic Interaction of Successive Motivational States within the Person*. New York: Cambridge University Press.

Andersen S., Harrison G. W., Lau M. I. , and E. E. Rutstr m (2008) “Eliciting Risk and Time Preferences” *Econometrica*, 76 (3), 583-618.

Andersen S., Harrison G. W., Lau M. I., and E. E. Rutstrom (2014) “Discounting Behavior: A Reconsideration” *European Economic Review*, 71, 15-33

Andreoni J. and C. Sprenger (2012) “Estimating Time Preferences from Convex Budgets” *American Economic Review*, 102 (7), 3333-56.

Attema A. E., Bleichrodt H., Gao Y., Huang Z., and P. P. Wakker (2016) “Measuring Discounting without Measuring Utility” *American Economic Review* 106 (6) 1476-1494.

Attema A. E., Bleichrodt H., Rohde K. I. M. and P. P. Wakker (2010) “Time-tradeoff sequences for analyzing discounting and time inconsistency” *Management Science*, 56, 2015-2030.

Augenblick N., Niederle M., and C. Sprenger (2015) “Working Over Time: Dynamic Inconsistency in Real Effort Tasks” *Quarterly Journal of Economics*, 130 (3), 1067-1115.

Balakrishnan U., Haushofer J. and P. Jakiela (2016) “How Soon Is Now? Evidence of Present Bias from Convex Time Budget Experiments”, IZA Discussion Paper No. 9653.

Benhabib J., A. Bisin, and A. Schotter (2010) “Present-Bias, Quasi-Hyperbolic Discounting, and Fixed Costs” *Games and Economic Behavior*, 69 (2), 205-223.

Benzion U., A. Rapoport and J. Yagil (1989) “Discount Rates Inferred From Decisions: An Experimental Study” *Management Science* 35, pp. 270-84.

Bernheim B. D. and A. Rangel (2004) “Addiction and cue-triggered decision processes” *American Economic Review*, 94(5), 1558-1590.

Bisin A. and K. Hyndman (2014) “Present-Bias, Procrastination and Deadlines in a Field Experiment” NBER Working Paper No. 19874.

Bleichrodt H., Y. Gao, and K. I. M. Rohde (2016) “A measurement of decreasing impatience for health and money” *Journal of Risk and Uncertainty* 52 (3), 213-231.

Bleichrodt H., K. I. M. Rohde and P. P. Wakker (2009) “Non-hyperbolic time inconsistency” *Games and Economic Behavior* 66, 27-38.

Bryan G., Karlan D. and S. Nelson (2010) “Commitment Devices”, *Annual Review of Economics* 2, 671-698.

Chakraborty A. (2017) “Present Bias”, working paper.

Cohen J., Ericson K. M., Laibson D. and J. M. White (2016) “Measuring Time Preferences” NBER Working Paper No. 22455.

Diamond P. and B. Koszegi (2003) “Quasi-hyperbolic discounting and retirement” *Journal of Public Economics* 87, 1839-1872.

DellaVigna S. and M. D. Paserman (2005) “Job Search and Impatience” *Journal of Labor Economics* 23 (3), 527-88.

Dohmen T., Falk A., Huffman D. and U. Sunde (2012) “Interpreting Time Horizon Effects in Inter-Temporal Choice”, IZA working paper 6385.

Ebert J. E. J. and D. Prelec (2007) “The fragility of time: time-insensitivity and valuation of the near and far future” *Management Science*, 53, 1423-1438.

Ericson K. M. and D. Laibson (2018) “Intertemporal Choice”, NBER Working Paper No. 25358.

Fishburn P. C. and A. Rubinstein (1982) “Time preference” *International*

Economic Review 23 (3) 677-694.

Green L., J. Myerson and E. Mcfadden (1997) “Rate of Temporal Discounting Decreases with Amount of Reward” *Memory and Cognition* 25 (5), 715-23.

Harvey C. M. (1986) “Value functions for infinite period planning” *Management Science* 32, 1123-39.

Halevy Y. (2008) “Strotz Meets Allais: Diminishing Impatience and the Certainty Effect ” *American Economic Review*, 98 (3), 1145-1162.

Halevy Y. (2015) “Time Consistency: Stationarity and Time Invariance” *Econometrica*, 83 (1), 335-352.

Hayashi T. (2003) “Quasi-stationary cardinal utility and present bias” *Journal of Economic Theory*, 112 (2), 343-352.

Imai T., Rutter T. A. and C. F. Camerer (2019) “Meta-Analysis of Present-Bias Estimation using Convex Time Budgets”, working paper.

Kable J. W. and P. W. Glimcher (2007) “The Neural Correlates of Subjective Value during Intertemporal Choice” *Nature Neuroscience* 10 (12), 1625-33.

