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Be patient when measuring hyperbolic discounting: Stationarity, time consistency and time invariance in a field experiment☆

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ABSTRACT

Hyperbolic discounting is one potential reason why savings remain low among the poor. Most evidence of hyperbolic discounting is based on violations of either stationarity or time consistency. Stationarity is violated when intertemporal choices differ for trade-offs in the near versus the more distant future. Time consistency is violated if the optimal allocation for specific dates changes over time. Both types of choice reversals may however also result from time-varying discount rates. Hyperbolic discounting is an unambiguous explanation for choice reversals only if the same individuals violate both stationarity and time consistency. Our field experiment in Nigeria examines the extent to which this is the case. The experiment measured both stationarity and time consistency for the same participants. Violations of the two rarely coincide, especially among more liquidity-constrained participants. Thus, in a context of liquidity constraints, eliciting only one type of choice reversal is insufficient to identify hyperbolic discounting.

1. Introduction

For the poor, consumption smoothing is hindered by fluctuating cash flows and limited access to formal credit and insurance (Collins et al., 2009). This is compounded by a constrained ability to save (Dupas and Robinson, 2013). One potential reason for low savings is hyperbolic discounting, meaning that implicit discount rates are lower for tradeoffs in the more distant future than for tradeoffs in the near future (Frederick et al., 2002). A hyperbolic discounter violates *time consistency*, i.e. she prefers to invest towards increased future consumption when asked far in advance, but when asked right before investing the money, she opts for sooner but lower consumption. She also violates *stationarity*, meaning that she prefers for example $110 in 31 days over $100 in 30 days, but rather has $100 today instead of $110 tomorrow (Green et al., 1994; Kirby and Herrnstein, 1995). Empirical observations of either violation have been interpreted as evidence of hyperbolic discounting.

However, hyperbolic discounting is an unambiguous explanation for such choice reversals only if the same person violates both stationarity and time consistency. A second yet often neglected explanation for choice reversals is a violation of *time invariance* (Halevy, 2015), which means that the marginal rate of substitution (MRS) changes over time.[1] For example, one month ago someone preferred $110 a day later over $100 the same day, but when asked again today she prefers $100 immediately over $110 tomorrow. This difference may among others be due to changes in the economic environment (Read et al., 2012), either through unanticipated shocks to household finances (Dean and Sautmann, 2016) or through anticipated changes in income (Epper, 2016). Crucially, when stationarity or time consistency are measured in isolation, one may wrongly interpret choice reversals caused by time-varying background wealth as evidence of hyperbolic discounting.

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[1] Thus, violations of stationarity and time consistency do not necessarily imply any form or irrationality. Violations of stationarity may also result from distrust in experimenters sending future payments and from uncertainty around future preferences and states. Experiments use small front-end delays to minimize the influence of these confounding factors (Harrison et al., 2005). Further, note that violations of stationarity and time consistency do not necessarily imply any form of irrationality.

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This paper therefore analyzes to what extent stationarity and time consistency overlap by means of a field experiment in rural Nigeria. The experiment elicited three convex time budget allocations (Andreoni and Sprenger, 2012a) using a longitudinal design adapted from Giné et al. (2016). Participants distributed a future gift over a sooner-smaller and a later-larger reward. Sooner and later rewards arrived 'tomorrow' and 'in one month' for the first allocation, 'in two months' and 'in three months' for the second allocation made on the same day, and 'tomorrow' and 'in one month' for the third allocation. The third allocation was made two months after the others and hence concerned the same calendar dates as the second allocation, but the time until the two payment dates was the same as in the first allocation.

The experiment elicited each of these three allocations for 240 participants. Rejecting stationarity requires different choices in the first and second allocation, elicited on the same day with varying front-end delays. Time consistency is rejected by differences in the second and third allocation, elicited at different points in time regarding the same calendar dates. Finally, time invariance is violated when a participant chooses differently in the first and third allocation, elicited on different days but both framed as an allocation over 'tomorrow' and 'in one month' (Halevy, 2015). If time invariance is satisfied, a hyperbolic discounter will violate both stationarity and time consistency. Observing either choice reversal is sufficient to infer hyperbolic discounting *only* in that case. If time invariance is not satisfied, observing a violation of either choice reversal is *not* sufficient to identify hyperbolic discounters. This paper sheds light on the severity of the potential misclassification.

We find that violations of time consistency and stationarity often do not overlap. While 43.4 percent of participants violates time consistency, only 24.2 percent violates *both* time consistency and stationarity, and 62 percent of violations result from time-variant choices instead. Moreover, for nearly half of this subsample, the two choice reversals move in different directions with one present-biased and one future-biased violation. This is not just noise in decision-making; participants who violate time consistency but not stationarity have significantly less access to informal credit and lose more wealth over time than other participants. This suggests that violations of time invariance are in part due to liquidity constraints. As a result, when observed in isolation, choice reversals are not sufficient evidence of hyperbolic discounting. Instead, identifying hyperbolic discounters requires a longitudinal design eliciting both stationarity and time consistency.

