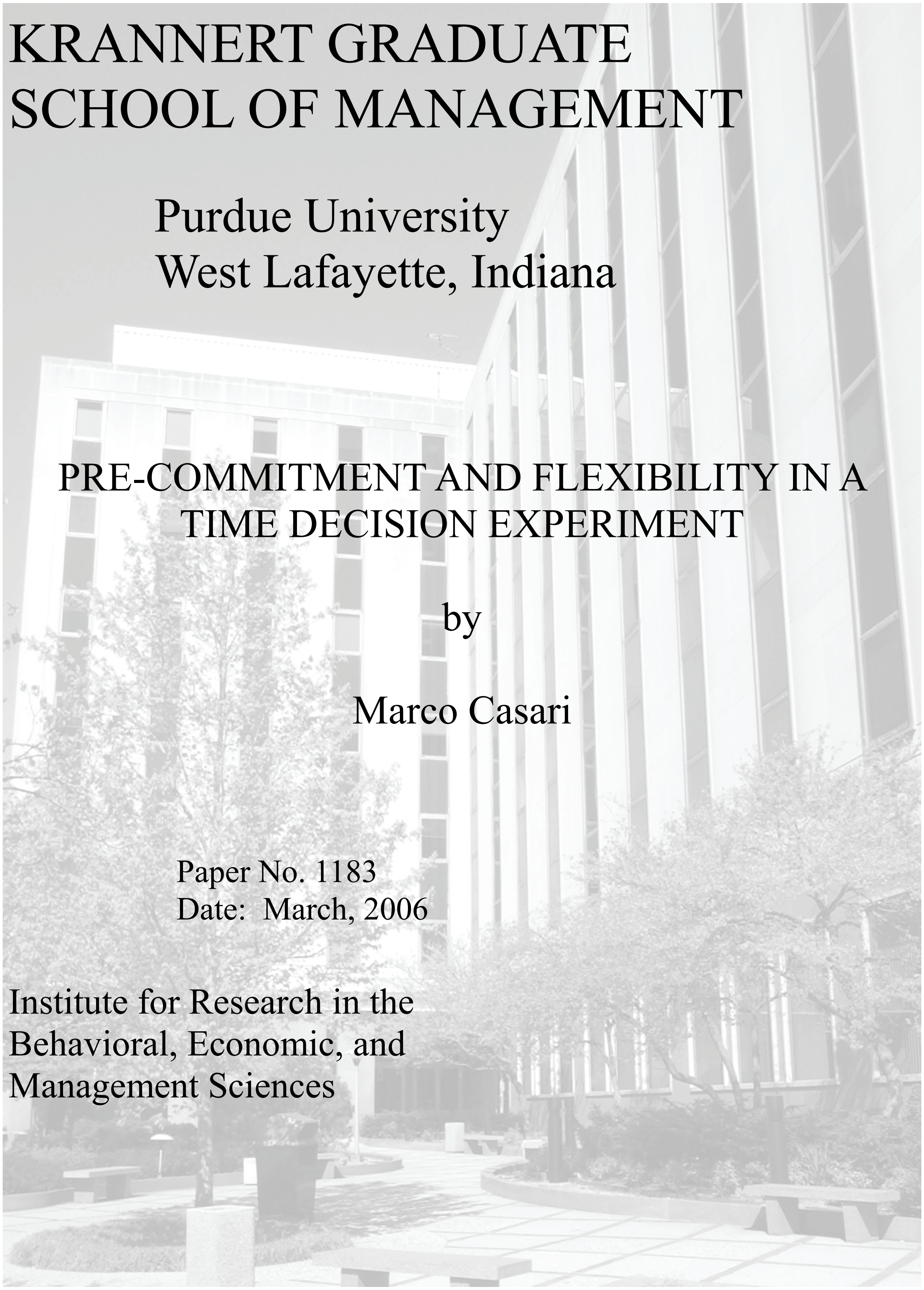

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PRE-COMMITMENT AND FLEXIBILITY IN A TIME DECISION EXPERIMENT

by

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PRE-COMMITMENT AND FLEXIBILITY

IN A TIME DECISION EXPERIMENT

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Abstract

This study presents experimental data on pre-commitment and flexibility where monetary rewards are delivered with an actual delay. Preference for pre-commitment is defined as willingness to pay a cost to restrict the size of the choice set available in the future. Preference for flexibility is defined as willingness to pay a cost to enlarge the choice set available in the future. The existing empirical evidence about these phenomena is rather limited. On the other hand, models of intertemporal choice differ widely on these issues, with some predicting only demand for pre-commitment, others only demand for flexibility, while others neither one. We find that two-thirds of the subjects cannot be accounted for with the canonical exponential discounting model and that there is demand for both pre-commitment and flexibility.

Keywords: experiments, time preferences, time inconsistency, preference for commitment, preference for flexibility, discounting.

JEL:.C91, D90, D81

1 INTRODUCTION *

In a medical study pregnant women were asked one month before delivery whether they preferred to have anesthesia during labor. The anesthesia would offer immediate pain relief but would also expose the newborn to a small risk of long-term side effects. Most women preferred to avoid anesthesia. Despite their earlier statements, during active labor many did choose anesthesia over pain (Christensen-Szalanski, 1984). If one month prior to delivery the same women could have signed a statement committing the physician to withhold anesthesia, thus disregarding the patient's future requests, how many would have sign up?

In this paper we provide experimental evidence regarding this type of pre-commitment decisions but involving money. Intertemporal decisions have recently received considerable attention from behavioral economists (for a review, Frederick et al., 2002). Typically, empirical studies focus on subjects' discount rate for short and long time horizons:

(a) Would you prefer $100 in two days or $110 in two months?

(b) Would you prefer $100 in one year and two days or $110 in one year and two months?

Most subjects in experiments prefer $100 in (a) and then reverse their choice by preferring $110 in (b). Under the canonical exponential discounting model, such choices are interpreted as time inconsistent behavior (Thaler, 1981, Benzion et al., 1989, Lowenstein, 1987, Chapman, 1996,

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* Correspondence address: Marco Casari, Krannert School of Management, Purdue University, 403 West State Street, West Lafayette, IN 47907, USA, tel +765-4943598, fax +765-4961567, email: casari@purdue.edu. This study was initiated when visiting the Universitat Autònoma de Barcelona, Spain. Discussions with Howard Rachlin have been particularly valuable. This paper has also benefited from comments of Colin Camerer, Dan Levin, Gary Charness, Jordi Brandts, Charlie Plott, Pierre Courtois, Gabriele Camera, Rosella Nicolini, and of participants at seminars at the Universitat Autònoma de Barcelona, Purdue University and at the ESA meeting in Montreal, Canada. All the remaining errors are mine. Thank you to Henrik Nordin for providing critical assistance in programming. Many thanks to Aurora Gallego, Nikos Georgantis for letting me use the LEE (Laboratori d'Economia Experimental) of the Universidad Jaume I of Castellon, Spain, and to Juan Gómez Pérez for the technical help. Administrative assistance was provided by Ricardo Flores. The financial support from an EU Marie Curie Fellowship and from the Russell Sage Foundation (grant #: 98-04-05) is gratefully acknowledged. Any opinions, findings, and conclusions or recommendations in this material are those of the author and do not necessarily reflect the views of the European Commission or of the Russel Sage Foundation.

Benhabib et al., 2005).[1] Scholars have attributed the choice reversal to discount rates declining for longer time horizons (Kirby, 1997, Ainslie, 1992, Ainslie and Haendel, 1983).[2]

The focus of the present paper is instead on preferences for pre-commitment, on which existing evidence is very limited (Ashraf et al., 2005, Ariely and Wertenbrach, 2002). A subject does pre-commit when she restricts her choice set:

(c) Would you prefer $109 in one year and two months, or

being able to choose, one year from today, between $100 in two days or $110 in two months?

If a subject that previously reversed her choice, now prefers $109 in one year and two months, she reveals a strict preference for pre-commitment.

Understanding whether decision makers are willing to pay to restrict their choice set is relevant for several reasons. First, when agents have time inconsistent preferences, pre-commitment may be welfare-improving. If such agents do voluntary pre-commit when a technology is available, the practical impact of time inconsistency may be quite limited. Given voluntary pre-commitment, policy makers' roles would simply be to ensure that time inconsistent agents have access to cheap pre-commitment options. On the contrary, if agents are unaware of their inconsistency (naïve), they will not voluntary pre-commit (Strotz, 1955, Phelps and Pollak, 1968). In this case optimal policies may call for strict constraints on choice sets. Although the implications of naivety or sophistication are profound, the behavioral evidence is still quite

[1] Some authors have questioned this finding, Harrison et al. (2005) and Rubinstein (2003). Pender (1996) explains the finding through a seasonality effect.