Kirby K. N. (1997) “Bidding on the Future: Evidence against Normative Discounting of Delayed Rewards” *Journal of Experimental Psychology: General* 126 (1), 54-70.

Kirby, K. N., Petry N. M., and W. K. Bickel (1999) “Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls” *Journal of Experimental Psychology: General*, 128, 78-87.

Laibson D. (1997) “Golden Eggs and Hyperbolic Discounting” *Quarterly Journal of Economics*, 112 (2), 443-478.

Laibson D., Maxted P., Repetto A., and J. Tobacman (2015) “Estimating Discount Functions with Consumption Choices over the Lifecycle”, working pa-

per.

Loewenstein G. (1987) “Anticipation and the Valuation of Delayed Consumption” *The Economic Journal*, 97 (387) 666-684.

Loewenstein G. and D. Prelec (1991) “Negative time preference” *American Economic Review*, 81 (2), 347-52.

Loewenstein, G. and D. Prelec (1992) “Anomalies in Intertemporal Choice: Evidence and an Interpretation” *Quarterly Journal of Economics* 107, 573-597.

Manzini P. and M. Mariotti (2009) “Choice over time”, in P. Anand, P. Pattanaik and C. Puppe (eds.) *Oxford Handbook of Rational and Social Choice*.

Mazur J. E. (1987) “An Adjustment Procedure for Studying Delayed Reinforcement” in *The Effect of Delay and Intervening Events on Reinforcement Value*. Michael L. Commons, James E. Mazur, John A. Nevin and Howard Rachlin, eds. Hillsdale, NJ: Erlbaum.

McClure S. M., Ericson K. M., Laibson D. I., Loewenstein G. and J. D. Cohen (2007) “Time Discounting for Primary Rewards” *The Journal of Neuroscience* 27 (21), 5796-5804.

Meier S. and C. Sprenger (2010) “Present-Biased Preferences and Credit Card Borrowing” *American Economic Journal: Applied Economics*, 2 (1), 193-210.

Montiel Olea J. L. and T. Strzalecki (2014) “Axiomatization and Measurement of Quasi-Hyperbolic Discounting”, *Quarterly Journal of Economics*, 129 (3), 1449-1499.

O’Donoghue T. and M. Rabin (1999) “Doing It Now or Later” *American Economic Review: Papers & Proceedings*, 89 (1), 103-24.

O’Donoghue T. and M. Rabin (2015) “Present Bias: Lessons Learned and To Be Learned” *American Economic Review: Papers & Proceedings*, 105 (5), 273-279.

Rabin M. (2002) “A perspective on psychology and economics” *European Economic Review*, 46 (4-5), 657-685.

Read D. and B. van Leeuwen (1998) “Predicting Hunger: The Effects of Appetite and Delay on Choice” *Organizational Behavior and Human Decision Processes* 76 (2), 189-205. “Time Discounting for Primary and Monetary Rewards” *Economics Letters* 106 (2), 125-27.

Reuben E., Sapienza P. and L. Zingales (2010) “Time Discounting for Primary and Monetary Rewards” *Economics Letters* 106 (2), 125-27.

Samuelson P. (1937) “A Note on Measurement of Utility” *Review of Economic Studies* 4, pp. 155-61.

Sayman S. and A. Öncüler (2009) “An investigation of time-inconsistency” *Management Science* 55, 470-482.

Schweighofer-Kodritsch S. (2018) “Time Preferences and Bargaining” *Econometrica* 86 (1), 173-217.

Shapiro J. M. (2005) “Is there a daily discount rate? Evidence from the food stamp nutrition cycle” *Journal of Public Economics*, 89 (2), 303-325.

Spiegler R. (2019) “Behavioral Economics and the Atheoretical Style”, *American Economic Journal: Microeconomics*, 11 (2), 173-94.

Stigler G. and G. Becker (1977) “De Gustibus Non Est Disputandum” *American Economic Review* 67, 76-90.

Takeuchi K. (2011) “Non-parametric test of time consistency: Present bias and future bias” *Games and Economic Behavior* 71, 456-478.

Thaler R. H. (1981) “Some Empirical Evidence on Dynamic Inconsistency” *Economic Letters* 8, 201-07.

Volpp K. G. and G. Loewenstein (2015) “Behavioral Economics and Incen-

tives to Promote Health Behavior Change” in Health Behavior: Theory, Research, and Practice, K. Glanz, B. K. Rimer and K. Viswanath (Editors), 5th Edition.

Shu S. B. and A. Gneezy (2010) “Procrastination of Enjoyable Experiences” *Journal of Marketing Research*, 47 (5), 933-944.