OXFORD

Oxford Open Economics, 2022, **1**, 1–12

https://doi.org/10.1093/ooec/odac006
Advance access publication date 7 October 2022
Research Article

Intertemporal planning with subjective uncertainty: anticipating your lazy, disorganized self

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Abstract

We investigate intertemporal planning problems as a way of gaining understanding of the characteristics of individual decision-makers and the choice options presented to them. A frequent simplifying assumption that is made in studies of this sort is that choice of options that yield lower monetary payments than other available options is suboptimal, but consideration of subjective uncertainty in fulfilling requirements to obtain future payments easily disposes of this notion. For example, if one chooses an option in which one pays zero interest for a year on a purchase but then fails to pay the item off before high interest charges kick in, this would be considered suboptimal, compared with paying the item off up front, or in some other fashion. The important point is that what makes an action optimal or suboptimal is often contingent on information that is essentially unobservable, specifically, the probability that one will fail to pay the item off in time. In the experiment, we make inferences about subjective uncertainty based on the choices one makes.

Keywords: intertemporal planning, dual selves, subjective uncertainty

INTRODUCTION

For analytical tractability, economic theory posits idealized rational decision-makers who are able to efficiently process information, evaluate alternatives and assign utility values in a precise fashion. No one, including economic theorists, actually believe that human beings are generally so constructed, but such modeling of decision-making is a useful starting point, provided that the general notion that humans have reasonably well-defined objectives that they work systematically, if imperfectly, to achieve is correct. Under such a scenario, the implications of economic theory seem to remain intact. Demand curves will still be downward sloping provided that people are rational in the most basic way, buying less as the price rises.

This paper is about intertemporal decision-making. What does it mean to be rational in intertemporal decision-making? The essential result on intertemporal choice in economic theory is that it is rational to discount future payments at a constant rate. That is, anything other than a constant subjective rate of time preference make a decision-maker vulnerable to money-pump arguments that, logically, render such preferences untenable, if having more money is preferred to having less, as a minimal assumption on preferences. The logical inconsistencies associated with non-constant discounting were first explored by Strotz (1955), and the tendency of some people (and rats, too) to discount in a non-constant manner have been documented in many experimental studies since then. The story, told by Thaler (1981), that I might prefer an apple today over two apples tomorrow but that I would more likely prefer two apples in 2 weeks and 1 day to one apple in 2 weeks has been used to motivate the idea of hyperbolic discounting. Thaler (1981), Benzion et al. (1989), Mischel (1966, 1974) Mischel & Ebbenson (1970) and Ainslie & Haendel (1983), which all employed only hypothetical payoffs, all emphasize stationarity violations (among other things). But careful incentivized studies by Holcomb & Nelson (1992) and Sopher & Sheth (2006) found little evidence for pervasive stationarity violations, in fact, although there typically will be a small but significant number of individuals who do violate stationarity. We suggest that the case for hyperbolic and other alternative notions of time discounting that have been proposed is much weaker than it might appear when the types of constraints we are exploring here are taken into account.

But intertemporal decision-making, as we encounter it in practice, can be rather more complex than simply comparing the present discounted value of alternative streams of income. Constant discounting is key for rationality, but this only refers to the preference side of the question. To the extent that a future plan involves active input from an individual, constraints (of the decision-making environment, of the individual's abilities and proclivities, etc.) need to be considered as well. Many relatively recent developments in marketing clearly seem designed to exploit the possibility that executing future planning is not easy for people. These include variations on payment schemes that allow one to avoid interest payments for a period of time, provided full payment is made in some finite period of time; offers to subscribe to a service that can be canceled within 30 days or to return the item for a full refund in some finite period of time; giving consumers a rebate on a gift card that is easy to misplace

Received: December 27, 2021. **Revised:** August 1, 2022. **Accepted:** August 5, 2022

and that does not have its value easily evident on the card; and so on. People may make a purchase or sign up for a subscription, reasoning that it will be costless to reverse the decision if one is dissatisfied, but it often turns out that returning an item or canceling a subscription is more trouble than one counted on, and it is easier to just not bother. Other provisions for returning an item or being reimbursed may be hidden in fine print and might include additional conditions that were not prominently displayed at the time of purchase. Just having to retrieve the receipt for a purchase will be enough to thwart many. Although many transactions of this sort may be small, the cumulative impact can be quite large, at least from the point of view of the business side of these transactions, even if individual consumers may catch on and avoid problems with a little bit of experience.