[2] Previous studies have adopted a cross-sectional design where a person is asked both questions at the same point in time. One novelty of this study is to include a longitudinal design, where participants make choices at different points in time. Hence, question (b) would be asked to the same subject one year after she answered question (a). This dynamic design offers a more direct test of the prediction that an inconsistent decision maker establishes a plan for a far-away time but may not implement it as it becomes closer in time.

limited (Della Vigna and Malmendier, 2004, Benartzi and Thaler, 2004).[3] The first contribution of this paper is to present empirical evidence on how common are preference for pre-commitment.

Second, while choice reversal over time may originate from inconsistent time preferences, it may also be the result of uncertainty about future outcomes. In the example about pregnant women, both issues may be at work. On one hand, choice reversal may be due to the temptation to ask for anesthesia that arises while experiencing pain. Given such preference-based explanation, pre-commitment could be an appealing option for the decision maker. An alternative explanation for choice reversal may be ignorance about the future level of pain. Only during labor does a woman realize how painful it is, and only then can she make an informed choice about whether or not to take anesthesia.[4] Under this uncertainty-based explanation, pre-commitment is *never* a good option. Far from being optimal, pre-committing can prevent a decision maker from revising a decision in light of new, relevant information. Actually, in the presence of uncertainty, there may be a strict preference for flexibility, i.e. for a larger choice set. The second contribution of the paper is to rule out that uncertainty is the *only* motive for choice reversal over time. The exponential discounting model augmented with an appropriate distribution of uncertainty is contradicted by evidence of pre-committing behavior.

The third contribution is to show that uncertainty about future states *is* an important motive for *some* people. The novel aspect of this study is that subjects face both pre-commitment and flexibility choices. Hence, we are able to classify subjects into those that prefer pre-commitment,

[3] There is some evidence of pre-commitment in animals (Ainslie, 1974; Kagel et al., 1995) and when people are under visceral influences like pain, addiction, or hunger (Schelling, 1984).

[4] Evidence is mix on this point (Christensen-Szalanski, 1984). In a follow-up interview one month postpartum, many women regretted their choice and expressed their preference to avoid using anesthesia (support for the preference-based explanation). Women at their first childbirth experience were more likely to reverse their choice than the average (support for the uncertainty-based explanation).

those that prefer flexibility, and those that are "in-between." We report that a sizable group of subjects that are willing to pay to keep their future options open.

This paper is structured as follows. Section 2 briefly reviews models of intertemporal decision in the literature. Section 3 outlines the experimental design employed to elicit time preferences. The results are presented in three distinct sections, Section 4, 5, and 6, which concern time discounting, choice reversal, and preferences for flexibility and pre-commitment, respectively. Conclusions follow in Section 7.

2 LITERATURE REVIEW

While many founding axioms of the exponential model of intertemporal decision making have been challenged by empirical findings (Frederick et al., 2002), the evidence of a higher discount rate for short horizon than for long horizon options is the one issue that has generated the most debate (Thaler, 1981, Pender, 1996, Chapman, 1996, Benzion et al., 1989, Lowenstein, 1987, Ainslie and Haendel, 1983). An implication of this finding is that a plan established for a far-away future might not be implemented as that future draws near.

In the literature at least three classes of motives are mentioned to explain choice reversal, time inconsistent preferences, the presence of a specific type of uncertainty, or the use of procedural rules in decision-making. A crucial dimension in which such models differ is their predictions over preferences for pre-commitment. Preference-based models generally allow for the possibility that an agent can prefer to pre-commit. Scholars have presented neurological evidence suggesting that humans use distinct areas of the brain to evaluate immediate and future decisions (McClure et al., 2004). When decision makers have hyperbolic or quasi-hyperbolic time preferences they may be willing to pre-commit if aware of their preferences (Elster, 1979, Phelps and Pollack, 1968, Laibson, 1997, O'Donoghue and Rabin, 1999). Another example is when decision makers experience self-control issues (Thaler and Shefrin, 1981, Benhabid and Bisin, 2004, Akerlof, 1991, Fundenberg and Levine, 2004,Bernheim and Rangel, 2004). An axiomatization of decision makers with self-control problems is presented in Gul and Pesendorfer (2001).

In the second class of models, agents have time consistent preferences and the explanation for choice reversal is uncertainty-based. In all such models pre-commitment is never optimal. Sozou (1998) considers a situation where the only component of time discounting is the risk of mortality of the decision maker, which is characterized by a constant hazard rate. The decision maker, though, is uncertain about her hazard rate. It is shown that for a wide class of probability distributions, the decision maker will exhibit diminishing discount rates. Azfar (1999) extends this framework to the case of exponential time preferences. Halevy (2002) incorporates in the intertemporal decision the actual mortality risk from life tables. Dasgupta and Maskin (2005) introduce waiting costs and invoke a different type of uncertainty, in the timing of the reward. In Fernandez-Villaverde and Mukherji (2000) there are shocks to preferences that are learned about only in the period before consumption decisions are made. Preference-based and uncertainty based models are of course not mutually exclusive. A more detailed comparison between preference-based and uncertainty based models is presented in the Appendix.

Finally, in the third class of models, the available options are compared attribute-by attribute, following a specification procedure. An instance of such models is Read (2001), who argues that diminishing discount rates originate from subadditive discounting and not from diminishing impatience. Others include Rubinstein (2003) and Leland (2002), which propose an approach based on similarity relations. According to these models, subjects should express no preference for pre-commitment.

3 EXPERIMENTAL DESIGN AND PROCEDURES

A total of 120 subjects were recruited from the undergraduate population of Jaume I University of Castellon, Spain. Six sessions were run with 20 subjects in each session. Recruitment was done through announcements in class and by people stopping by at the laboratory to sign-up. Exactly 50% of the subjects were women and about 88% of them were economics or business major. The overwhelming majority of the subjects had participated to other, unrelated economic experiments in the same laboratory.

An experimental session included several tasks:[5] *(1)* Measuring risk attitude; (2) Measuring individual discount rates; (3) Detecting choice reversal; (4) Assessing preferences for pre-commitment and flexibility (stage one); (5) Questionnaire, and (6) Email on a specified date with follow-up decisions (stage two of (4), post-laboratory task).

In Task 1 there were ten binary choices about lotteries. The purpose of these choices was to elicit individual risk attitude. A subject chose between a "safe" Option A and a "risky" Option B. The potential payoffs for Option A (2.00€ or 1.60€) were less variable than the potential payoffs for Option B (3.85€ or 0.10€). In the first decision, the probability of the high payoff for both options was 1/10. In subsequent decisions, the probability of the high payoff outcome increased by 1/10. A risk neutral person would choose A in lotteries one through four and then switch to B in lottery five. The incentive structure was identical to that in Holt and Laury (2002).

In Task 2 subjects faced choices between pairs of delayed monetary rewards, A1 and A2. Option A1 was a sooner-smaller reward of 100€ that was paid in two days, or A1=(SS, t_2)=(100,

[5] Complete instructions are available online at http://www.mgmt.purdue.edu/faculty/casari/timex.htm.

2). Option A2 was a later-larger reward of 110€ that was paid at time $t_3 > 2$, or A2=(LL, t_3)=(110, t_3). In the first decision, A2 paid in 9 days (t_3 =9). In each of the following decisions t_3 was progressively increased by at least one day and at most 21 days. Particular care was taken to avoid calendar effects.[6]

As soon as the subject chose A1 over A2, Task 2 was interrupted. At that decision, we set $\Delta^*= t_3$. Any subject with a positive discount rate will eventually switch. A switch had to be confirmed in a follow-up choice where $t_3= \Delta^* + 2$, otherwise Task 2 would continue.[7] Moreover, if the switch did not occur for $t_3 < 228$ days (January 10, 2005), Task 2 was interrupted. Before moving to Task 3, a list of all decisions was presented and the subject had a chance to modify Task 2 choices. Using the delay t_3 of the switching decision, together with the delay t_3 of the previous decision, one can elicit individual discount rates.

In Task 3 subjects faced choice between pairs of delayed monetary rewards, A1 and A2, which differed from the options faced in Task 2 only in the time of payment because of an added *front-end delay* t_1 (Figure 1). Option A1 was (100, t_1+2) and option A2 was (110, t_1+ Δ^*), where Δ^* was the delay elicited in Task 1. In the first decision, A1 paid in 9 days (t_1 =7) and A2 paid in 7+ Δ^* days. In following decisions, t_1 was progressively increased by at least seven days and at most 21 days.

