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No need for more time: Intertemporal allocation decisions under time pressure

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No need for more time: Intertemporal allocation decisions under time pressure*

Florian Lindner[†] Julia Rose[‡]

August 18, 2016

Abstract

Time preferences drive decisions in many economic situations, such as investment contexts or salary negotiations. These situations are characterized by a very short time frame for decision making. Preferences are potentially susceptible to the confounding effects of time pressure, as proposed by dual-systems theory (Evans, 2006; Kahneman and Frederick, 2002). Results of standard methods of time preference elicitation can therefore not be directly mapped to environments characterized by severe time pressure since the underlying assumption of these models is that preferences are stable. To address the stability of time preferences under time pressure, we conduct a laboratory study with 144 subjects using convex time budgets (Andreoni and Sprenger, 2012) in order to elicit time preferences with and without time pressure in a within-subject design. We find lower present-bias under time pressure compared to the condition without time pressure on the aggregate, whereas utility function curvature and long-run discounting are stable across conditions. The findings are confirmed on the individual level. Embedding our results in dual-systems theory, how information is presented can serve as a potential means to exogenously decrease present-bias under time pressure.

JEL-Classification: C91, D12, D81, D91.

Keywords: Time preferences, time pressure, decision making, allocation decision, budget, experiment.

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1 Introduction

Very limited time to reflect on and finally make decisions characterizes many economic situations. The sooner the better - too little time for too much to do is an omnipresent phenomenon. Most common examples for time pressure in an economic environment are traders selling and buying stocks within seconds, bidders making offers in auctions, but also bargaining situations such as salary negotiations between employees and employers. A variety of factors influence decision-making in these contexts. In the standard model of Cox et al. (1982), for example, risk preferences affect bidding behavior in auctions. There is also recent evidence that outcomes in bargaining games depend on time preferences (Schweighofer-Kodritsch, 2015). What these models do not take into account is the finding that preferences are potentially susceptible to the confounding effects of time pressure. In case that preferences are indeed not stable with regard to influences of limited time for decision-making, results obtained by standard methods of, for example, risk and time preference elicitation cannot be easily mapped into an environment like auctions and bargaining situations, which are predominantly characterized by severe time pressure. The assumption that preferences might in fact be prone to such influences is rooted in the theory of dual-system models (Evans, 1989, 2006; Kahneman and Frederick, 2002). These theories distinguish between System I, entailing cognitive processes which are fast, automatic, and unconscious; and System II, attributed with slow, deliberate, and conscious reflections (Evans, 2008). With System II being relatively slow, time-pressure can disrupt its operations and judgment may consequently rely more on heuristics and simplistic assessments (Kahneman and Frederick, 2002).

In fact, there is evidence for a significant influence of time pressure on risk preferences, as for example found in Zur and Breznitz (1981) and Kocher et al. (2013). A common finding is that behavior becomes more heuristic, which fits very well into the framework of dual-system models. However, limited attention has been drawn to the influence of time pressure on time preferences. To the best of our knowledge, this paper is the first to experimentally analyze the influence of a limited time frame on intertemporal decision-making and to embed it in the framework of dual-systems theory. Since time preferences are at the core of decision-making in many real-life situations, our paper closes the existing gap in the literature with respect to a first approach to short-term situation-dependent stability of time preferences.

We therefore analyze whether aggregate and individual time preferences change when the time limit to make intertemporal allocation decisions is extremely short. Applying a within-subject design

to elicit time preferences with and without time pressure in a Convex Time Budget environment (Andreoni and Sprenger, 2012), we find subjects on the aggregate to be present-biased when deciding without a binding time limit and exhibiting time-consistent preferences under time pressure. Parameter estimates for utility function curvature and discount rates are not significantly different between conditions. On the individual level, when introducing the individual difference between estimates as a measure for stability, we find that the majority of subjects exhibits stable preferences across conditions for those who are able to reach a decision within the given time limit. In line with the theory of dual-systems models, decisions apparently become more heuristic with subjects selectively focusing their attention on task features that appear relevant (Evans, 1989, 2006). Given the fact that less present-bias is observed on the aggregate under time pressure, a focal point for decision-making seems to be the high possible payment when waiting for a certain period of time in contrast to the possibility of an immediate payment. As most real-life decisions have to be made under severe time pressure, one implication of our findings is that present-bias can be significantly reduced by the way available information is structured, such as emphasizing the benefits rather than the immediacy of payoffs.

The remainder of the paper is organized as follows. After a brief review of related literature in section 2 and the design of our study in section 3, we outline the theoretical background for the estimation strategies applied in the analysis in section 4. Section 5 presents a descriptive overview of results and parameter estimates. Section 6 concludes.

2 Related Literature

The overview of the related literature covers two main aspects. First, we give a brief review of psychological findings on dual-systems theories along with recent economic studies concerned with the dual-systems approach. Second, we focus on the related experimental literature concerned with time preferences and time pressure. Combining both aspects enables us to embed our findings in a profound psychological framework to derive important practical implications.

In the literature of dual-systems theory, a multitude of different models have evolved over the last decades. Adapting the most neutral terminology, studies distinguish between two systems, System I and System II. Even though theories differ with respect to their respective terminology and exact definitions, they agree on at least two major points (Evans, 2008): System I entails cognitive processes which are fast, automatic and unconscious, whereas processes of System II are slow, deliberate and conscious.

Two very similar recent approaches, which we will also adapt in this paper, are presented by Kahneman and Frederick (2002) and Evans (2006). Kahneman and Frederick (2002) state that System I, as soon as judgment problems arise, quickly proposes intuitive answers. System II then monitors the quality of the respective proposals. However, since System II is operating relatively slow, its operations can be disrupted by extraneous influences such as time pressure. As a consequence, judgment heuristics are likely to yield simplistic assessments and are not always corrected by System II. In the process, biases are likely to disrupt decision-making: a *weighting bias*, for example, is defined by giving an available cue either too much or too little weight. The heuristic-analytic theory of Evans (2006) follows a similar approach: Heuristic processes of System I, which are fast, automatic, and belief biased lead the decision-maker to selectively focus on task features that appear to be important. Relevant prior knowledge is additionally introduced in the process. According to their theory, biases are only observed in case either logically relevant information is excluded, or logically irrelevant information is induced by heuristic processing. System I is therefore fast and heuristic, processes are default intuitive judgments but must be endorsed by the analytic System II, which often does so casually. In other words, System I processes are the underlying, unconscious processes which can be interrupted by conscious reflections of System II. However, System II processes require a sufficient amount of time and to be able to consciously reflect on respective judgments (Dijksterhuis et al., 2006). Therefore, decisions under time pressure are very likely to be guided solely by heuristic and unconscious System I processes. A comprehensive overview of different definitions and concepts in the field of dual-systems models can be found in Evans (2008).