We investigate intertemporal planning problems as a way of gaining understanding of the characteristics of individual decision-makers and of the choices presented to them. We are particularly interested in uncovering whether decision-makers choose in a way that is consistent with them having in mind constraints, whether exogenous (e.g. scheduling constraints) or endogenous (e.g. knowing that one may be forgetful in the future), such that they rationally anticipate that they may have trouble following through on a particular plan. Opting for a payment plan that offers zero interest for a year then failing to pay off the item before a high retroactive interest charges kicks in is one type of mistake, and if one anticipates trouble following through on such a plan, one might be better off paying off the full balance up front or at least before the end of the year. What is key here is that what makes an action optimal or suboptimal is often contingent on information that is essentially unobservable. For example, if one anticipates that one is disorganized and will probably fail to pay off the item in time, then it may be optimal to not choose the zero interest option, even if the alternative is to pay everything up front. On the other hand, if you are an organized type, then the zero interest option is probably a good idea. An important observation here is that choosing an option with a maximum possible monetary payoff that is less than the maximum possible payoff of another available option is not, in itself, suboptimal behavior. In the experiment, we impute subjective probabilities in order to rationalize the most prominent observed choice regularities in the experiment. Although some of the most prominent patterns of choice we observe in the experiment involve individuals choosing options with larger possible payoffs over those with lower possible payoffs, the options we give to subjects vary on more dimensions than just the dollar amount available (e.g. the number of opportunities to collect a given amount of money—one chance vs. four chances), and there are systematic patterns of choice that we observe that are related to these other dimensions.

The rest of the paper is organized as follows. In Section 2, we outline the basic theoretical model for choices over alternative future income payments to be collected. The model amounts to a characterization of the choice problem facing subjects in our experiment as one of the choices between Anscombe–Aumann lotteries, where the subjective ('horse race') probabilities arise from the uncertainty that subjects have about various dimensions of the payment collection environment induced in the experiment. The objective ('roulette') probabilities are degenerate, as we do not introduce explicit objective risk into the experiment. In Section 3, we describe the experiment in detail, and in Section 4, we analyze and interpret the results of the experiment. Section 5 contains conclusions.

A MODEL OF INTERTEMPORAL PLANNING WITH TEMPTATION

Our general strategy in this paper is to treat a laboratory situation as one in which actual risk aversion and actual discounting of future payments should not, for all practical purposes, be manifest, simply because the stakes are too small, and the lengths of time too short, for this to make any sense. Instead, we seek to introduce other factors into the decision-making environment that may loom large, in the sense that they may induce a degree of uncertainty in the subjects regarding the relative feasibility of being able to successfully execute an intertemporal plan that will allow them to collect on the various options available to them in the experiment. In this way, although there is no explicit objective uncertainty in the experimental options, there may be subjective uncertainty. We rely on subjects' choice patterns to reveal the exact nature of the uncertainty that they perceive. Thus, our starting point in the experiment will be to treat the monetary payoff available in each choice option as representing the utility of that option, apart from any subjective uncertainty that might arise from a subject's consideration of his or her own ability to follow through on a plan collect the monetary option in question. In this section, we, nonetheless, consider the formalities of the choice structure that one should have in mind in general, but the reader who is primarily interested in the experiment, as such, should not need to dwell upon these details for long.

Ex-ante choice

Accordingly, we consider, as in Section 5 of Fishburn & Rubinstein (1982), choices over lotteries (p,t), where p is an objective probability distribution over a prize $x \in X$, where X is a finite set (for initial convenience) of monetary prizes containing 0, to be obtained in period t; time is discrete. We will call the set of such lotteries (P,t) conditional on t. We then define a preference relation $\geq$ over (P,t) satisfying the von Neumann Morgenstern axioms. Then there exists a utility function U(P,t) on the conditional lotteries given t. As in Fishburn and Rubinstein, we assume utility independence of the fixed value of t. This gives the representation $U(p,t) = \rho(t)u(p) + w(t)$ and u(p) is a von Neumann–Morgenstern utility over P. If p is the constant lottery 0 (which gives 0 for all outcomes of the lottery), then $U(0,t) = \rho(t)u(0) + w(t)$. If u(0) is normalized to 0, then $U(0,t) = w(t)$. It seems reasonable to normalize U(0,t) to 0 for all t, provided that 0 is the worst possible outcome, as it will be in the experiment. This then makes $U(p,t) = \rho(t)u(p)$. Assuming impatience, $\rho(t)$ is decreasing. Technical details are contained in Fishburn & Rubinstein (1982).

We can now consider the problem facing subjects in the experiment. We provide full details of the experiments in Section 3, but, briefly, the experiment consisted of a large set of pairwise choice questions between alternative ways of receiving a single monetary payment in the future. It was understood that after all of the *ex-ante* choices had been made, a single one of the questions would be chosen at random for each subject individually, and the choice the subject made on that question would determine the monetary earnings possibilities for the subject (a flat show-up payment of $5 was also made at the end of the experiment). Possible payments were always to be collected within a 1-hour window of time 1–8 weeks from the date of the experiment in the laboratory where the experiment was conducted. Some options allowed multiple possible collection days, while others provided a single possible collection day. Some options also required a subject to correctly complete a trivia quiz and bring the quiz with them when collecting their payment. The eight possible payment dates can be

thought of as eight discrete states in which a payment is either available or unavailable. Let α_t denote availability in period t ($\alpha_t = 1$) or unavailability ($\alpha_t = 0$). A state of the world s_i specifies α_t for each t. In the experiment, there were thus 16 states of the world.