When the subject chose A2 over A1, Task 3 was interrupted. At that decision we set $t_1^*= t_1$. Task 3 would continue unless this preference was confirmed in a follow-up choice where $t_1= t_1^*$

[6] If delays of payment t_3 or t_2 fell on Saturday, Sunday, or an official holiday, the delay was automatically adjusted either backward or forward to make it easy for subjects to cash the reward. The summer period was also excluded. Difficult periods were the Christmas vacations (December 22-January 6) and several other national or local festive days (for example October 9 and 12, November 1, December 6 and 8, February 27, March 19, May 1, June 29). Classes ran up to May 28, and then there were exams up to June 30. The summer period excluded was July 25-September 5. The university was closed in August. One should consider that about 90% of the subjects' families lived in the university town or in the region (Valencia province).

[7] At this point one or two additional decisions may be prompted in order to bracket the exact willingness to wait in days into a narrower interval. The difference in wait t_3 between the "A1" and "A2" choices was split in two, and eventually the relevant half interval divided in two again if the half interval was more then eight days long.

+ 7. Alternatively, if there was no switch before $t_3 < 339$ days (April 1st, 2005), the procedure was interrupted.[8] At this point the subject had an opportunity to confirm or modify her Task 3 choices. The procedures in Tasks 2 and 3 were modifications of the delay-titration procedure introduced by Mazur (1987) and used in Kirby and Herrnstein (1995). *The purpose of these decisions was to detect choice reversal over time.* There is no reversal if the subject always chose A1 in Task 3.

Choices in Task 4 aimed at measuring preferences for soft pre-commitment, strict pre-commitment, and flexibility. A typical decision involved two stages, a choice between the sets {A1, A2} and {B1, B2} during the session (Task 4) and an email choice to select the preferred option within the set chosen in stage one, after exactly t_1^* days from the session (Task 6). Options {A1, A2} were those individually calibrated in Tasks 2 and 3. Hence, A1=(SS, t_1^*+2) and A2=(LL, $t_1^*+\Delta^*$).

Following Rachlin (2000), the present study includes both strict pre-commitment and soft pre-commitment decisions (Figures 2 and 3). If commitment is strict, Task 4 options sets are {A1, A2} and {B}, where B is comparable to A2, although it may be less attractive. When the subject picks {B}, she is still required to send an email later on confirming the B option. Commitment is soft when Task 4 option sets are {A1, A2} and {B1, B2}, where B1 is less attractive than A1 while B2 is (mostly) identical to A2.

Four decisions are about soft pre-commitment (Table 1). Option B1 was made relatively less attractive than option A1 either by further delaying it in time (Decision 4) or by lowering its amount (Decisions 1-3). In addition, three decisions were of strict pre-commitment. In the simplest case there was no cost to strictly pre-commitment because option B was identical to option A2 (decision 5). By choosing {B} over {A1, A2}, a subject simply ruled out the

[8] The actual total number of decisions per subject in tasks 2 and 3 varied between 17 and 46.

possibility of picking A1 at a later date. In other cases there was a cost to strictly pre-commit because option B was less attractive than A2. The cost in choosing B over A2 could be either monetary (decisions 7) or in terms of additional waiting (decision 10). Finally, there were four decisions regarding flexibility. These decisions had the same formal structure as those pertaining to strict pre-commitment (Figure 3), but instead of paying a "cost" to restrict the choice set, subjects had to pay a "cost" to make it wider, as option B was now more attractive than A2. In some cases there was a monetary cost (decisions 6 and 8) and in others a delay cost (decisions 9 and 11).

The timing of the post-session email (Task 6) was subject-specific, as it depended on the elicited front-end delay t_1^*. On the day of the decision a subject could reply to the email message, call the laboratory, or stop by in person at the laboratory to communicate her decisions.[9]

There were five components to the payment. Components 1, 2, and 3 were paid in cash at the end of the session and components 4 and 5 were paid at a future date at least two days after the session. The first component was a show up fee of 3€.[10] The second component was a payment of one random decision in Task 1, where a bag containing ten tokens was used as random device. The third component was a reward for the correct understanding of exponential discounting.[11]

The other components were larger payments of 94-110€ that one participant out of every ten would receive. The fourth component was based on the decisions in Task 2. The actual payment was carried out at a later date, but the selection was done immediately at the end of the session

[9] Subjects were instructed to record all task 4 options and choices on a wallet-size memo. Approximately a week before the stage two decision date, an email was sent to the subject with the list of all his previous decisions and future choices. If the email bounced back an SMS was sent to the cell phone or a call was made to remind the subject. Some subjects, though, could not be reached. A tolerance of up to two days was accepted, but at the cost of 1/3 of the potential prize per day of delay or anticipation.
[10] The participation fee was 2€ in the first two sessions.
[11] Questions S,T,U. Fifty cents for each correct answer.

by a subject randomly drawing a number out of a bag. That provided a true moment of suspense. One person per session was selected and given a signed letter with university letterhead promising a later payment of 100€ or 110€. The specific decision paid out of Task 2 was determined with a second random draw. The time and amount of the actual payment reflected the subject's choice during the experiment in that decision.[12]

The fifth component was based on a randomly selected decision from tasks 3 or 4. One person per session was selected, but the selected name was not immediately revealed to the participants. Instead, along with all participants' contact information, the name was placed in an envelope that was then sealed in front of them and signed by two subjects. The envelope was stored in the laboratory and any participant could ask to have it opened when all decisions and payments were completed. This procedure was followed in order to give credibility to the promise of a later payment. Only the subjects who emailed their following choices were eligible to receive this last large payment. When the date of payment approached, the selected person was privately contacted to arrange an appointment for the payment day. The average payment per subject was 16.06€ ($19.11), of which an average 5.61€ ($6.68) per person was given immediately after the session (conversion rate at the time, 1€ = $1.19).

The procedure aimed to keep transactions costs low and constant across all possible options. Choosing the early options would not save the extra trip of coming back to the lab to retrieve the money. The large rewards were never paid immediately after the session, and were paid with at least a two-day delay. Moreover, the transaction cost of returning was paid only by the person

[12] All post-session handling of payments was done by the personnel affiliated with LEE, the Jaume I University laboratory of experimental economics. They are professors in the departments of economics. They are also involved in paying subjects for other experiments not related to the present one. Subjects had participated in other experiments of other types before and were familiar with paid economic experiments. These circumstances made it credible that the experimenter was going to honor the promise to pay in the future. Participants were periodically informed by email about how the experiment was proceeding and could also send emails to a dedicated account to inquire about the experimental procedures.

selected for payment. Payments were made in cash, hence no trip to a bank was necessary. In Task 4, pre-commitment did not save the cost of sending an email later on. In fact, only people that sent the later email at the pre-specified date could participate in the draw for the second large payment.

After signing up, all the students were informed about the payment procedures. More precisely, it was explained that everyone would receive a small payment for participating and one out of ten would be randomly chosen to receive a large payment of 100/110€, which could be delayed days or months. This had no obvious effect on recruiting, and none of the subjects explicitly canceled his or her participation because of this warning. No senior student was allowed to sign up.

Subjects were seated at computer terminals that were separated by partitions. Instructions were read aloud and questions answered. First, instructions for Task 1 were read and the corresponding decisions taken with pen and paper. Then, Task 2 through 4 instructions were read and the corresponding decisions taken via a Visual Basic PC application. Finally, a questionnaire was distributed and completed with pen and paper. No communication among subjects was allowed. All subjects received a hard copy of the instructions. Including instruction readings, a session lasted between 2 and 2.5 hours.[13]

4 RESULTS ON TIME DISCOUNTING

Subject choices on time discounting (Task 2) are summarized in Figure 4. Two major patterns emerge. First, there is wide individual diversity in the level of time discounting, with some subjects willing to wait as much as 40 times longer than others. Second, in general, subjects

[13] Sessions were run between April 26 and April 28, 2004. The actual last payment took place on May 30, 2005. In task 2, the maximum wait Δ^* was 276 days. In task 3, the front-end delay was 7-395 days and the furthest possible time of payment was 611 days.

discount future rewards quite heavily. Given a choice between 100 over 110 euros, the median subject is willing to wait at least 13 days but at most 17 days for the latter. When using annual capitalization, this median wait corresponds to discount rates between 215% and 281%.[14] For the purpose of this paper, measuring subjects' discount rates is simply an instrumental task to better elicit preferences for pre-commitment and flexibility. Still, we will briefly discuss three potentially distorting factors: liquidity constraints, implicit default risk, and misunderstanding of exponential discounting.