A related, however slightly different, approach to the outlined psychological model is followed by economic theories of dual-self models. Several studies as, for example, Fudenberg and Levine (2006) and Thaler and Shefrin (1981) present a model of impulse control and offer a unified explanation for a variety of empirical regularities. According to their theory, many decision problems can be modeled as a game between a short-run impulsive self and a long-run patient self. In contrast to the patient long-run self, the short-run self is completely myopic. Their model, supported by experimental evidence, suggests that increased cognitive load makes temptations harder to resist and gives more weight to the decisions of the short-run, impulsive self. These findings are supported by recent papers. Kocher et al. (2016) conduct an experimental asset market to analyze the relationship between self-control abilities and systematic overpricing on financial markets. By exogenously introducing variations in self-control abilities to deplete cognitive resources, they find

a strong effect of self control on market mispricing. Traders with a low level of induced self-control engage in more speculative trading. In a different area but with also strongly significant findings, Dreber et al. (2016) examine the role of self-control in the field of social preferences. Based on the model of Fudenberg and Levine (2006), they find that self-control requires some time for deliberation. Especially with regard to time pressure in an experimental environment, they find giving to increase with a decreasing time limit for decision-making as a result of lower self-control.¹

Even though psychological and economic approaches seem to be very different concepts at first glance, the major important factor of distinguishing between to separate but possibly interacting systems remains. Results of both approaches find time pressure to promote decisions guided by a heuristic, fast, and unconscious system, or myopic and impulsive self, respectively.

Both time preferences and decision-making under time pressure, have recently been separately analyzed in a growing body of literature in experimental research. Analyzing response times and explicitly constraining time frames in which answers have to be given has gained in importance over the last few years; for a comprehensive overview of studies in this field see Spiliopoulos and Ortman (2016).

A first strand of literature in the field of time pressure is concerned with decision-making under limited time in bargaining. All studies find that efficiency decreases when subjects have limited time for making decisions. Sutter et al. (2003), for example, conduct an ultimatum game and find that, when provided with only a limited time to accept proposer's offers, subjects reject in about 60% of the cases when compared to only 20% without time pressure. In a recent study, Karagözoglu and Kocher (2015) conduct an unstructured experimental bargaining game with reference points. In line with the findings of Sutter et al. (2003), disagreement rates are found to be much higher under high time pressure than under low time pressure (31.4% vs. 4.5%). Cappelletti et al. (2011) analyze bargaining in an experimental ultimatum game under time pressure and cognitive load. Their results indicate that time pressure leads proposers to increase their offers in case their endowment is sufficiently high, whereas there are no significant differences in behavior when varying subjects' cognitive load.

¹In an earlier series of studies, Rand et al. (2012) analyze response times as well as explicitly conduct experiments under time pressure. Across all studies, they find shorter response times and increasing time pressure, respectively, being correlated with an increased level of cooperation and conclude cooperation to be intuitive. Even though Tinghög et al. (2013) find no such significant effect of time pressure on cooperation in a series of related experiments, Rand et al. (2013) confirm their previous findings with aggregate analysis based on fifteen studies. Overall, findings suggest that increased cooperation under time pressure is a result of subjects intuitively deciding more cooperative under limited time.

A second strand of literature is concerned with level-k reasoning under time pressure. Kocher and Sutter (2006) conduct an experimental beauty-contest game and find slower convergence and lower payoffs under high time pressure compared to treatments under low time pressure. However, the findings also suggest that time-dependent payoffs under high time pressure lead to quicker decision-making, whereas the quality of decisions is not reduced. In a related study, Lindner and Sutter (2013) find that in an experimental 11-20 money request game, subjects' play is close to, or even indistinguishable from, Nash equilibrium under time pressure. As a possible reason they state that time pressure promotes intuitive reasoning, therefore reduces the focal attraction of choosing higher, and per se more profitable, numbers in the game.

Third, and most closely related to our study, are a variety of studies analyzing the influence of time pressure on individual risk preferences. A seminal paper in this field is the study of Zur and Breznitz (1981), who find that subjects' decisions are less risky under high as compared to medium and low time pressure: They attribute this to the filtration of information and acceleration of its processing as strategies to cope with time pressure. In a more recent study, Kocher et al. (2013) find that under time pressure, risk attitudes under gains are not affected, whereas an increased risk aversion for losses is observed. For mixed prospects, however, subjects become simultaneously more loss averse and more gain seeking dependent on the task's framing. In general, behavior is observed to be more heuristic. Similar findings are obtained by Madan et al. (2015), who state that under higher time pressure subjects choose risky options more often, independent of the outcome value. Additionally, they find time pressure moderately increasing risk seeking in decisions from experience. Similar results are obtained by Kirchler et al. (2015): In a recent series of studies with more than 1,700 subjects in three countries, they find time pressure to increase risk aversion for gains and risk taking for losses.

Hu et al. (2015) analyze the interaction of emotion and time pressure on decision-making in a risky environment. They find that both emotion and time pressure have a significant influence; positive emotions as well as high time pressure lead subjects to decide in a risk-seeking way. A study by Saqib and Chan (2015), who conduct a series of experiments, states results in line with previous findings: under time pressure, subjects are risk-seeking over gains and risk-averse over losses whereas prospect theory predicts opposite behavior. Additionally, they find that subjects perceive the maximum outcome to be more likely to occur, which is then used as a reference point to evaluate all other outcomes.

In the literature on time preferences, several recent studies are concerned with the stability of preferences over time. The majority of studies, however, only analyzes long-term stability of time preferences across subjects and find time preferences to be stable over time. In a field study conducted over two years, Meier and Sprenger (2015) analyze the stability of time preferences also both on an individual as well as an aggregate level. They find preferences to be remarkably stable over time in general. Wölbart and Riedl (2013) find similar results in a laboratory environment. They elicit discount rates as well as risk aversion and probability weighting in an experimental study and find individual characteristics to be remarkably stable over time when subjects had to return to the laboratory five to ten weeks after the first experiment for a follow-up experiment. On the aggregate level, they find discount rates do not differ significantly; on the individual level both elicited discount rates are highly correlated.