Now consider an Anscombe–Aumann lottery in which for every state of the world, s_i, there is a prize consisting of a lottery (p^i, t^i). Since we know the von Neumann–Morgenstern utility associated with this, we can substitute the utility $\rho(t^i)u(p^i) = r_i$, say. Then Anscombe & Aumann (1963) show that (with their way of defining a mixture space, etc.) imposing the von Neumann–Morgenstern axioms on a preference relation over the vector r gives a representation.

$$W(r) = \sum_i q_i r_i,$$

where the summation is taken over the states i and q_i is the subjective probability of the state i occurring. The options in the experiment can be evaluated using this utility function. In Section 3, we simplify the above analysis in two ways. First, we compute the probability that a particular monetary payoff will be collected, even if that payoff is available in several different states. Thus, we are supposing that the q_i are independent of the r_i. Second, we also suppose that $r_i = x_i$, i.e. the discounted utility of the payoff is the payoff itself.

Concerning the first simplification, it should be noted that for the *ex-ante* choices being considered here, we do not think this is a serious issue, but in considering actual collection behavior of subjects, having received their collection options and now, on a specific possible future collection date, considering whether to collect, the size of a payment, for instance, net of the implicit cost of going to collect the payment, is surely going to be an issue. To put this another way, in considering the *ex-ante* choices, the probability that one will be able to collect is of primary importance and the actual cost of collecting on a specific day in the future is hard to know today. We address this question in the next subsection. The second simplification is motivated by an argument about discounted utility theory analogous to one made by Rabin (2000) concerning expected utility theory and risk aversion. Rabin argued, essentially, that one must be wary of attributing to risk aversion choices among uncertain monetary prospects when the prizes are small because even small amounts of risk aversion over small stakes will imply implausibly high levels of risk averse behavior over larger stakes. In the context of discounted utility, the discounting function already mentioned, $\rho(t^i)$, is the main issue. To give a simple example, if one chooses \$10 today over \$11 in 1 month, and we attribute this to time discounting only, then we could expect to see the individual also choosing \$10 000 today over (roughly) \$30 000 in 1 year. While the first is not hard to believe, the second is most implausible. As we are dealing with stakes of, at most, \$40 and time spans of, at most, 8 weeks, we are solidly in the range of 'small stakes' and 'short time periods.' Thus, we will implicitly assume $\rho(t^i) = 1$ for any t in our experiment. Adding consideration of what the curvature of $u(p^i)$ might be is similarly not going to be of any help in understanding short-term, small-stakes intertemporal choice behavior. In fact, we just invoke Rabin's critique directly for this part of the analysis and assume the $u(p^i) = p^i = x_i$, since the objective distributions are degenerate here. Thus, we attribute any deviations from strict monetary value maximization in *ex-ante* choices to the subjective constraints decision-makers face and not to discounting or to risk aversion.

Dual selves

The idea of dual or multiple selves when considering choices whose successful execution depends upon doing things that an individual may or may not be able or inclined to follow through on has been explored by many writers (Ainslie & Haendel 1983, Benabou & Pycia 2002, Chatterjee & Vijay Krishna 2009, Fudenberg & Levine 2006, Hammond 1976, Schelling 1978, and Strotz 1955, to name only a few). For our purposes here, we note that our analysis above is consistent with a dual-self approach in which there is a likelihood of a future self being 'in control' who may not wish to follow through with a particular plan. We model this future self as a subjective probability that one will not be able to following through, due to self-knowledge of one's abilities, or of external constraints that one may face. This is a more concrete interpretation of what may seem to some as esoteric talk. We are emphasizing here not the idea that people may have multiple personalities, but rather that life can be complicated, and decisions that seem simple may be more complex, upon closer reflection.

Dynamic choice

In this section, we consider the question of how a decision-maker would execute a dynamic choice problem in which there are (possibly) several dates on which one might be able to collect one's payment. Time is discrete, and the problem is a finite horizon problem with T being the last period. It is convenient to count backward in time, so period T is counted as period 0. Let c_t denote the opportunity cost of leisure in period t, distributed according to an absolutely continuous probability distribution $F_t(.)$. Let $G_t(.) = 1 - F_t(.)$. Each period, the agent decides to stop or to wait. If she decides to stop in period t, her payoff is $x_t - c_t$, where x_t is specified in the choice problem. In period 0 before the cost is realized, define

$$EV_0 = x_0 F_t(x_0).$$

Define $V_t = \max\{x_t - c_t, \delta EV_{t-1}\}$. Then any T period option k, such as in the experiment, will be worth.

$$EV_T.$$

Note that this has to be non-negative because never collecting gives a payoff of 0. Here, the availability probabilities are endogenous, given the distributions of the opportunity costs and the options chosen, unlike in our consideration of the *ex-ante* choices. In Section 4, we conduct some analysis of the actual collection behavior of subjects, subsequent to the day of the experiment, once they have had one of their choices randomly selected to determine their earnings for the experiment.