The discount rate implied in subject choices is rather high in comparison with the relevant credit market conditions, although not unusual in the literature.[15] For instance, a one-year car loan granted from the campus branch of a major bank was offered to students at a 7.5% interest rate. Using such a rate in the experimental design leads to a wait of at least 481 days. If access to credit is precluded, this market rate may be irrelevant. According to a bank teller interviewed, car loans were uncommon among students. More generally, Spanish undergraduates have limited access to credit cards and bank credit lines.[16]

When asked directly, experiment participants had the same perception. About 73.3% stated that their chances of getting either a bank loan or a credit card were less than 90% ("credit constraint"). About 35% stated that their chances were less than 50% ("severe credit

[14] Among the assumptions necessary to interpret this calculation as a measure of subjects' impatience are instant utility at the moment of receiving the monetary reward and linear utility function in money.

[15] Eckel et al. (2004), Table 5, for comparable levels of individual discount rates elicited through a field experiment and Frederick et al. (2002), Table 1, for an overview of rates found in the psychological and economic experimental literature.

[16] The most frequent credit line was a loan of few hundred dollars in order to pay for tuition that was granted at a 5.5% rate. The money would be given after a 3-4 day period and had to be repaid within 11 months. Credits of about 200-400 euros could be obtained to attend language classes at a 6.75% rate. The interest is compounded once a year. Students qualified for credit cards only if they had a monthly deposit in the account or a guarantee from one of their parents, but in practice credit cards were issued mostly to exchange students that went abroad. Personal communication from a bank teller of Caiman Catalonia, UAB campus branch, Bilateral, Spain, May 12, 2003.

constraint").[17] Students with credit constraints showed less willingness to wait than the others and that impact is significant at a 5% level (Table 2). Harrison et al (2002) reported a similar effect of credit constraints using a sample of the Danish population. When using just the six most significant regressors, having a loan is also a significant variable (Table 2, col. (2)), which may simply signal the absence of credit constraints.

Steep discounting of future rewards may be partly due to the implicit default risk contained in the promise of a later reward. When the earlier option is certain while the later option has a default risk of at least 0.091, a risk-neutral agent always prefers the earlier option. Subjects were asked to state their perceived risk associated to a reward in two days and in one month.[18] About 35% of the subjects expected to cash a reward with at least 99% probability in both two days and one month ("very low or no risk"). When restricted to this sub-sample, yearly interest rates for the median subject range from 109% to 140%.[19] Although substantially lower than the risk un-adjusted rates, these figures are still a far cry from market interest rates.[20] Surprisingly, when controlling for other factors, perceived risk is not significantly correlated with waiting time (Table 2). One reason may be that we use a too coarse of a measure for perceived risk.[21] Maybe subjects were just confused. One must say that participants faced simple binary choices.

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[17] Question L

[18] Questions Q and R.

[19] The median willingness to wait ranged from 26 to 33.5 days. Assume in both options no risk is involved.

[20] The difference may not be too troublesome. It may simply come from a magnitude effect, i.e. small amounts are discounted more then large amounts (Thaler, 1981, Green, Myerson, and McFadden, 1997). Impatience levels should not be computed on money amounts but on the *utility* of money. Ok and Yusufcan Masatlioglu (2003) show that the magnitude effect is compatible with the exponential discounting model, given an appropriately concave utility function. Using a different design, Coller and Williams (1999) elicit lower discount rates among college students.

[21] Also, subjects' risk attitude has little predictive power. The regression coefficients show correct signs for risk averse and risk neural subjects, but neither coefficient is significant. Moreover, other proxies for risk attitude and impatience, such as smoking or fastening seat belts, are insignificant.

Moreover, several informational aides were provided.[22] Three numerical questions were asked to measure understanding of exponential discounting. Subjects were paid for correct answers.[23] When controlling for other factors, "all correct answers" (about 29.1%) is not significant in explaining waiting time (Table 2). In conclusion, the only strong correlation found is that credit constraints lead to a shorter waiting time for the larger reward.

5 RESULTS IN CHOICE REVERSAL

A preference for a sooner-smaller reward may be reversed for a later-larger reward when a common front-end delay is added to both options (Figure 1). That is what we call choice reversal. Subject behavior with respect to choice reversal is summarized in Figure 5 (Task 3).

About 10% of the subjects were always consistent. These subjects either had a low discount rate or never reversed their choice. About 65% of the subjects reversed their choice. For the median subject in that group, it took a front-end delay of 42 days before she reversed her Task 2 choice. Kirby and Herrnstein (1995) report choice reversal for an even higher proportion of subjects. Subjects in the category "hard to classify" were either the victims of software problems or exhibited erratic behavior.[24] A large portion of it is most likely due to calendar effects, the inability or unwillingness to cash the reward on a particular day because of events such as birthdays, examination, or traveling out of town. All public festivities and vacations were not

[22] Information includes the delay difference in days, the calendar date for each option, including the day of the week, the amount difference in euros, the annual discount rate, and a graphical representation of the wait in the form of line of asterisks proportional to the length of the delay.
[23] Questions S, T, U. A hand calculator was provided. Fifty cents was paid for each correct answer. Wagenaar and Sagaria (1975) reports a poor ability of subjects to forecast exponential growth.
[24] See note to Figure 5 for the breakdown. An example of erratic behavior is when a subject ended Task 2 confirming their choice for the sooner-smaller reward A1. On the first decision of Task 3 she jumped to the later-larger reward A2, hence showing choice reversal. She did not confirm that (A1 choice), but later chose A2 again, and eventually ended up confirming A1, hence a consistent choice.

proposed as possible dates, but important subjective events were difficult to identify. Notably, there is no evidence that "hard to classify" subjects are confused or unskilled students.[25]

Factors that may explain choice reversal are explored in the probit regression of Table 3. Extremely high discounters reverse their choices more often. The behavior of extremely high discounters may be derived from a preference for immediacy due to either impatience or high default risk of a promise in the very first week. Low discounters, instead, reverse their choices significantly less than average. To interpret this latter result one must consider that the experiment was truncated at a fixed date. Many low discounters may have eventually reversed their choice if a long enough front-end delay was allowed. Default risk may have played a role as well, especially in evaluating a scenario before or after the summer break. From the results, one concludes that either that role was minor or not working in the direction of choice reversal.[26] The significant impacts of two other variables, "not working" and "wearing seat belts," have unclear interpretations.

The experimental design adopted presents both advantages and drawbacks. For each subject it allowed us to elicit with good precision the minimum front-end delay that induced choice reversal. Customizing options for each subject was extremely useful, as individual discount rates were so diverse (Figure 4). This was instrumental in measuring preferences for pre-commitment. Still, we did not force choice reversal on subjects, as we set a reasonable maximum delay for payments after which the experiment stopped. A drawback of the design is the possibility that subjects manipulated the procedure. In task 2, just one randomly selected decision was paid. Hence, the longer the sequence of decisions, the worse was the expected payment in terms of

[25] There is no systematic correlation between being "hard to classify" and being inconsistent in risk attitude choices (Task 1), or getting all discounting questions wrong, or having a low admission score to college (nota de selectividad), or lacking to send an email in Task 6. These results come from an unreported probit regression.
[26] While 16 people did reverse their choice with as little as 7 days of front-end delay, about 28 people required more than 70 days, which, given the timing of the sessions, post-poned both rewards to after the summer.

delay. As a consequence, there was a slight incentive to reveal a higher discount rate than the truthful one. To do that, a subject needed to know how the algorithm generated subsequent decisions. Those details were not explained in the instructions, and nobody asked about them. Still, after the first session, some subjects may have had contact with future participants and explained their understanding of the algorithm. That would have had to be done quickly, though, between two and fifty-two hours after the session. There is little evidence in the data about this session contagion effect. Session dummies in Table 2 show no significant effect on waiting time.

For task 3, there is an analogous potential bias, as the payment scheme was similar. There was a slight incentive for subjects to reverse their choice.[27] Again, there is little evidence in the data about a session contagion effect. Session dummies in Table 3 show no significant effect on the fraction of choices reversed. Still, one may believe that this bias is the main force behind the results, and we simply failed to detect it. This would imply that the subjects were, in truth, exponential discounters. If that is the case, the adopted design is biasing the results *against* expressing preferences for strict pre-commitment. Hence, if a fraction of subjects do pre-commit, that has to be interpreted as a lower-bound for the true preferences for pre-commitment. That brings us to the next section.

[27] Andersen et al. (2005) study the impact of an *iterative* multiple price list format, which presents similarities and differences with the method adopted for this work. They found no significant difference in discount factor elicitations in comparison with a standard multiple price list format.