In a different strand of literature, a series of studies analyzes the influence of a variety of exogenous shocks on the stability of aggregate and individual time preferences. Chuang and Schechter (2015) provide a comprehensive overview of the literature in this field and use a unique dataset which follows households in rural Paraguay, containing data from experiments over almost a decade. The experiments elicit time preferences, risk preferences and social preferences. Findings indicate that, whereas survey measures for social preferences provide evidence for stability across time, all other measures for time preferences and social preferences indicate only weak evidence for stability. The authors' explanation for these findings are exogenous shocks; results suggest that the variability in preference measures may be mostly due to noise. Similar findings with respect to a variability of discount rates are obtained by Krupka and Stephens (2013). Using a panel dataset from the Seattle and Denver Income Maintenance Experiment, they test the stability of measured discount rates over time in response to changes in both macroeconomic events and household-level labor market outcomes. They find that elicited discount rates vary systematically over time in response to changes in current household-level labor market outcomes and the inflation rate. Overall, they state that measured discount rates are responsive to changes in factors that are related to an individual's nominal rate of interest. In a different approach, Imas et al. (2015) conduct a field experiment in Congo and find that the direct exposure to violence substantially increases individual present bias.

3 Experimental Design

A within-subject design was implemented to elicit subject's time preferences and to compare behavior under time pressure and without time pressure. The elicitation method used in the experimental task are Convex Time Budgets (CTB; Andreoni et al., 2015; Andreoni and Sprenger, 2012). Subjects were faced with 24 decisions in each condition, where each decision implied choosing one option out of a set of six different allocations of a given future value budget of 7.50€ between an earlier and later date in time. In addition to the corner solutions (receiving a smaller sooner payment X € at an earlier date vs receiving 7.50€ at a later point in time), subjects are provided with the option to choose four inner allocations. These allocations satisfy the condition $Px_t + x_{t+k} = Y$, where x_t and x_{t+k} are the chosen allocations at the earlier and later point in time; $P = \frac{Y}{X}$ captures the experimental gross interest rate.² For each decision in the condition without time pressure, subjects had a time frame of 60 seconds per decision, which could be exceeded in case subjects needed more time for making their decisions. In the time pressure treatment, subjects had a time limit of five seconds per decision; afterwards the program automatically proceeded to the next decision screen. To control for order effects, half of the subjects first participated in the task without time pressure succeeded by the decisions under time pressure, for the other half of the subjects this order was reversed.

To be able to estimate all parameters of interest, decisions vary in time horizons and price ratios. The 24 decisions were divided into four different blocks with six decisions each, whereas blocks vary from each other with respect to time horizons. In the first block, subjects faced allocations between today and five weeks from today, in the second block between today and nine weeks from today. The third block involved allocations between in five weeks from today and ten weeks from today, whereas in block four decisions had to be made between in five weeks from today and in ten weeks from today. The comparison of blocks with identical delay length (block one vs. three, two vs. four) then allows to identify present-bias (Frederick et al., 2002; Laibson, 1997). Comparing blocks with different delay length (block one vs. two, three vs. four) allows to characterize the degree of impatience and the estimation of a long-run discounting parameter. Within each block, decisions vary in experimental gross interest rates, which allows the identification of utility function curvature. An overview of the experimental design together with standardized daily and

²This method accounts for a major drawback of other standard elicitation methods as, for example, the Double Multiple Price List (DMPL) approach of Andersen et al. (2008). In their method, subjects are restricted to corner solutions while choosing between a smaller sooner payment and a larger later payment. Only in case of an actual underlying exponential utility function, this restriction is non-binding. If subjects have convex preferences, meaning that they preferred choosing interior solutions to the corner solutions available, the DMPL method restricts their behavior. In contrast to the DMPL method, where utility function curvature is identified via decisions in a separate risk elicitation task, in the CTB method curvature is identified via the degree of price sensitivity in intertemporal choice.

Table 1: Experimental Design

Days until 1st payment (t)	Delay (k)	Price Ratio P	Implied Annual Interest Rate
0	35	1.05, 1.11, 1.18, 1.25, 1.43, 1.82	65%, 164%, 312%, 519%, 1301%, 4276%
0	63	1.00, 1.05, 1.18, 1.33, 1.67, 2.22	0%, 33%, 133%, 304%, 823%, 2093%
35	35	1.05, 1.11, 1.18, 1.25, 1.43, 1.82	65%, 164%, 312%, 519%, 1301%, 4276%
35	63	1.00, 1.05, 1.18, 1.33, 1.67, 2.22	0%, 33%, 133%, 304%, 823%, 2093%

Notes: For each of the 24 decisions in the CTB, earlier dates and delay lengths are given together with the respective price ratios. Effective yearly rates are calculated with quarterly compounding.

annual interest rates are displayed in Table 1.

Seven sessions were conducted in the *blinded* with a total of 144 participants between June, 11 and June 18, 2014. Subjects were recruited with the help of ORSEE (Greiner, 2015) out of a standard subject pool without any restrictions. The experiment was computerized in z-Tree (Fischbacher, 2007). Whereas the order of blocks was fixed, the order of the respective decisions within each block was randomized across subjects and treatments. Each decision was presented on a single screen. An example for a subject’s decision screen can be found in the appendix in the instructions handed out to subjects (appendix B). The elicitation of time preferences was conducted as the second part of an experiment with five separate parts in total, lasting for about one and a half hours of which the two CTB tasks took about 20 minutes. Printed instructions were given to subjects before each part and were read aloud by the experimenter. Detailed instructions can be found in appendix B. At the end of the task, one of the 48 CTB decisions was randomly drawn for payment. All payments were transferred to the subject at the respective dates of the decision randomly chosen for payment to account for equal transaction costs with regard to present and future payoffs.³

4 Theoretical Framework and Estimation Strategies

The specific experimental design allows to estimate all parameters of interest with non-linear least squares (NLS) and interval-censored Tobit (ICT) methods to be able to compare aggregate as well as individual estimates across treatments in addition to descriptive results.

For the subsequent analysis, subjects’ preferences are assumed to be stationary and time-independent with constant relative risk aversion (CRRA): $u(x_t) = x_t^\alpha$. Discounting is modeled to be of a quasi-hyperbolic form to be able to capture dynamic inconsistencies in subjects’

³This also implied that even payments *today* were transferred to a subject’s bank account. The experimental payment dates thus implied that the transfer of payments was initiated on this day, which holds transaction costs constant across dates.

discounting behavior by including a parameter for present-bias (Laibson, 1997; O'Donoghue and Rabin, 1999). Preferences are then defined in the following way:

$$U(x_t, x_{t+k}) = x_t^\alpha + \beta^{t_0} \delta^k x_{t+k}^\alpha \quad (1)$$

where x_t and x_{t+k} are the chosen allocations of payment at the earlier and later date, respectively. α captures utility function curvature, δ is the measure for standard long run discounting, and β captures subjects' present-bias and is therefore a measure for time-inconsistency. t_0 is a time indicator with $t_0 = 1$ if the present is considered and 0 otherwise. k denotes the delay length of later payments in days. As its major advantage, this utility function curvature nests linear utility ($\alpha = 1$) as well as standard exponential discounting ($\beta = 1$).