Relationship to other studies of choice

As our approach is a bit different from what others have done in the past, some additional comments may be in order. Andersen et al. (2018), in a large and comprehensive study with subjects for whom detailed demographic information, including information about financial assets, are available, have shown that if a variable reference point in the utility function is allowed, then the critique of Rabin about the level of risk aversion over small stakes is not relevant. The main thrust of their analysis is that choice behavior in the laboratory does not seem to bear any, or much, relationship to 'real' wealth levels, i.e. that subjects do not seem to integrate their 'real world' assets with whatever wealth they may be endowed with in the context of the experiment they are conducting, so it is appropriate to treat the situation as one in which the wealth reference point subjects are working with is

that of what is happening in the experiment. We do not object to this formulation, but as our experiment effectively thrusts the subjects into a 'real world' framework by making collection of a payment something that has to be dealt with outside of the laboratory, in the course of their everyday lives, we think it is appropriate to apply Rabin's critique, as well as our own analogous critique of intertemporal discounting as an explanation. We will return to discuss these issues further in our analysis of collection behavior.

THE EXPERIMENT

The cases that we have used in the introduction to illustrate planning problems involve delayed payments for purchases. In an experimental setting, it would be possible to construct scenarios in which something is purchased with delayed payments to be made, but there are practical problems in implementing such a study, both from the perspective of ecological validity (one needs to have on offer items that someone would actually think they would want and not just notional units of an abstract trade good) and from the perspective of laws concerning the charging of interest, as well as human subjects regulations, which would make collecting delayed payments difficult.

We instead study planning problems by offering subjects alternative payment schemes (a methodology we have used in previous studies of intertemporal choice, e.g. Sopher & Sheth 2006). In this kind of scenario, certain payments can be made to look more attractive but might have conditions attached to them, in the sense that collecting the payment might require one to show up at a particular time and place, to have a special coupon for the payment and/or to have completed some simple task and to present evidence that one has done so in order to be able to collect a payment. Such an approach avoids the practical problems just mentioned. Subjects receive no payment, or a reduced payment, under clearly specified conditions that they are informed of in advance. If they manage to fulfill the conditions, then they receive full payment. In order to explore planning problems in a meaningful way, we offer choices between payments that are relatively easy to collect and payments that include conditions and thus are relatively difficult to collect. A payment option is easier to collect on if there are more opportunities. For example, consider the three options illustrated below. For each option, only one collection may be made. So Option A will yield at most $40, Option B will yield at most $20 and Option C will yield at most $28. If you can pick up $20 in either 1, 2, 3 or 4 weeks, as in Option B below, which is easier than Option A, which allows you to collect $40 in 1 week only. Option A is still better than Option B, if you have no trouble going to the place you need to go to in order to collect, of course. Option C gives one four possible pick up times, but the amount one can pick up differs from week to week, so one needs to come at the right time to collect. One way that we can make an option more difficult to collect on is to add conditions that must be satisfied for certain options, in addition to showing up at the right place and time to

collect. For example, one might be required to complete a questionnaire that includes questions that need to be researched on the internet and bring the results when coming to collect. In our study, we make use of trivia quizzes that one can easily complete with internet searches. The difficulty is not in finding the answers (we purposely have chosen questions with clear and easy to find answers), but in taking the time to complete the task, and then remembering to bring the results when coming to collect.

Example of different payment options (you may collect only one payment)

Pick up (from today)	Option A	Option B	Option C
1 week	$40	$20	$4
2 weeks		$20	$28
3 weeks		$20	$4
4 weeks		$20	$28

The choice questions we use are all pair-wise comparisons, giving subjects a choice between two options. The options are similar to those shown above but may differ in the magnitudes and timing. That is, there are 'one shot' options, such as Option A, 'simple' options, such as Option B, and 'complex' options, such as Option C. 'One-shot' and 'complex' options always have conditions attached, while 'simple' options never have conditions attached. Choices between 'one shot' options and 'simple' options allow us to document and make inferences about factors that lead individuals to choose comparatively risky options (i.e. options that, perhaps due underestimation of the costs involve, might lead one to miss the benefits of a choice). We also are able to follow up on whether people actually manage to collect their payments, for those choice questions that are used to determine earnings in the experiment. Many questions were asked in the study, but only one, which was randomly chosen, was used to determine earnings. Choices between 'one shot' and 'complex' options and between 'simple' and 'complex' options, similarly allow us to make other inferences.