6 RESULTS IN PREFERENCES FOR FLEXIBILITY AND PRE-COMMITMENT

Choices to elicit preferences for flexibility and pre-commitment (task 4) are listed in Table 1.[28] The results presented here are the most novel and allow us to tentatively classifying subjects into types. This section focuses exclusively on those subjects that did reverse their choice in Task 3. Such subjects had first stated to prefer (100, 2) to (110, Δ*) and then to prefer A1=(110, t_1^*+Δ*) over A2=(100, t_1^*+2). In Task 4 the choice was between the set {A1, A2} and the single option {B2}, where a subject selecting {A1, A2} knew that exactly after a delay t_1^* she would need to select either A1 or A2. In choices eliciting strict pre-commitment, the option B2 was made less attractive than in Task 3 (decisions 7, 10), while in choices eliciting flexibility, option A2 was made less attractive than in Task 3 (decisions 6, 8, 9, 11).

When pre-commitment is costless (A2=B2, question 5), a large portion chose to do so (61.5%). Remember that in question 5 the top option A2 was available both with and without pre-commitment. When either a time or a monetary cost was added, the preference for pre-commitment dropped considerably.[29] For instance, 23.1% of the subjects that reversed their choice were willing to wait three extra days in order to pre-commit (question 10).

There exists also a taste for flexibility, which is evident in the choice of {A1, A2} in questions 6, 8, 9, 11, which ranges from 3.9% to 18%. The maximum percentage is reached when A2 had an extra delay of three days.

Preference for soft pre-commitment was also studied. Such decisions present a set {A1, A2} versus a set {B1, B2}, where B2=A2 and option B1 was made less attractive than A1 (decisions 1, 2, 3, 4). Although some scholars have found soft pre-commitment more appealing than strict

[28] Two additional decisions were made at the end of Task 4, which are not listed in Table 1 because are not relevant for the present analyses: (12) A1=(t_1*+2, 100 – 5), A2=(t_1*+Δ_3*, 110), B=(t_1*+2, 110 – 6) and (13) A1=(t_1*+2 + 2, 100), A2=(t_1*+ Δ_3* + 2, 110), B=(t_1*+ Δ_3* + 2, 110)

[29] In the design of the experiment the cost was arbitrarily chosen and hence a different cost would have yielded a different choice pattern. A lower cost to pre-commit may have resulted in higher levels of pre-commitment choices.

pre-commitment (Rachlin, 2000), in this study it was somewhat less popular. Choices ranged from 7.7% to 17.9%, which was always less than choices for strict pre-commitment.[30]

Using Task 4 questions, subjects were classified into three types. Subjects that expressed a preference for strict pre-commitment in either questions 7 or 10 were placed in one category. Subjects that expressed a preference for flexibility in at least one question among 6, 8, 9, and 11 were placed in a second category. The remaining subjects were in the third category. If a subject was sometimes in favor of flexibility and sometimes in favor of pre-commitment, she was assigned to the third category. This procedure yielded 23.1% of the subject as preferring to pre-commit, 24.3% as preferring flexibility, and 52.6% falling into the in-between category (Figure 5).[31]

Smokers that never tried to quit were the ones most likely to have a preference for pre-commitment. This finding is weakly significant when we control for other factors (Table 4).[32] Apart from that, no other strong regularities emerge from the probit regression in Table 4, except that subjects with a loan are more likely to pre-commit.

Among the subjects with a preference for flexibility, there were many subjects willing to wait more than 60 days and many subjects that answered correctly all of the exponential discounting questions. In a sense, the further away the future is and the more difficult it is to predict your cash needs, the more a subject may want to keep her options open. Yet neither the absence of

[30] In particular, it is puzzling the comparison between questions 1 and 5 (and to a lower extent question 3 and 7). This difference cannot be explained with differential in transaction costs because, irrespectively of their choice, subjects had to send an email at a later date in order to be eligible for payment. If the choice was to pre-commit, the email simply confirmed that choice.

[31] A reclassification using both soft and strict pre-commitment decisions yields 14 subjects with a strict preference for flexibility and 31 subjects with some preference for pre-commitment.

[32] It is intriguing to relate a subject's time decisions with stated smoking habits. When we do not control for other factors, former smokers were willing to wait considerably longer than all others (median value) and reversed their choices less frequently. Interestingly enough, those who tried, unsuccessfully, to quit smoking were the most likely to reverse their choices and the least likely to pre-commit. One may suspect many naïve types are among them, inconsistent and yet blissfully unaware of it.

implicit default risk nor risk attitude significantly impacts preferences for flexibility. Oddly, subjects with a very short willingness to wait for the larger amount are also more likely to have a preference for flexibility. It may be simply a "weekend effect," as subjects want to have cash before the following weekend and will opt for the immediate reward if no other source is found in the meanwhile, but will postpone otherwise.

The last task for the subjects was to communicate their choice, or to confirm it, at a later, pre-specified date (Task 6). A total of 77 of the subjects responded by phone or email, which was 64.2% of the sample. The response rate was moderately higher for subjects that did reverse their choice (about 5 percentage point difference).[33]

Table 5 summarizes response rates and choices for the subjects that did reverse their choice in Task 3. In questions 1-5, 7, and 10 subjects chose A1=(100, 2) over A2=(110, Δ*) during the session, and then, after a delay t_1^*, faced the exact same choice set in the email decision. If nothing changed, we should again observed 100% of A1 choices. Instead, on average, only between 24.4% and 50% of this subset chose A1. While the magnitude of this change may have been influenced by the self-selection of the subsample, other factors are probably at work as well. We do not have a clear explanation for this phenomenon. Several interpretations could be put forward, including (a) the liquidity constraints or wealth position of the subjects may have changed; (b) changes in perceived default risk of rewards; (c) procedural difference between cross-sectional versus longitudinal design; (d) confounding effects due to post-session interaction among subjects; (e) unstable time preferences;[34] (f) others.

[33] The emails of some people were unclear and so the number of useful replies is somewhat lower than 77 (for instance, in question 6, 73 clear replies out of 120 total subjects; 50/78 for subjects that did reverse choice, and 24/42 for others). It was explained that only replies arriving within two days before or after the specified day would be considered valid. Almost all of the responses were received on the specified day.

[34] If time preferences are unstable, it is possible the subjects that did not reverse their choices in the first place, may do it after a delay. That may lead to a *net increase* the fraction of subjects that reverse their choice after a delay.

7 CONCLUSIONS

Behavioral economists have recently questioned the validity of exponential discounting as a descriptive model of intertemporal choices, in particular the application of the same discount factor to both short-term and long-term horizons (Thaler, 1981, Pender, 1996, Chapman, 1996, Benzion et al., 1989, Ainslie and Haendel, 1983). In this study we do not test for the best functional form of discounting[35] but instead examine a more fundamental question: why many subjects do reverse their choices over time. We provide novel experimental evidence that helps to clarify whether choice reversal is a preference-based or an uncertainty-based phenomenon.

We carried out an experimental study where monetary rewards were offered and paid with an actual time delay. The participants had the opportunity to pre-commit or opt for flexibility. A novel aspect of the design is that pre-commitment and flexibility are studied jointly. We find three main results.

First, the canonical model of exponential discounting can account for about one third of all choices. Participants face binary choices of a sooner-smaller reward versus a later-larger reward. About 65% of them initially choose the sooner-smaller reward and reverse that stated preference is favor of the later-larger reward when a front-delay in added to both options. That is a direct violation of the predictions of the canonical exponential discounting model and confirms findings from previous studies (Kirby and Herrnstein, 1995, Kirby, 1997, Ainslie and Haendel, 1983).

Second, there is demand for pre-commitment. Preference for pre-commitment is defined as willingness to pay a cost to restrict the size of the choice set available in the future. Among the subjects that do reverse their choices in our experiment, about 23% choose to pre-commit. In

[35] For instance Benhabib et al. (2005) and Tanaka et al. (2005) compare quasi-hyperbolic discounting with other functional forms.

other words, we report evidence that support preference-based models of choice reversal and, more specifically, of a significant share of "sophisticated" decision makers (Laibson, 1997, Gul and Pesendorfer, 2001, Phelps and Pollack, 1968). The actual share in the population may be larger than one quarter for cheaper pre-commitment technologies and different patterns of uncertainty.

The second contribution of the paper is to rule out that uncertainty is the *only* motive for choice reversal over time. No uncertainty-based explanation (Sozou, 1998, Azfar, 1999, Dasgupta and Maskin, 2005, Fernandez-Villaverde and Mukherji, 2000) predicts pre-commitment choices, which we report. Hence, augmenting the exponential discounting model with elements of uncertainty about the agent's own survival, the implicit risk of rewards, or other future events cannot fully account for subjects' intertemporal choices.