A subject's utility is maximized subject to the future value budget constraint:

$$(1 + r)x_t + x_{t+k} = B \quad (2)$$

where $(1 + r) = P$ is the experimental gross interest rate or price ratio.

The standard Euler equation is obtained by maximizing subjects' utility (1) subject to the future value budget constraint (2):

$$MRS = \frac{x_t^{\alpha-1}}{\beta^{t_0} \delta^k x_{t+k}^{\alpha-1}} = P \quad (3)$$

where the marginal rate of substitution (MRS) equals the price ratio (P).

The NLS regression equation is based on the demand function:

$$x_t = \frac{B(\beta^{t_0} \delta^k P)^{\left(\frac{1}{\alpha-1}\right)}}{1 + P(\beta^{t_0} \delta^k P)^{\left(\frac{1}{\alpha-1}\right)}} \quad (4)$$

where B denotes the future value budget, which in our case equals 7.50 €. Note that equation 4 is only defined for $\alpha \in (0, 1)$. However, this can be considered as a minor problem for our subsequent analysis due to the fact that experimental data provides vast evidence for the majority of subjects being risk averse for high and close to risk neutral, but still risk averse, for lower stakes (Holt and Laury, 2002, 2005). Additionally, even though estimating a non-linear estimation equation does not account for the interval nature of the data, previous papers have shown that estimating an ICT regression model performed as a robustness check for the NLS regression produces equivalent

results (Andreoni et al., 2015; Lührmann et al., 2015). Moreover, the estimate for utility function curvature α cannot be separately identified from the stochastic disturbance term τ as explained below. Thus, we perform ICT regressions as robustness checks of NLS techniques, while the latter is the focus of our parametric analysis.

The basis for the ICT regression is a simplified form of the log-linearized marginal rate of substitution (3) with indexes i for individual and j for budget number:

$$y_{ij}^* = \ln\left(\frac{x_{t(ij)}^*}{x_{t+k(ij)}^*}\right) = \gamma_1 t_{0ij} + \gamma_2 k_{ij} + \gamma_3 \ln(P_{ij}) + e_{ij} \quad (5)$$

As part of the parameter estimation, five cut points have to be defined. With regard to simplification, we define the cut points to be the upper bounds of the respective intervals. Additionally, to allow for stochastic choice and to be able to account for inconsistencies in subjects' decisions, a stochastic disturbance term τ as a weight on the error term e is included, which is assumed to be distributed according to a logistic distribution function and i.i.d. across choices and individuals. A more detailed description of the ICT estimation is given in appendix A.2.

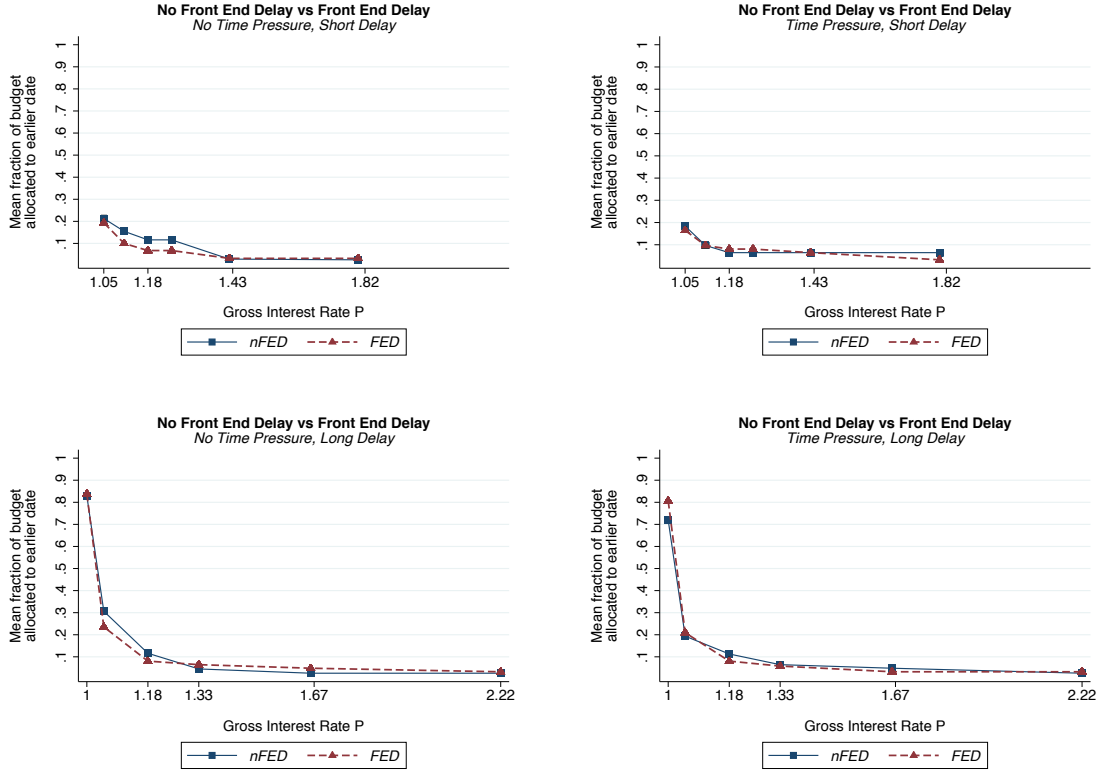
5 Analysis

5.1 Descriptive Analysis

For a descriptive analysis of present bias with and without time pressure, Figure 1 compares the mean allocated share of the budget to the earlier date in decisions without front end delay (nFED) and front end delay (FED) separated into short (five weeks) and long delay lengths (nine weeks).⁴ For nFED decisions, the earliest possible date at which subjects can choose to receive a fraction of their payment is *today*, whereas for FED decisions, the earliest possible date of payment is *in five weeks* from the day of the experiment. With subjects allocating a higher fraction of their budget to the earlier date when the respective date is in the present in the condition without time pressure for both short as well as long delay, results indicate present bias on the aggregate level. Without time pressure, results are significant for experimental gross interest rates of 1.11, 1.18, and 1.25 at the 10%-level (Wilcoxon signed-rank test) in the short delay condition (for all

⁴62 out of originally 144 participants are included in this analysis. For 53 subjects, we were not able to observe an input for one or more of the decisions in the condition with time pressure. We therefore decided to exclude the respective subjects from the analysis. Another 29 subjects were excluded due to multiple switching. Multiple switching is defined as allocating a lower fraction of the budget to the earlier date at a higher price ratio compared to a lower price ratio and can be interpreted as an extreme form of non-monotonic demand (Andreoni et al., 2015; Andreoni and Sprenger, 2012). Since our theoretical model does not account for this kind of non-standard preferences and violations of the law of demand, these subjects do not enter this analysis. However, for aggregate parameter estimates we compare the standard NLS estimation method to an ICT estimation allowing for stochastic choice; following the approach of (Lührmann et al., 2015). We are then able to compare results obtained for the subset of consistent subjects to the whole sample.