Briefly, our results are as follows. In 'A type' vs. 'B type' questions, B type options that give multiple opportunities to collect a smaller sum of cash than the one-shot A type option are chosen surprisingly often (about half of subjects choose this). In this 'insurance' type of behavior, people seem to be anticipating difficulties in following through on a plan (to, say, come on a certain day to get $40) and opting for options that pay less but give one more opportunities to pick up a payment of some kind (such as having four opportunities to collect $20). There are no violations of stationarity (shifting all payments out in time have no effect on choice frequencies), but, due to the behavior just mentioned, there are plenty of violations of strict dominance—not taking the option that offers the highest payoff. There are the kinds of shifts in choice frequencies one would expect, though. For example, some people (about a quarter of our subjects) choose a simple 'B type' option over a complex 'C type' option, when B pays $12 in either of four weeks, and C pays either $4, $28, $4 or $28 over 4 weeks, but a lot more (about two-thirds of subjects) choose B over C when B pays $20 in either of 4 weeks. This would seem to provide an empirical basis for the idea of 'dual selves,' broadly defined. Surely anyone would take $40 over $20 today, but when the payments are in the future, it is harder to predict your ability to follow through on a plan. As part of our data analysis in Section 4, we conduct regression analysis focusing on estimating the probability of choosing the more complex (and payoff-dominant) option. We also investigate actual 'collection behavior,' and relate that to the patterns of choice exhibited in the full questionnaire, in order to assess whether 'decision failure' (failing to pick up one's payment) is systematic.

Parameters for generating the choice questions

Table 1 contains the basic parameters for the choice questions in the study. Each matrix represents 3 alternatives, A, B and C, or D,

E and F. Set 1 refers to the choices involving A, B and C, while Set 2 refers to the choices involving D, E and F. Set 3 and Set 4 are simply a doubling of the payoffs in Sets 1 and 2, respectively. The t in the first column denotes how many weeks in the future a payment may be collected. The numbers under A, B and C or D, E and F indicate how many dollars can be collected by a subject at the date in the future that the row represents. Every combination (A vs. B, B vs. C and A vs. C or D vs. E, E vs. F and D vs. F) is presented to a subject. The 12 matrices thus represent 36 choice questions in the study. We will analyze choice behavior partly by way of choice patterns over the sets of questions noted above. There are six choice questions in all for any given pair of matrices. Going down in a column for any set, the lower matrices have all monetary payoffs shifted into the future by 2 weeks. The matrices in Set 3 and Set 4 are just 'doubled' version of the matrices in Sets 1 and 2, respectively, where the monetary payoffs are doubled, but all other aspects of the choices are the same. The basic choice pattern we will consider is the set of responses to six choice questions for any two matrices that are in the same row in Set 1 and Set 2. We will then check for consistency of the observed choice pattern when all payment are shifted into the future (by looking at choice patterns in the second and third rows of matrices) and when all payments are doubled (by looking at choice patterns for corresponding matrices in Sets 3 and 4). Notice that the only difference between Set 1 and Set 2 is that Option A payoffs are doubled to get Option D, and Option B payoffs are multiplied by (5/3) to get Option E. Option F in Set 2 is identical to Option C in Set 1. As we shall see, these changes lead to significantly different choices in the pairwise choice questions within Set 2, with more subjects choosing C over B in Set 1 questions, but the reverse (more choosing E over F) in Set 2 questions. Further, B is chosen over A nearly half of the time in Set 1 questions, but E is rarely chosen over D in Set 2 questions. These clear differences in choice behavior over the different sets enable us to set bounds corresponding to different choice patterns observed on a set of parameters representing a subject's uncertainty about his or her ability to collect a future payment. Before analyzing choice patterns in detail, however, we summarize the results of the experiment by way of regression analysis. We then analyze choice patterns, and, finally, the actual payment collection behavior of subjects. But first, we provide some details on the conduct of the experiment.

Procedures

The experiment was conducted as a computer-based questionnaire. There were three sessions, each with 19 or 20 subjects, with a total of 59 subjects, conducted during February of 2011 at Rutgers University-New Brunswick. Subject responded to 72 questions all in all. The questions were all derived from the options presented above in Table 1. Subjects were first presented with the 36 questions that can be constructed from pairwise choices among the three alternative options in each matrix of options shown in Table 1. Each subject responded to the same questions, but they were presented in a random order, independently determined for each subject. The same set of 36 questions was then posed again, again in an independently determined random order, in order to provide a basis for measuring the consistency of the choice behavior observed. At the end of the experiment, one of the questions was drawn, independently for each subject, to determine the subject's earnings in the experiment. For the question drawn, each subject's earnings potential was determined by the choice the subject made on that question. Appendix A contains the instructions for the experiment and the payment coupon used to record all of the options available to the subject for the chosen option that would determine earnings. Each subject was paid a $5 show up fee for participating, plus an additional payment, based on the chosen option, provided that they managed to show up at the right time and completed all necessary requirements. There was no instance in which a subject did not manage to correctly complete the trivia quiz correctly, when that was a requirement of being paid. However, there were a nontrivial number of instances in which a subject did not manage to show up at all in order to collect his or her payment. An analysis of this 'collection behavior' is contained in the results reported in Section 4 below. Average earnings were $19.57, including those people who only received the show up fee. The experiment took approximately one-half hour to complete in the laboratory.