The third contribution is to show that uncertainty about future states *is* an empirically important motive in choice reversal. Although uncertainty-based models are insufficient to account for all the evidence against exponential discounting, they are able to explain a much wider portion of the data. Such models, though, can be hard to falsify directly because one can always rationalize *any* discount function invoking an unobserved subjective perception of risk. Our empirical tests exploit the model predictions about choices on sets of alternatives. In particular, there should be no demand pre-commitment and there may be demand for flexibility. Preference for flexibility is defined as willingness to pay a cost to enlarge the choice set available in the future. Among the subjects that do reverse their choices in our experiment, about 24% do value flexibility, which constitutes direct evidence in support of the class of uncertainty-based explanations.[36]

What emerges from this study is a multiplicity of subject types with respect of time preferences, where some subjects do not reverse their choices, some do reverse their choices and want to pre-commit, some reverse their choices and have a preference for flexibility, and some reverse their choices but are unwilling either to pre-commit or to pay for flexibility. This latter category is actually the largest one, as it represents 34% of the participants. Those could be decision makers with either a "mild" level of implicit risk for future options or "naïve" subjects that are unaware of their time inconsistency. Given that the uncertainty-based and preference-based explanations are not mutually exclusive, a descriptive model of intertemporal choice may eventually include elements from both explanations.

APPENDIX

Consider an agent comparing alternative consumption profiles, $\underline{c} = (c_o, c_1, \ldots, c_T)$ that spread consumption among discrete time intervals between today (t=0) and period T under the budget constraint $K = \Sigma_{t=0,..,T}\ (1+r)^t\, c_t$, where r is the interest rate of the available saving technology. The immediate utility of consumption is given by $u(c_t)$, which is increasing in consumption, $u' > 0$. The present utility U_0 of consumption profile $\underline{c}$ is:

$$U_0(\underline{c}) = \Sigma_{t=0,..,T}\ \boldsymbol{\lambda}(\mathbf{t})\ \mathbf{s}(\mathbf{t})\ u(c_t) \qquad (1)$$

The present value depends on a discount function $\boldsymbol{\lambda}(\mathbf{t})$ and on a survival function $\mathbf{s}(\mathbf{t})$. The discount function measures time preferences of the agent: $0 \leq \boldsymbol{\lambda}(\mathbf{t}) \leq 1$ indicates today's utility value of one unit of utility delayed t periods (impatience). The survival function specifies the probability that the reward can be realized after a delay of t periods. Hence in this class (1) of intertemporal models, *time discounting* is the product of two components - the level of impatience embedded into the *time preferences,* $\boldsymbol{\lambda}(\mathbf{t})$, and the *survival uncertainty,* $\mathbf{s}(\mathbf{t})$, which may relate either to the credibility of a promise of a future reward, to the survival of the decision maker itself, or to both. Although this class includes an infinite number of models, we focus on three models only, exponential, augmented-exponential, and hyperbolic discounting models. These models have received considerable attention in the literature and their predictions are summarized in Table A1.

[36] The perceived additional risk associated to the later reward was elicited in the experiment but turned out to be not correlated with actual choice reversal or preference for flexibility behavior. Such lack of direct correlation is surprising, although it may reflect the imprecision of the elicitation procedure.

The exponential discounting model is a special case of (1) where $\lambda(t) = \delta^t$ and the future consumption level is achieved with certainty, $s(t) = 1$. In the exponential model, δ is the *discount factor* is $0 \leq \delta \leq 1$ while the *discount rate* $r = (1-\delta) / \delta$. The exponential model is regarded as a useful normative model. Without uncertainty, an exponential discounter will never reverse her choices.

To rationalize the empirical evidence of choice reversal, scholars have proposed discount functions that embed a present-bias in time preferences. An appropriate function $\lambda(t)$ can represent a decision maker with a lower discount rate for short horizon than for long horizon choices. As pointed out by Strotz (1955– 56), in any discounting model that is present-biased, an agent establishes a plan of future actions today but may deviate from it in the future. A descriptive model in this category which is widely used in the psychological literature is hyperbolic discounting, $\lambda(t) = 1/(1 + k\,t)$. Economists have mostly used a simplified version of this, quasi-hyperbolic discounting, which was originally proposed by Phelps and Pollak (1968) and has been brought back to scholars' attention by Laibson (1997), $\lambda(t) = \beta\delta^t$ if $t > 0$ and $\lambda(t) = 1$ if $t = 0$. The quasi-hyperbolic discounting model has the advantage of being analytically tractable and of adding just an extra parameter, $0>\beta>1$. In both models, future consumption levels are achieved with certainty, $s(t) = 1$. An axiomatic approach for non-exponential time preferences is presented in Ok and Masatlioglu (2003).

$$U_0(\underline{c}) = \Sigma_{t=0,..,T}\ [1/(1 + k\,t)]\ u(c_t) \qquad (2)$$

An entirely different explanation for choice reversal is based on the survival probability. Sozou (1998) presents a model where the agent is infinitely patient, $\lambda(t) = 1$, and the only component of time discounting is the risk of mortality, $s(t)$. The risk that a reward which is still available after a delay of t is lost between t and t+1 is the hazard rate, $h(t) = [s(t)-s(t+1)]/s(t)$. When considering marginal rates of intertemporal substitutions, his model can be observationally indistinguishable from either the exponential or the hyperbolic models. In particular, the exponential model is equivalent to a situation where the hazard rate h(t) has a constant value. Instead, a present-biased time-preference model is equivalent to a survival model where the hazard rate falls with increasing delay t. Important real situations are characterized by declining hazard rates, for instance students dropping out during their first years in high school (Mortenson, 1999) or start-up firms going bankrupt in several countries, including the US, Germany, Italy, and France (Bartelsman et al., 2003). Whenever hazard rates are declining the decision maker may reverse her choice, yet be time consistent. Trivially, the hyperbolic discounting model is equivalent to $\lambda(t) = 1$ and $s(t) = 1/(1 + k\,t)$. A more subtle result of Sozou (1998) is to show that if the decision maker has a prior belief over her hazard rate, she may exhibit diminishing time discounting. Given a constant hazard rate but a subjective uncertainty over its actual value generates diminishing time discounting. This result is remarkably robust to the specific probability distribution over the prior belief. Azfar (1999) extended this result to the case of exponential time preferences (3, augmentment-exponential):

$$U_0(\underline{c}) = \Sigma_{t=0,..,T}\ \delta^t\, s(t)\, u(c_t) \qquad (3)$$

Halevy (2005) extended it further by showing that, under some conditions, there may be diminishing time discounting even when the hazard rate is increasing in t. Increasing hazard rates are particularly relevant when the risk involved is physical survival. Life table statistics for developed countries exhibit sharply increasing hazard rates of mortality in age (U.S. National Center for Health Statistics, 2004). When the time horizon is relatively short, the most relevant issue is not the survival of the decision maker but the implicit default risk in delivering the promised reward (Benzion et al., 89). For example, suppose you paid in full for five years of electric energy supplied by Enron and the company went bankrupt in the meanwhile.

To disentangle models (2) from (3) using empirical data one can focus on the role of uncertainty and the preferences for pre-commitment. The augmented-exponential model (3) predicts choice reversal or no choice reversal for different categories of distributions of uncertainty. A survival probability with a constant or increasing hazard rate is incompatible with choice reversal. A declining a hazard rate, instead, may or may not lead to choice reversal. Still, even if there is evidence that the survival probability **s(t)** in model (3) is characterized by a constant hazard rate, choice reversal cannot be taken as a proof of time inconsistent behavior. One can always argue along the lines of Sozou (1998), Azafar (1999) and Halevy(2005) that prior beliefs about the hazard rate may rationalize the choice. As those prior beliefs are subjective and unobserved, model (3) turns out to be very hard to falsify using choice reversal data alone, even when survival probabilities are known.

A more indirect route to compare the models is to assess the overall level of uncertainty of future rewards, s(0)-s(T). The following implications allow a partial comparison between the exponential versus the augmented-exponential models:

a) If impatience levels and survival probabilities are independently distributed, there may be some choice reversals when there is positive uncertainty and none with certainty, i.e. s(t)=1. In the latter case, if the hazard rate of uncertainty is non-decreasing there will still be no choice reversals.

b) The higher the level of uncertainty the more risk attitude influences the discount rate. Assuming that s(t) and risk aversion are independently distributed, risk averse agents should exhibit a higher discount rate than risk neutral agents.