Figure 1: Comparison of present-bias with and without time pressure



Note: The top row of the figure compares the mean allocated share of the budget to the earlier date between nFED and FED decisions for a time delay of five weeks, whereas the bottom row shows differences for a delay length of nine weeks.

other rates, $p > 0.317$) and for gross interest rates of 1.05 and 1.18 in the long delay condition (for all other rates, $p > 0.157$). In contrast, decisions turn out to be largely time-consistent in the condition under time pressure for both delay lengths. Differences are not significant with $p > 0.157$ (Wilcoxon signed-rank test) for both delay lengths and all interest rates except for $P = 1.00$ in the long delay condition ($p < 0.020$). An overview of all exact mean allocations and respective p-values for all interest rates can be found in table 4 in appendix A.1. Overall, the descriptive results indicate that time pressure may lead subjects to a more efficient way of decision-making in a sense that decisions are less time-inconsistent.

Embedding our findings in the context of dual-self models and dual-systems theory, at first our results seem to contradict the findings of Fudenberg and Levine (2006) and Thaler and Shefrin (1981). Whereas they find less efficient decision-making such as present-bias to be implied by a lack of self-control induced by cognitive load, our results suggest the opposite: increased time pressure leads to less present bias. However, these findings only contradict dual-self theories at first glance. Taking a closer look at related psychological models of dual-systems theories, results can be explained. Time pressure induces fast, heuristic System I processes to be the driver of judgments;

simplistic assessments are at the core of decision-making (Kahneman and Frederick, 2002). The decision-maker selectively focuses on seemingly relevant task features. In our experimental setting, the high but delayed payments are given relatively more weight and therefore more importance than the immediacy of payments. This, in turn, entails a quite important implication: Modifying the structure of presented information significantly influences decision-making in situations under time pressure. As a consequence, biases cannot only be enlarged but also counteracted. Our findings suggest that, by making certain important pieces of information more salient, present-bias can exogenously be influenced and even decreased in situations where only limited time is available to make decisions.

5.2 Parameter Estimation

To be able to quantify and confirm the directional findings of our descriptive analysis, we estimate all relevant parameters of interest using NLS techniques. Additionally, we are able to analyze individual differences in more detail. ICT regressions for both conditions are performed as robustness checks where we allow for stochastic choices. Even though NLS methods have some minor disadvantages as described in the previous section, the regression is very straightforward to perform and produces results that are largely consistent with what we obtain via estimating an ICT model. The latter is more involved and less transparent, therefore we only use NLS estimates for a subsequent analysis on the individual level. The ICT estimation procedure follows the approach of Lührmann et al. (2015); more detailed information is provided in the appendix. Additionally, we provide both NLS and ICT regressions for all subjects with no missing inputs as robustness checks in appendix A.3.

Table 2 displays aggregate results of our parameter estimation for time pressure as well as no time pressure conditions. As expected, effects go in the same direction for both specifications as already indicated by the descriptive analysis. Results obtained by NLS indicate a moderate present-bias without time pressure, with $\beta = 0.9948$ being significantly different from exponential discounting at the 10%-level ($p = 0.092$, Wald test). Under time pressure, however, with $\beta = 1.0039$, time-consistency cannot be rejected ($p = 0.328$, Wald test). The null hypothesis of the degree of present bias being equal across conditions can be rejected at the 5%-level ($p = 0.026$, Wald-tests). Results therefore confirm descriptive findings and indicate more efficiency under very limited time with respect to increasing time consistency with increasing time pressure.

Comparing differences in utility function curvature across conditions ($\alpha = 0.9757$ without time

Table 2: Aggregate Parameter Estimates

Estimation Results

	No Time Pressure		Time Pressure	
	(NLS)	(ICT)	(NLS)	(ICT)
α	0.9757*** (0.0033)	0.9978** (0.0011)	0.9759*** (0.0034)	0.9991** (0.0005)
β	0.9948* (0.0030)	1.0032 (0.0138)	1.0039 (0.0040)	1.0352* (0.0180)
δ	0.9995 (0.0001)	0.9998 (0.0003)	0.9996 (0.0001)	1.0004 (0.0005)
<i>rate</i>	0.2001	0.0411	0.1723	-0.1616
τ	-	47.9009 (20.5501)	-	133.0675 (59.4319)
Observations	1488	1488	1488	1488
# Clusters	62	62	62	62

Note: Parameters are estimated via NLS and ICT regressions; where ICT indicates results obtained by specifying Fechner errors. ***, **, and * indicate significance on the 1%, 5%, and 10% level, respectively, for testing the hypotheses of linear utility ($\alpha = 1$) and exponential discounting ($\beta = 1$) on an aggregate level (Wald tests). For ICT it is not possible to identify utility function curvature α separately from the stochastic disturbance term τ . Standard errors are given in parentheses and clustered on the individual level. Parameters are nonlinear combinations of regression coefficients and computed via the Delta method. ICT regressions are estimated using the Broyden-Fletcher-Goldfarb-Shanno (BFGS) optimization algorithm.

pressure, $\alpha = 0.9759$ under time pressure), linear utility can be rejected at the 1%-level ($p = 0.000$ in both conditions, Wald test). Here, parameters do not differ significantly across conditions ($p = 0.954$, Wald test). Likewise, parameters for long-run discounting do not differ significantly across conditions with $\delta = 0.9995$ (no time pressure) and $\delta = 0.9996$ (time pressure) ($p > 0.999$, Wald test). As a whole, on an aggregate level subjects exhibit stable time preferences across conditions for NLS methods with respect to utility function curvature and long-run discounting.

Additionally, estimates go in the same direction across regression methods. ICT estimates quantitatively confirm the findings obtained by NLS regressions. Overall results suggest that subjects' decisions are at least as time-consistent under time pressure than under the condition without time pressure. Moreover, discounting slightly decreases in the time pressure condition compared to no time pressure, although not significantly.