EXPERIMENTAL RESULTS

Regression analysis: aggregate choice patterns

Table 2 contains regression results that summarize the experimental data. The regression is a linear probability model (LPM), estimated with a random effects error specification to account for the repeated cross-sectional nature of the data. In order to identify the average effects of such things as whether the option is 'one shot', 'simple' or 'complex', or presence or absence of a trivia quiz as a requirement for collection, or the number of collection dates available, on the propensity to choose dominant (i.e. higher monetary value) options, we organize the data as a panel of observations and take specific account of individual heterogeneity. Individuals may have different propensities to choose dominant options due to heterogeneity in the underlying factors that impinge on the likelihood of being able to collect a payment. For example, someone who knows him/herself to be disorganized and forgetful could be more likely to choose a dominated option if the dominant option only has one collection date. An LPM for a binary response y may be specified as

$$P\left(y=1\middle|\,\mathbf{x}\right)=\beta_0+\beta_1x_1+\cdots+\beta_Kx_K,$$

where $P(y=1|\mathbf{x})$ is the probability that the dominant of the two options in a question is chosen. That is, the event that the monetarily dominant option is chosen is coded as $y=1$, and otherwise $y=0$. Assuming that x_i is not functionally related to the other explanatory variables, $\beta_i=\partial P(y=1|\mathbf{x})/\partial x_i$. Therefore, β_i is the change in the probability of success given a one-unit increase in x_i. If x_i is a binary explanatory variable (as it always will be in our analysis), then β_i is just the difference in the probability of 'success' (where success means choosing the monetarily dominant option) when $x_i=0$ and $x_i=1$, holding the other x_j fixed. Since all of the regressors are 0–1 variables, our analysis is not vulnerable to one of the usual criticisms made of the LPM that the fitted values for P may be larger than 1 or less than 0.

Another advantage of using the LPM, instead of some nonlinear transformation function, such as the logit or probit, is that it is straightforward to allow for individual heterogeneity in choice behavior. We estimate the model by specifying the error term as $u_{im}=e_{im}+c_i$. That is, the error is modeled as being the sum of an individual specific component c_i and an idiosyncratic component e_{im} that varies from observation to observation on an individual. We use a random effects specification in the estimation.

$$P\left(y=1x,c_i\right)=\beta_0+\beta_1x_1+\beta_Kx_K+c_i+e_{im}. \tag{6.2}$$

The default category is the B vs. C choice or the E vs. F choice, Set 1, with the 'Early' time delay of 1 week, when the earliest

Table 1. Future payment choice options in the experiment

	Options (Set 1) 'Early'				Options (Set 2) 'Early'		
t	A	B	C	t	D	E	F
1	10	6	2	1	20	10	2
2	0	6	14	2	0	10	14
3	0	6	2	3	0	10	2
4	0	6	14	4	0	10	14
5	0	0	0	5	0	0	0
6	0	0	0	6	0	0	0
7	0	0	0	7	0	0	0
8	0	0	0	8	0	0	0
	'Middle'				'Middle'		
	A	B	C		D	E	F
1	0	0	0	1	0	0	0
2	0	0	0	2	0	0	0
3	10	6	2	3	20	10	2
4	0	6	14	4	0	10	14
5	0	6	2	5	0	10	2
6	0	6	14	6	0	10	14
7	0	0	0	7	0	0	0
8	0	0	0	8	0	0	0
	'Late'				'Late'		
	A	B	C		D	E	F
1	0	0	0	1	0	0	0
2	0	0	0	2	0	0	0
3	0	0	0	3	0	0	0
4	0	0	0	4	0	0	0
5	10	6	2	5	20	10	2
6	0	6	14	6	0	10	14
7	0	6	2	7	0	10	2
8	0	6	14	8	0	10	14
	Options (Set 3) 'Early'				Options (Set 4) 'Early'		
t	A	B	C	t	D	E	F
1	20	12	4	1	40	20	4
2	0	12	28	2	0	20	28
3	0	12	4	3	0	20	4
4	0	12	28	4	0	20	28
5	0	0	0	5	0	0	0
6	0	0	0	6	0	0	0
7	0	0	0	7	0	0	0
8	0	0	0	8	0	0	0
	'Middle'				'Middle'		
	A	B	C		D	E	F
1	0	0	0	1	0	0	0
2	0	0	0	2	0	0	0
3	20	12	4	3	40	20	4
4	0	12	28	4	0	20	28
5	0	12	4	5	0	20	4
6	0	12	28	6	0	20	28
7	0	0	0	7	0	0	0
8	0	0	0	8	0	0	0
	'Late'				'Late'		
	A	B	C		D	E	F
1	0	0	0	1	0	0	0
2	0	0	0	2	0	0	0
3	0	0	0	3	0	0	0
4	0	0	0	4	0	0	0
5	20	12	4	5	40	20	4
6	0	12	28	6	0	20	28
7	0	12	4	7	0	20	4
8	0	12	28	8	0	20	28