One crucial difference between uncertainty-based and preference-based explanations of choice reversal is the demand for pre-commitment technologies. Consider an agent with preferences defined on sets of consumption profiles $\{y, x_1, x_2,.. , x_n\}$ and where today (t=0) {y} is preferred to any $\{x_i\}$, i=1,…,n. An agent has a preference for pre-commitment if she prefers {y} to any $\{y, x_i\}$. Although y is the most preferred consumption profile today, the agent may switch to x_i at a future date. A switch is a choice reversal. We say that an agent has *strict preferences for pre-commitment* when she chooses to pay a positive price to restrict her choice set from $\{y, x_i\}$ to {y}. Gul and Pesendorfer (2001) have presented an axiomatization of agents subjected to self-control problems. On the contrary, we say that an agent has *strict preferences for flexibility* when she chooses to pay a positive price to expand her choice set from {y} to $\{y, x_i\}$. An exponential discounter should be indifferent between choice sets $\{y, x_i\}$ and {y}. Depending on the type of agent, we have the following predictions for the exponential, augmented-exponential, and hyperbolic discounting models:

c) The hyperbolic discounting model in the sophisticated version is compatible with demand for strict pre-commitment; the other models are not compatible with it.

d) The augmented-exponential model is compatible with demand for flexibility; the other models are not compatible with it.

Table 1: Preferences for pre-commitment and flexibility

	OPTION A				OPTION B				% B choices
	A1		A2		B1		B2		
	Delay, t	Amount, €	Delay, t	Amount, €	Delay, t	Amount, €	Delay, t	Amount, €	N=78
SOFT PRE-COMMITMENT									
1. Monetary cost, low	t_1^*+2	100	$t_1^*+\Delta^*$	110	t_1^*+2	**100 – 2**	$t_1^*+\Delta^*$	110	**12.8%**
2. Monetary cost, high	t_1^*+2	100	$t_1^*+\Delta^*$	110	t_1^*+2	**100 – 6**	$t_1^*+\Delta^*$	110	**7.7%**
3. Monetary cost, high	t_1^*+2	100	$t_1^*+\Delta^*$	110	t_1^*+2	**100 – 6**	$t_1^*+\Delta^*$	**110 – 2**	**10.2%**
4. Time cost, low	t_1^*+2	100	$t_1^*+\Delta^*$	110	t_1^*+2 + **5** (1)	100	$t_1^*+\Delta^*$	110	**17.9%**
STRICT PRE-COMMITMENT									
5. No cost	t_1^*+2	100	$t_1^*+\Delta^*$	110			$t_1^*+\Delta^*$	110	**61.5%**
7. Monetary cost, low	t_1^*+2	100	$t_1^*+\Delta^*$	110			$t_1^*+\Delta^*$	**110 – 2**	**17.9%**
10. Time cost, low	t_1^*+2	100	$t_1^*+\Delta^*$	110			$t_1^*+\Delta^*$ + **3** (3)	110	**23.1%**
FLEXIBILITY									
6. Monetary gain, low	t_1^*+2	100	$t_1^*+\Delta^*$	**110 – 2**			$t_1^*+\Delta^*$	110	**87.2%**
8. Monetary gain, low	t_1^*+2	**100 – 2**	$t_1^*+\Delta^*$	**110 – 2**			$t_1^*+\Delta^*$	110	**96.1%**
9. Time gain, low	t_1^*+2	100	$t_1^*+\Delta^*$ + **3** (3)	110			$t_1^*+\Delta^*$	110	**82.0%**
11. Time gain, low	t_1^*+2 **+ 5** (3)	100	$t_1^*+\Delta^*$ + **5** (4)	110			$t_1^*+\Delta^*$	110	**89.7%**

Notes: Percentage of B choices is based only on subjects who did reverse their choices (N=78); Notes on timing of options offered: (1) B4abdelay; [5 or 7] one exception 31 days; T-2 is always bigger than this amount; (2) B9abdelay; [2,3,4] two exceptions 18 and 46 days; (3) B11adelay; [1-7] one exception 32 days and nine exceptions of 0 days; no crossing over of the earlier option A1 on either A2 or B; (4) B11abdelay; [5-8] five exceptions 46 and 50 days.

Table 2: What can explain time discounting?

Dependent variable: willingness to wait in days	(1)	(2)
Credit constraints	-31.3502 (15.3630)**	-27.5008 (13.5024)**
No or very low risk	16.5159 (13.5376)	13.6165 (12.6841)
Risk neutral or risk seeking subject	15.6532 (17.5820)	
Risk averse subject	-15.0113 (18.7959)	
Not working	-14.2973 (13.5946)	
No loans	-23.6868 (18.2746)	-33.2019 (15.7380)**
Male	0.0133 (13.7663)	
Smoker, never tried to quit	-0.8868 (18.4721)	
Never smoked	-11.7516 (14.0100)	
Wears seat belts in front and back seats	-2.0164 (14.2565)	
All discount answers correct	13.8828 (15.3513)	18.9746 (13.3431)
Session 2	-26.8425 (23.0791)	
Session 3	-43.0460 (22.7054)*	-26.1607 (16.3165)
Session 4	-23.6455 (23.3089)	
Session 5	-28.3012 (22.3267)	-13.3698 (16.3408)
Session 6	9.7528 (22.0798)	
Constant	105.0070 (28.7751)***	82.0139 (19.5001)***
Observations	120	120
R-squared	0.17	0.11

Notes: OLS regression, Stata program, Standard errors in parentheses. A subject is classified as risk averse if she showed consistency in lottery choices and switched to option B in decision 8, 9, or 10 (Task 1 description in Section 3). A subject is classified as risk neutral/seeking if she showed consistency in lottery choices and switched to option B in decision 1,2,3,4, or 5. Smoking questions N and O; seat belts (questions P, always when in front, frequently or always when in the back seat). No loan (question I=4, not even from parents) Not working (question G, not even part time). * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3: What can explain choice reversal?

Dependent variable: 1=subject that reversed choice, 0=all other subjects	(1)	(2)
0-4 days (extremely high discounters)	1.3777 (0.6689)**	1.1669 (0.5875)**
5-7 days	0.0582 (0.4143)	
8-14 days	--	
15-30 days	0.1134 (0.4249)	
31-60 days	0.5546 (0.4695)	
> 60 days (low discounters)	-0.9320 (0.4829)*	-1.0783 (0.3775)***
Credit constraints	-0.0627 (0.3594)	
No risk or very low risk	0.0240 (0.3062)	
Risk neutral or risk seeking subject	-0.3869 (0.3975)	
Risk averse subjects	-0.2470 (0.4204)	
Not working	-0.7253 (0.3257)**	-0.6944 (0.2864)**
No loans	0.6412 (0.4140)	0.3059 (0.3505)
Male	-0.1009 (0.3071)	
Smoker, never tried to quit	-0.1126 (0.3180)	
Never smoked	-0.5097 (0.4114)	-0.2579 (0.3424)
Wears seat belts in front and back seats	0.4723 (0.3191)	0.4613 (0.2711)*
All discount answers correct	-0.2362 (0.3405)	
Session 2	-0.2668 (0.5166)	
Session 3	0.2333 (0.5033)	
Session 4	-0.5843 (0.5091)	
Session 5	-0.3750 (0.5005)	
Session 6	-0.5058 (0.5117)	
Constant	0.7419 (0.6653)	0.5394 (0.3424)
Observations	120	120

Notes: see notes to Table 2. Probit, See notes to Table 2, Standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: What can explain pre-commitment and flexibility?