Our estimates for present-bias therefore not only confirm individual results but again support the findings of dual-systems theory. Especially due to the fact that estimates for utility function curvature and long-run discounting do not significantly differ across conditions, subjects seem to selectively focus on the high payoffs with down-weighting other prominently displayed information, such as the timing of payments (Evans, 2006; Kahneman and Frederick, 2002).

In a next step, we analyze and compare individual estimates to be able to characterize the stability of preferences in more detail. We estimated all parameters via NLS for simplicity. In line with related papers (Andersen et al., 2008; Andreoni et al., 2015; Andreoni and Sprenger, 2012; Lührmann et al., 2015), we find a high level of heterogeneity across subjects for all parameters of interest. An overview of the summary statistics for individual estimates for all parameters and both conditions is given in appendix A.4. We also give an overview of the summary statistics for all subjects with no missing input. Again, individual results clearly indicate a stability of preferences across conditions for the vast majority of subjects.

To be able to test stability across conditions for individual subjects, we compute the differences between parameters without time pressure and under time pressure. To check whether these differences are significant and stability can therefore be rejected for those cases, Wald tests are performed. This measure allows us to not only reject or support stability on the individual level, but also to characterize directional effects across conditions.

Table 3 gives an overview of differences in parameters on the individual level. For each parameter of interest, the table indicates whether the estimated parameter on the individual level in the time pressure condition was below or above the parameter in the condition without time pressure. Additionally, we checked whether the differences were significant; stability is rejected for all p-values below the 10%-level (Wald tests). For 32 (51.61%) subjects, all three parameters are identical across both conditions and therefore preferences are stable.

In 14 cases, parameters for utility function curvature α under time pressure are slightly below (6 subjects) or above (8 subjects) the condition without time pressure, however, differences are not significant and stability cannot be rejected. In total, for 74.19% of all subjects, α remained stable across conditions. Only for 16 subjects stability can be rejected at least at the 10%-level. This again confirms aggregate estimates and descriptive results, where equality of utility function curvature across conditions cannot be rejected.

For present bias β , results are quite similar. In 13 cases parameters are not significantly different from the no time pressure condition (below for 4 subjects, above for 9 subjects). In total 72.58% of all subjects exhibit a stable degree of present bias, whereas for 17 out of 62 subjects stability can be rejected. However, in contrast to individual estimates for utility function curvature, for 17 of all subjects (27.41%), estimated β 's under time pressure are higher than under no time pressure. These results again reflect aggregate findings and suggest that indeed for a high fraction of all subjects decision-making becomes more efficient under time pressure.

For long-run discounting δ , results are similar to those for estimates of α across conditions. While for a fraction of 74.19% of all subjects stability cannot be rejected (for 8 subjects, parameters under time pressure are below the estimates without time pressure, for 6 subjects the opposite is true), for only 16 subjects stability can be rejected at least at the 10%-level.

Taken as a whole, findings confirm descriptive and aggregate estimation results. Subjects display largely consistent preferences on the majority. However, a large fraction of subjects displays decreasing present-bias under time pressure when compared to the condition without time pressure. This again implies the possibility of interventions to exogenously reduce present-bias in decisions under time-pressure. Overall, our findings indicate that on the aggregate as well as the individual level subjects seem to have largely consistent preferences. With regard to time-consistency, subjects' decisions on aggregate are at least as efficient under time pressure compared to no time

pressure in a sense that less present-bias is found when having to decide on allocating monetary rewards to earlier and later points in time. Utility function curvature is stable across conditions, long-run discounting slightly decreases under time pressure. On the individual level, a high level of heterogeneity for individual parameter estimates is observed, confirming results of previous related studies. Regarding stability across conditions, in the majority of cases estimates for utility function curvature as well as present bias and long-run discounting are stable on the individual level. Concerning time-consistency, results embedded in the model of dual-systems theory according to Kahneman and Frederick (2002) and Evans (2006) lead to an important implication. With the fast, heuristic and unconscious System I being the driver of decisions under time pressure, subjects are predicted to selectively focus on pieces of information that seem to be relevant. In our case, we find individuals placing a high weight on the respective amounts of payments, compared to a low weight placed on the possible immediacy of receiving money leading to a decrease in present-bias under time pressure.

Table 3: Stability of individual parameter estimates

	α		β		δ	
	Stability not rejected	Stability rejected	Stability not rejected	Stability rejected	Stability not rejected	Stability rejected
TP <NTP	6 (9.68%)	9 (14.52%)	4 (6.45%)	9 (14.51%)	8 (12.9%)	6 (9.68%)
TP = NTP	32 (51.61%)	-	32 (51.61%)	-	32 (51.61%)	-
TP >NTP	8 (12.9%)	7 (11.29%)	9 (14.52%)	8 (12.9%)	6 (9.68%)	10 (16.13%)
Total	46 (74.19%)	16 (25.18%)	45 (72.58%)	17 (27.41%)	46 (74.19%)	16 (25.18%)

Note: For each parameter of interest, the table indicates whether the estimated parameter on the individual level in the time pressure condition (TP) was below, equal, or above the parameter in the condition without time pressure (NTP). Stability is rejected for all p-values below the 10%-level (Wald tests).

6 Conclusion

Hardly any decisions in economic or business environments are made without a binding time constraint. Trading decisions at the stock market, salary negotiations between employers and employees, submitting bids in auctions - all these situations are examples for a very short time frame to make decisions. With underlying individual preferences being the driving force of a multitude of observed decisions, we analyze the stability of time preferences as a next step in the process of being able to characterize individual decision-making in different contexts. Our findings indicate that on the individual as well as the aggregate level, utility function curvature and long-run discounting are stable across conditions with high time pressure and without time pressure on the whole. However, aggregate results display that subjects are present-biased without time pressure, whereas exponential discounting cannot be rejected in the condition without time pressure.

We analyze our results in the light of dual-systems theory following the approach of Evans (2006) and Kahneman and Frederick (2002) to be able to draw an important practical implication. With System I being the fast, unconscious and heuristic driver of decisions under time pressure, decisions are based on selected pieces of presented information. We find subjects focusing on the amount of payments rather than their possible immediacy, therefore reducing present-bias. We conclude that by structuring the information given in the decision-process under time pressure, present-bias can indeed be reduced and the efficiency of decision-making can be significantly increased.