Table 2. Regression: probability of choosing the payoff-dominant option

Variable	Coefficient	Std. Error	z-stat.	Prob. > z
Constant	0.75	0.07	10.73	0.00
Type2	−0.01	0.04	−0.16	0.88
Type3	−0.19	0.04	−4.30	0.00
Set2	−0.42	0.03	−12.82	0.00
Set3	−0.02	0.03	−0.52	0.61
Set4	−0.43	0.03	−13.08	0.00
Type2/Set2	0.35	0.06	6.22	0.00
Type2/Set3	0.05	0.06	0.95	0.34
Type2/Set4	0.36	0.06	6.27	0.00
Type3/Set2	0.45	0.06	7.87	0.00
Type3/Set3	−0.01	0.06	−0.10	0.92
Type3/Set4	0.38	0.06	6.72	0.00
Time2	0.01	0.03	0.37	0.71
Time3	0.03	0.03	1.17	0.24

Random-effects GLS Regression, N = 4248, Number of Subjects = 59, Choices/subject = 72. Wald Chi-square(39) = 727.84, Prob. > Chi. Sq. = 0.00.

collection can be made, as shown in Table 1. These are captured in the constant term.

The regressors, besides a constant term, are

Type2 = 1 if the question is A vs. C or D vs. F choice, 0 otherwise

Type3 = 1 if the question is A vs. B or D vs. E choice, 0 otherwise

Set2 = 1 if the question is part of Set 2, as in Table 1, 0 otherwise

Set3 = 1 if the question is part of Set 3, as in Table 1, 0 otherwise

Set4 = 1 if the question is part of Set 4, as in Table 1, 0 otherwise

Type2/Set2 = 1 if both Type2 = 1 and Set2 = 1, 0 otherwise

Type2/Set3 = 1 if both Type2 = 1 and Set3 = 1, 0 otherwise

Type2/Set4 = 1 if both Type2 = 1 and Set4 = 1, 0 otherwise

Type3/Set2 = 1 if both Type3 = 1 and Set2 = 1, 0 otherwise

Type3/Set3 = 1 if both Type3 = 1 and Set3 = 1, 0 otherwise

Type4/Set4 = 1 if both Type3 = 1 and Set4 = 1, 0 otherwise

Middle_delay = 1 if the initial period (when the earliest collection can be made) is 3 weeks, 0 otherwise

Late_delay = 1 if the intial period (when the earliest collection can be made) is 5 weeks, 0 otherwise.

In summary, choices are coded as 1 if the choice is the dominant option (larger dollar amount); 0 otherwise. The choices are regressed on indicator variables representing, in total, every possible configuration of the experimental design variables. The regression is thus a 'saturated' regression, and the estimated dependent variable is, for each possible configuration of the experimental variables, the exact average frequency with which the monetary-dominant option was chosen, for that given configuration of the design variables. Cross effects for the 'type' variables with the 'time delay' variables and cross effects for the 'set' variables with the 'time delay' variables were included, but not reported, as the 'time' variables themselves are not different from zero, and all cross effects with the 'time' variables are also not different from zero. The coefficient estimates are reported in Table 2.

As noted above, there is no detectable difference in choice behavior when all possible payments in all options are shifted into the future by the same number of weeks. The coefficients on 'Middle delay' and 'Late delay' are essentially zero. Thus, there are no stationarity violations, which is not really surprising, as such violations normally only occur, if at all, when some payment options are immediate and thus (relevant to the present study) do not require any sort of planning or difficulties to collect. Also notable is the fact that there is no detectible difference in choice behavior between Set 3 options and Set 1 options, meaning that doubling all possible payments has no detectible effect on choice behavior. Further, the estimated difference in choice behavior for Set 2 and Set 1 is the same as that between Set 4 and Set 1. That is, in other words, there is no detectable difference in choice behavior when the Set 2 options are doubled to generate the Set 4 options. In summary, neither time-shifting payoffs nor doubling of payoffs changes choice behavior.

Table 3 provides a 'digest' of the regression results by adding up the estimated coefficients for all relevant variables in order to arrive at the average observed frequency with which the dominant option is chosen in each 'type' of question (i.e. A vs. B, B vs. C or A vs. C, for Set 1, or D vs. E, E vs. F, or D vs. F, for Set 2) in each 'set' category of options. In the next subsection, we analyze the choice patterns at the individual level, but here we can summarize the 'average' choice patterns observed. The average choice pattern in Set 1 is C is preferred to B, C preferred to A and A preferred to B. In Set 2, the average pattern is E preferred to F, D preferred to F and D preferred to E. For all but the F vs. E choice in Set 2, the average choice is also the payoff-dominant choice. Of particular interest, then, is this one violation of dominance (only 31% choose the dominant option), but the fact that only a bare majority of subjects chose the dominant option in the A vs. B choice in Set 1 is also of interest. The same overall choice patterns occur for Sets 3 and 4 (where all payoffs are doubled) as for Sets 1 and 2, so we do not explicitly discuss these. Similarly, the same overall choice frequencies occur when all payoffs are shifted into the future by the same amount, so we do not explicitly discuss patterns for these different payments timings either.