This paper makes three unique contributions to the literature. First, the experiment links choice reversals to violations of time invariance. To our best knowledge, Halevy (2015) is the only study with similar analyses, but using a different subject pool (undergraduate students in economics). Giné et al. (2016) link measures of stationarity to time consistency for a subject pool that is more comparable to ours, but do not provide measures of time invariance. Meier and Sprenger (2015) measure stationarity and time invariance, but not time inconsistency. Other experimental studies either analyze violations of stationarity (e.g. Coller and Williams, 1999; Harrison et al., 2002; Carvalho et al., 2016) or of time consistency (e.g. Sayman and Öncüler, 2009; Read et al., 2012), without linking the two.

Second, we test whether liquidity constraints can explain why stationarity and time consistency often do not overlap, i.e. why participants violate time invariance.[2] Unlike Halevy (2015), we can identify liquidity-constrained participants using rich survey data on participants' financial characteristics. We find that compared to other participants, those who are relatively most constrained are significantly more likely to violate time consistency without also violating stationarity. We identify liquidity-constrained participants as those with less access to credit and greater reductions in wealth, independent of whether the household explicitly reports a shock. This distinguishes our paper from Giné et al. (2016) and Dean and Sautmann (2016), whose empirical analyses focus mainly on *unanticipated* expenditure and income shocks, and from Carvalho et al. (2016), who link stationarity to the timing of *anticipated* income. Our measure captures both anticipated and unanticipated liquidity constraints.

Third, the finding that liquidity constraints result in violations of time invariance relates to the literature on the temporal stability of time preferences. Identifying temporal stability (or time invariance) requires a longitudinal design in which the experimental methodology and the subject pool are fixed (Frederick et al., 2002). The main incentivized field experiment with such a design, Meier and Sprenger (2015), finds that any observed temporal instability can be explained by random noise. By contrast, Krupka and Stephens (2013) use a panel with hypothetical choices collected during a period of high inflation and find that elicited discount rates are correlated to economic factors such as the inflation rate and household income, suggesting that temporal instability of expressed time preferences is not purely random. This is more consistent with our findings, supporting the theory that standard experimental measures of time preferences and stationarity capture financial constraints and changes in non-experimental wealth rather than innate discount rates (Dean and Sautmann, 2016; Epper, 2016).

These findings have potential implications for policies that promote savings in low-income settings. Savings play an important role in smoothing consumption, in particular for the poor with volatile cash flows and limited access to formal financial services (Collins et al., 2009). Hyperbolic discounting is one of the main theories used to explain low savings rates, but this theory is based on observed violations of *either* stationarity *or* time consistency. Our findings suggest that such violations are often driven by liquidity constraints. Hence, policies that aim at promoting savings among the poor should not only address hyperbolic discounting, but also consider the role of liquidity constraints when designing mechanisms to improve their ability to save.

This paper is structured as follows. The next section outlines a conceptual framework to interpret the relation between stationarity, time consistency, and time invariance. Section 3 describes the experiment. Section 4 presents our results and discusses the role of liquidity constraints. Section 5 concludes.

2. Conceptual framework

To show why violations of stationarity as measured in most (cross-sectional) time preference experiments do not necessarily overlap with time inconsistent behavior, this section first outlines the types of intertemporal allocations considered in the experiment. We then describe how one can infer violations of stationarity, time consistency and time invariance from these allocations, and discuss conditions under which one can identify hyperbolic discounting. Finally, we formulate hypotheses on how liquidity constraints resulting from changes in background wealth may lead to non-overlapping violations of stationarity and time consistency.

Consider a consumer allocating a gift of g vouchers over two future payment dates. She allocates x vouchers to a later date, denoted p_L, and the remaining $g - x$ vouchers to a sooner date, p_S. Each voucher allocated to the later date is worth v_L. Vouchers allocated to the sooner date are worth v_S and are never worth more than vouchers allocated to the later date, $v_S \leq v_L$.

Allocations are made at the start of two distinct rounds, at decision moments τ_1 and τ_2. The consumer allocates her vouchers between a sooner and later payment date in the first round, $\{p_{1S}, p_{1L}\}$, and

[2] In that respect, our subject pool is of particular interest; subject pools from university labs may have better access to sound financial instruments. In their context, allocations involving monetary rewards are potentially influenced by the interest rate at which participants can save and borrow outside the experiment (Chabris et al., 2008). Augenblick et al. (2015) overcome this problem by eliciting time preferences using effort rather than monetary rewards. In our context of thin financial markets, changes in consumption are likely to follow small changes in income very closely (Halevy, 2014), so that intertemporal allocations of monetary rewards are more closely related to the MRS.