7 References

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Appendix

A Econometric Specification and Robustness Checks

A.1 Descriptive Analysis

Table 4: Descriptive Comparison of Present-Bias

Mean Allocated Share to the earlier Date - No Front End Delay vs Front End Delay														
		No Time Pressure						Time Pressure						
		<i>P</i>	1.05	1.11	1.18	1.25	1.43	1.82	1.05	1.11	1.18	1.25	1.43	1.82
Short Delay	<i>nFED</i>	0.2129	0.1548	0.1161	0.1161	0.0290	0.0258	0.1834	0.0968	0.0645	0.0645	0.0645	0.0645	0.0645
	<i>FED</i>	0.1935	0.1000	0.0677	0.6774	0.0323	0.0323	0.1645	0.0968	0.0806	0.0806	0.0645	0.0323	
	<i>p-value</i>	0.4222	0.0606	0.0833	0.0833	0.9908	0.3173	0.4835	1.0000	0.3173	0.3173	-	0.1573	
		<i>P</i>	1.00	1.05	1.18	1.33	1.67	2.22	1.00	1.05	1.18	1.33	1.67	2.22
Long Delay	<i>nFED</i>	0.8290	0.3065	0.1161	0.0452	0.0258	0.0258	0.7193	0.1936	0.1129	0.0645	0.0484	0.0258	
	<i>FED</i>	0.8387	0.2355	0.0806	0.0484	0.0484	0.0323	0.8065	0.2097	0.0806	0.0581	0.0323	0.0323	
	<i>p-value</i>	0.5714	0.0350	0.0833	0.5510	0.1573	0.3173	0.0206	0.6547	0.1573	0.9908	0.3173	0.3173	

Note: All values correspond to the descriptive analysis in figure 1 in the main part. *P* denotes the experimental gross interest rate of the respective decision, short delay corresponds to a delay of 5 weeks, whereas long delay corresponds to nine weeks. *p*-values indicate the significance of differences across no front-end delay (nFED) and front-end delay (FED) decisions (Wilcoxon signed-rank test). For FED decisions under Time Pressure at an experimental gross interest rate of 1.43, the *p*-value is missing since decisions for each subject are identical across conditions.

A.2 ICT Regression

Due to the interval nature of our data, we perform interval censored tobit (ICT) regressions as robustness checks for NLS regression methods following the approach of Lührmann et al. (2015), where observed choices are interpreted as ordinal indicators of preference and optimality is assumed to hold only for the underlying, unobserved optimal choices from fully-convex budgets. Furthermore, the observed choices are related to the optimality conditions in a probabilistic way, the model allows for stochastic choice. Fechner or "white noise" errors capture the assumption that individuals maximize utility while having a set of alternative preference relations. When deciding in a specific decision problem, the individual acts on one of these preference relations, where the specific one is selected randomly (Loomes et al., 2002). Our model therefore includes a stochastic disturbance term τ as a weight on the error term e , which is assumed to be distributed according to a logistic distribution function and i.i.d. across choices and individuals.

The ICT regression is based on the simplified OLS equation with the latent variable y_{ij}^* to be estimated. i and j are indexing variables for individuals and budgets, respectively:

$$y_{ij}^* = \ln\left(\frac{x_{t(ij)}^*}{x_{t+k(ij)}^*}\right) = \gamma_1 t_{0ij} + \gamma_2 k_{ij} + \gamma_3 \ln(P_{ij}) + e_{ij} \quad (6)$$

where t_0 is the indicator variable for the present, k is the delay length and P is the experimental gross interest rate; $\gamma_1 = \frac{\ln(\beta)}{\alpha-1}$, $\gamma_2 = \frac{\ln(\delta)}{\alpha-1}$, $\gamma_3 = \frac{1}{\alpha-1}$. e_{ij} is supposed to be normally distributed ($e_{ij} \sim \mathcal{N}(0, \sigma^2)$).

For each decision and individual, the six choices ($c = 1, 2, \dots, 6$) can be categorized in the following way according to their preference for sooner payment:

$$c = \begin{cases} 1, & \text{if } y^* > K^1, \\ 2, & \text{if } K^1 > y^* > K^2 \\ \vdots & \\ 6, & \text{if } K^5 > y^*. \end{cases}$$

where K^1, \dots, K^5 are five cut points which capture both observed and unobserved parts of preferences. However, these cut points are not to be interpreted as indifference points between adjacent choices. With the above distribution of the error term e_{ij} , the probabilities of the individual's choices for each decision are:

$$\begin{aligned}
Pr(c_{ij} = n) &= Pr(K_j^{n-1} < y^* < K_j^n) \\
&= Pr(K_j^{n-1} - (\gamma_1 t_{0ij} + \gamma_2 k_{ij} + \gamma_3 \ln(P_{ij})) < e_{ij} < K_j^n - (\gamma_1 t_{0ij} + \gamma_2 k_{ij} + \gamma_3 \ln(P_{ij}))) \\
&= \Lambda\left(\frac{1}{\tau}(K_j^{n-1} - (\gamma_1 t_{0ij} + \gamma_2 k_{ij} + \gamma_3 \ln(P_{ij})))\right) - \Lambda\left(\frac{1}{\tau}(K_j^n - (\gamma_1 t_{0ij} + \gamma_2 k_{ij} + \gamma_3 \ln(P_{ij})))\right)
\end{aligned}$$

where $\Lambda(t) = (1 + e^{-t})^{-1}$ is the CDF of the logistic distribution; the derivation for the corner solution probabilities is analog. We define the cut points to be the upper side of each interval per assumption.

As already outlined in Section 4, the parameters $\gamma_1, \gamma_2, \gamma_3$ in equation 6 are only defined up to τ , the stochastic disturbance term. Therefore, the estimate for utility function curvature, α , cannot be estimated precisely due to a lack of identification since $\alpha = \frac{\tau}{\gamma_3} + 1$. However, the estimates for present-bias β and long-run discounting δ are not affected since they are identified from the ratio of γ coefficients ($\beta = \exp(\frac{\gamma_1}{\gamma_3}), \delta = \exp(\frac{\gamma_2}{\gamma_3})$).

A.3 Robustness Checks for NLS and ICT specifications

Table 5 displays aggregate estimates for NLS and ICT regressions for all subjects with no missing input, including the subset of subjects with inconsistent choices as robustness checks to the results presented in the main analysis in Section 5.2. Results mainly go in the same direction as for estimates presented in the main part. β and discounting slightly decrease under time pressure compared to the condition without time pressure, whereas utility function curvature remains almost constant.