Dependent variable:	1=subject did *pre-commitment*, 0=others		1=subject with preference for *flexibility*, 0=others	
	(1)	(2)	(3)	(4)
0-4 days (extremely high discounters)	0.0963 (0.6855)		0.9639 (0.8696)	1.0695 (0.5665)*
5-7 days	0.3185 (0.6031)		1.2080 (0.7510)	1.0910 (0.4950)**
8-14 days	--		--	
15-30 days	-0.3332 (0.7261)		0.8922 (0.8362)	0.6677 (0.5441)
31-60 days	-0.0387 (0.6115)		-0.1602 (0.7613)	
> 60 days (low discounters)	(A)		1.8403 (0.9346)**	1.5016 (0.6331)**
Credit constraints	-0.0352 (0.5026)		0.1256 (0.5980)	
No risk or very low risk	-0.3139 (0.4574)		0.1445 (0.4530)	
Risk neutral or risk seeking subject	0.0839 (0.7226)		-1.2465 (0.8707)	-0.7031 (0.6348)
Risk averse subjects	0.3914 (0.6364)		-0.9242 (0.9711)	
Not working	-0.4770 (0.4347)	-0.4056 (0.3875)	0.3700 (0.5365)	
No loans	-0.8521 (0.6090)	-0.9031 (0.4866)*		
Male	-0.5343 (0.4760)	-0.5383 (0.3782)	-0.0746 (0.5405)	
Smoker, never tried to quit	0.7877 (0.5413)	0.8765 (0.4752)*	-0.5235 (0.6493)	
Former Smoker	-0.2630 (0.7303)		0.6783 (0.8825)	
Tried to quit unsuccessfully	-0.6289 (0.5238)	-0.6367 (0.4666)	0.0071 (0.5612)	
Wears seat belts in front and back seats	-0.0209 (0.4672)		-0.5195 (0.5893)	
All discount answers correct	0.0377 (0.5296)		1.6990 (0.6107)***	1.2785 (0.4220)***
Session 2	-0.3304 (0.7144)		0.6395 (0.7608)	
Session 3	-0.2265 (0.6913)		-0.6597 (0.9066)	
Session 4	-0.0755 (0.7411)		-0.2648 (0.7805)	
Session 5	1.1017 (0.6907)	1.2894 (0.4627)***	0.1800 (0.7454)	
Session 6	-0.6644 (0.7658)		0.5423 (0.7703)	
Constant	0.5224 (0.9048)	0.2182 (0.5005)	-1.9662 (1.1900)*	-1.6498 (0.3862)***
Observations	78	78	78	78

Notes: Subject coding for pre-commitment based on questions 7, 10 and for flexibility based on questions 6, 8, 9, 11 as in Figure 5. See notes to Table 2. (A) in (1) "31-60 days" and "> 60 days" were just one dummy variable because "> 60 days" was perfectly correlated with no commitment. Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%, Probit.

Table 5: Second email choice. Subjects that did reverse their choice only.

	Initial Choice (% B in Task 4)	FREQUENCY OF SECOND EMAIL CHOICE (Task 6)			
		A		B	
		Reply rate|A	A1|A	Reply rate|B	B1|B
	(1)	(2)	(3)	(4)	(5)
SOFT PRE-COMMITMENT					
1. Monetary cost, low	*12.8%*	61.8% *	33.3% *	50.0%	0.0%
2. Monetary cost, high	*7.7%*	58.3% *	31.0% *	83.3%	0.0%
3. Monetary cost, high	*10.2%*	58.6% *	24.4% *	75.0%	16.7%
4. Time cost, low	*17.9%*	56.3% *	27.8% *	78.6%	9.1%
STRICT PRE-COMMITMENT					
5. No cost	*61.5%*	46.7% *	50.0%	70.8% *	-
7. Monetary cost, low	*17.9%*	57.8% *	32.4% *	71.4%	-
10. Time cost, low	*23.1%*	58.3% *	25.7% *	61.1%	-
FLEXIBILITY					
6. Monetary gain, low	*87.2%*	90.0%	77.8%	58.8% *	-
8. Monetary gain, low	*96.1%*	33.3%	100.0%	62.7% *	-
9. Time gain, low	*82.0%*	57.1%	50.0%	60.9% *	-
11. Time gain, low	*89.7%*	25.0%	50.0%	64.3% *	-

Notes: (*) percentages based on more than a total of 30 subjects

Appendix Table A1: Summary of Predictions

	Exponential time preferences $U_0(\underline{c}) = \Sigma_{t=0,..,T}\ \delta^t u(c_t)$	Exponential time preferences with uncertainty $U_0(\underline{c}) = \Sigma_{t=0,..,T}\ \delta^t s(t)\, u(c_t)$	Hyperbolic time preferences $U_0(\underline{c}) = \Sigma_{t=0,..,T}\ [1/(1 + k\, t)]\, u(c_t)$	
			Naïve	Sophisticated
Choice reversal over time	NO	NO/YES	YES	YES
Strict preference for pre-commitment	NO Indifferent	NO Indifferent or preference for flexibility	NO Indifferent	YES

Figure 1: Discount rates and choice reversal (Task 2 and Task 3)

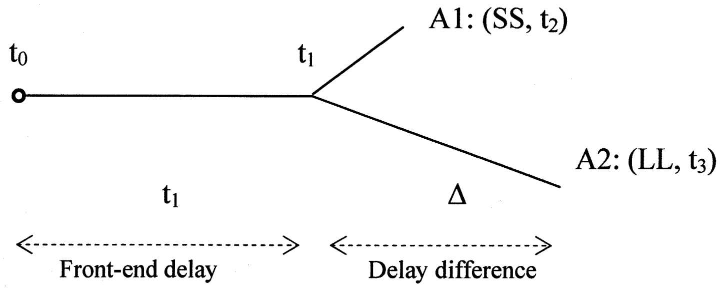


Figure 2: Soft pre-commitment (Task 4)

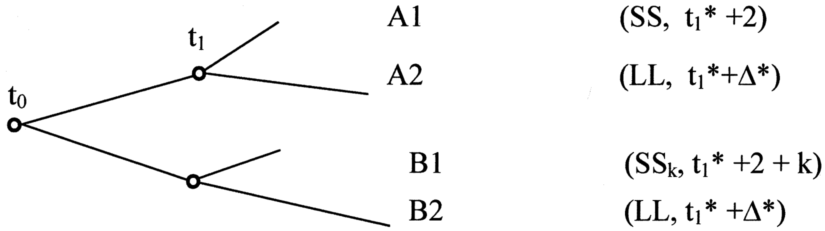
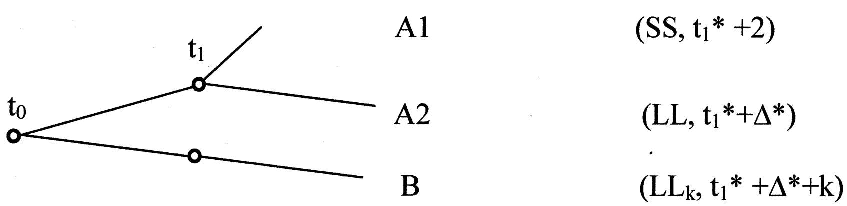


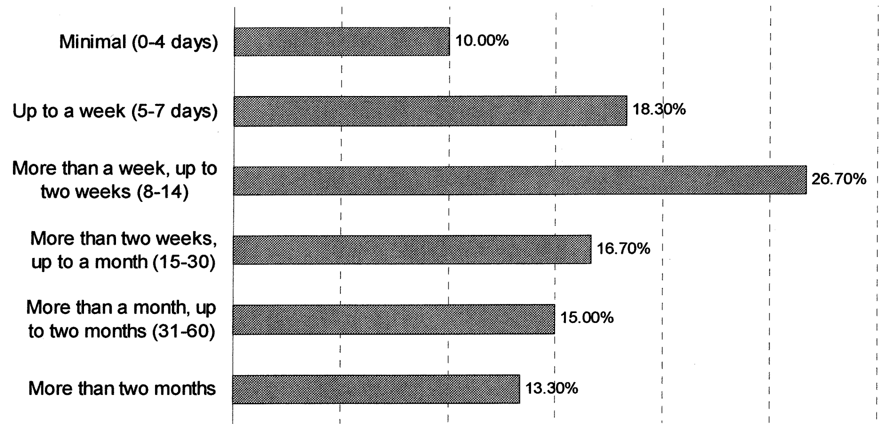
Figure 3: Strict pre-commitment (Task 4)



Notes: $k \geq 0$, $SS_k \leq SS$, $LL_k \leq LL$; Both t_1* and Δ_3* as determined in Tasks 2 and 3.

Figure 4:

Individual time discounting: minimum willingness to wait for 110 euros versus 100 euros



Note: Number of subjects: 120. The waiting time tabulated is a lower bound to the willingness to wait. For 90% of the subjects it is elicited with an approximation of 8 days or less. The distribution is censored because there was a maximum at about 250 days to how much subjects could wait in the experiment.

Figure 5: Choice reversal and a tentative classification of subjects

No choice Reversal	Choice Reversal			Hard to Classify
12 (10%)	78 subjects (65.0%)			30 (25.0%)
	Preference for Flexibility	Preferences neither for flexibility nor pre-commitment	Preferences for Pre-commitment	
	19	41	18	

Notes: Total no. of subjects 120. "No choice reversal": max 395 days of front-end delay allowed in Task 3; it includes 6 subjects always preferred A2 in Task 2. "Hard to classify": 7 subjects were excluded because the software package did not handle properly the transition from task 2 to task 3 while 23 had choice patterns difficult to interpret because they did not confirm their final choice, or had various switches back and forth. The classification in pre-commitment/flexibility types is based on questions 6-11 from Table 4; see section 6 for details.