Table 5: Aggregate Parameter Estimates

Estimation Results

	No Time Pressure		Time Pressure	
	(NLS)	(ICT)	(NLS)	(ICT)
α	0.9502*** (0.0060)	0.9907*** (0.0026)	0.9558*** (0.0056)	0.9923*** (0.0028)
β	1.0000 (0.0051)	1.0137 (0.0131)	0.9993 (0.0055)	1.0080 (0.0173)
δ	0.9993 (0.0001)	0.9993 (0.0003)	0.9994 (0.0001)	1.0000 (0.0004)
<i>rate</i>	0.3033	0.2624	0.2317	-0.0177
τ	- -	15.5875 (3.6558)	- -	20.5974 (6.1224)
Observations	2184	2184	2184	2184
# Clusters	91	91	91	91

Note: Parameters are estimated via NLS and ICT regressions; where ICT indicates results obtained by specifying Fechner errors. ***, **, and * indicate significance on the 1%, 5%, and 10% level, respectively, for testing the hypotheses of linear utility ($\alpha = 1$) and exponential discounting ($\beta = 1$) on an aggregate level (Wald tests). For ICT it is not possible to identify utility function curvature α separately from the stochastic disturbance term τ . Standard errors are given in parentheses and clustered on the individual level. Parameters are nonlinear combinations of regression coefficients and computed via the Delta method. ICT regressions are estimated using the Broyden-Fletcher-Goldfarb-Shanno (BFGS) optimization algorithm.

A.4 Individual Parameter Estimates

Table 6 displays individual parameter estimates. Even though standard deviations are higher for the time pressure condition and indicate a higher level of heterogeneity, medians for parameters are

equal across conditions, which is again evidence for stability on the individual level. Additionally, medians are close to the aggregate estimates presented in Section 5.2.

Table 6: Individual Parameter Estimates (1)

Individual Parameter Estimates

all subjects with no inconsistencies and no missing input

Parameter	N	Median	Mean	Standard Deviation	10th Percentile	90th Percentile
<i>No Time Pressure</i>						
α	62	0.9992	0.6660	2.5574	0.9752	0.9995
β	62	0.9961	0.9750	0.1621	0.9378	1.0566
δ	62	0.9996	0.9894	0.0526	0.9962	0.9996
<i>Time Pressure</i>						
α	62	0.9992	-1.2080	16.2188	0.9182	0.9996
β	62	0.9961	1.0190	0.3502	0.9364	1.0668
δ	62	0.9996	0.9781	0.1294	0.9976	0.9996

Note: All estimates are obtained using NLS, only includes subjects with consistent decisions and no missing inputs.

Table 7: Individual Parameter Estimates (2)

Individual Parameter Estimates

all subjects with no missing input

Parameter	N	Median	Mean	Standard Deviation	10th Percentile	90th Percentile
<i>No Time Pressure</i>						
α	90	0.9992	0.6149	2.5014	0.9256	0.9996
β	90	0.9961	0.9851	0.1941	0.9230	1.1120
δ	90	0.9996	0.9940	0.0616	0.9938	0.9999
<i>Time Pressure</i>						
α	91	0.9992	-.6361	13.4224	0.8921	0.9995
β	91	0.9961	1930825	$1.84e^{07}$	0.7904	1.0668
δ	91	0.9996	0.9873	0.1098	0.9954	1.0017

Note: All estimates are obtained using NLS, contains all subjects with no missing input. For one subject it was not possible to calculate individual parameters in the condition without time pressure.

B Instructions

Instructions are translated from German. Differences in the two order conditions (no time pressure followed by time pressure vs. time pressure followed by no time pressure) are given in parentheses.

The second part of the experiment consists of **48 decisions**. In each of these 48 decisions you have to decide on how to allocate your budget between two points in time, one time is **earlier** and one is **later**. Both the earlier and the later point in time will vary across decisions.

Each of the subsequent 48 decisions will be presented to you on a single screen. All these decisions consist of **six options**. Each option consists of an **earlier payment AND** a **later payment**. You are asked to choose your preferred option by clicking the button below the respective option. In each decision you can only chose **one** of the six options. Please note that later payments increase when earlier payments decrease.

Example

*In this example you are asked to choose your preferred combination of a payment **in X Weeks AND** a payment **in Y Weeks**. The value of the **earlier** payment varies between **A Euro** and **0 Euro**, whereas the value of the **later** payment varies between **0 Euro** and **B Euro**. This decision problem would be presented on screen as follows:*

Periode							Verbleibende Zeit [sec]
2 von 6							58
In X WEEKS <i>and</i> in Y WEEKS							
Payment in X WEEKS	7.10 €	5.70 €	4.30 €	2.90 €	1.40 €	0.00 €	
<i>and</i> payment in Y WEEKS	0.00 €	1.50 €	3.00 €	4.50 €	6.00 €	7.50 €	
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	

You will be making **48 such decisions in total**. Each decision is displayed on a separate screen. For decisions 1 to 24 you have a maximum of **60 seconds [only 5 seconds]** to decide on the option of your choice; for decisions 25 to 48 you have **only 5 seconds [60 seconds]** to make your decisions. In the upper left part of the screen the number of the current decision situation is displayed to inform you in which of the 48 decision situations you currently are.

Your payment in this part is determined as follows

At the end one of the 48 decision situations is chosen randomly; your chosen option in this decision situation is then actually paid out. You will only be informed about the randomly chosen decision situation at the end of the experiment. Since you do not know which of the 48 decisions is chosen, it is optimal to decide as if each single decision is relevant for payment. You do not have to make use of the whole decision time, however, in case you exceed the given time limit you will receive a payment of 0 Euro for this part.

Important

All payments from this part of the experiment will be transferred to your specified bank account. This applies to both the payments you receive today as well as the payments at a later point in time. The exact dates of the bank transfer are determined by the option you chose in the decision situation which was randomly chosen for payment by the computer. This will be displayed to you at the end of the experiment in detail.

Questions

In case you have any questions please raise your hand now. The experimenter will come to you and answer your questions privately.

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Florian Lindner, Julia Rose

No need for more time: Intertemporal allocation decisions under time pressure

Abstract

Time preferences drive decisions in many economic situations, such as investment contexts or salary negotiations. These situations are characterized by a very short time frame for decision making. Preferences are potentially susceptible to the confounding effects of time pressure, as proposed by dual-systems theory (Evans, 2006; Kahneman and Frederick, 2002). Results of standard methods of time preference elicitation can therefore not be directly mapped to environments characterized by severe time pressure since the underlying assumption of these models is that preferences are stable. To address the stability of time preferences under time pressure, we conduct a laboratory study with 144 subjects using convex time budgets (Andreoni and Sprenger, 2012) in order to elicit time preferences with and without time pressure in a within-subject design. We find lower present-bias under time pressure compared to the condition without time pressure on the aggregate, whereas utility function curvature and long-run discounting are stable across conditions. The findings are confirmed on the individual level. Embedding our results in dual-systems theory, how information is presented can serve as a potential means to exogenously decrease present-bias under time pressure.

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