The F vs. E choice in Set 2 can be summarized as a choice between two chances to collect $14 (in Week 2 or Week 4) and four chances to collect $10 (in Weeks 1, 2, 3 or 4). A total of 69% of subjects preferred to have four chances at $10 over two chances at $14. Evidently, subjects do not take it for granted that they will be able to get back to the laboratory to collect their money at the specified time and want to have more chances to do so (and are willing to pay a price for this). (The fact that the first opportunity to collect for option F is a week later than for option E may be a factor as well.) The A vs. B choice in Set 1 can similarly be summarized as a choice between one chance to collect $10 (in Week 1) and four chances to collect $6 (in Weeks 1, 2, 3 or 4). Only 54% of subjects chose to have one chance at collecting $10, so a similar observation applies here as well, though less strongly: many subjects prefer to 'insure' with more chances to collect a single smaller payment. Interestingly, the same price ($4) in payoff must be paid to take the option with more chances to collect in both situations, though it is a larger proportion of the highest

Table 3. Average frequency of dominant option choices by question type and set

	Type 1 (B vs. C)	Type 2 (A vs. C)	Type 3 (A vs. B)		Type 1 (E vs. F)	Type 2 (D vs. F)	Type 3 (D vs. E)
Set 1 (A,B,C) as in Table 1	0.73	0.73	0.54	Set 2 (E,F,G) as in Table 1	0.31	0.65	0.96
Set 3 (doubled versions of Set 1)	0.73	0.73	0.54	Set 4 (doubled versions of Set 2)	0.31	0.64	0.93

Table 4. Binary choice pattern representation

Digit in representation	Type of choice	Set
Leftmost digit:	3: F vs. E	Set 2 or Set 4
Second from left:	2: D vs. F	Set 2 or Set 4
Third from left	1: D vs. E	Set 2 or Set 4
Fourth from left	3: C vs. B	Set 1 or Set 3
Fifth from left:	2: C vs. A	Set 1 or Set 3
Rightmost digit:	1: A vs. B	Set 1 or Set 3

All choices are listed with the payoff-dominant option first. The digit is 1 if the choice was the payoff-dominant choice; 0 otherwise.

payoff available in the A vs. B choice in Set 1 than in the C vs. B choice in Set 2.

Of the other choice questions, it is only for the D vs. E choice in Set 2 that we observe anything close to unanimity: a total of 96% of subjects chose option A (one chance to collect $20, in 1 week) over option E (four chances to collect $10, in 1, 2, 3 or 4 weeks). The other choice questions all had roughly two-thirds of subjects choosing the payoff-dominant option. Overall, these choice frequencies hint at a fair degree of heterogeneity in the underlying individual choice patterns. In the next subsection, we proceed to study these patterns in more detail.

Analysis of choice patterns across sets: individual choice patterns

We now look more deeply into choice behavior at the individual level. We will analyze choice patterns across Set 1 and Set 2 (or across Set 3 and Set 4), as a way of constraining the number of possible explanations for behavior. That is, rather than considering choice questions one by one, we will consider overall patterns of behavior and ask what sort of factors could account for the full patterns of choice. There are six pair-wise choice questions across Set 1 and Set 2 (or Set 3 and Set 4) for any given timing of payoffs (i.e. for any two option matrices in a given row in Table 1), so there are $2^6 = 64$ possible choice patterns that one might observe. In order to more efficiently represent and manage the analysis of choice patterns, we code a choice of the payoff-dominant option with a 1, 0 otherwise, and then concatenate the choice codes into a six-digit representation, where the digits are 0s and 1s. We will follow the convention that the digits represent choices in the following order, from left to right (as described in more detail in Table 4): D vs. E, D vs. F, F vs. E, A vs. B, C vs. A and C vs. B. Thus, for example, 111 111 represents a pattern in which the dominant option is always chosen and 110 111 represents the 'average' choice pattern discussed in the previous subsection.

Table 5 contains the frequency distribution of the observed patterns, aggregated overall six of the possible two-set/time delay combinations. Since all choice questions were repeated in the second half of the experiment, there are 12 observations per subject. There were 59 subjects in the experiment, so there are $12 \times 59 = 708$ observations in all. Although there are 64 different possible choice patterns, more than 60% of choice behavior is captured by just four of the choice patterns: 11111, 000011, 110 101 and 000010. Note that the average choice pattern, 110 111, implied by the averages from Table 3, is only the fifth most frequently observed choice pattern, occurring 6% of the time. However, this pattern, along with patterns 110 100 and 110 101, which only differ by one or two choices from it, together account for 20% of all choices patterns, so it is possible that small deviations or 'trembles' from the dominant pattern accounts for some of these patterns. The most frequent pattern, by far, is the one in which the dominant payoff choice is always chosen (111111), accounting for 26% of all choice patterns. Pattern 000011 and pattern 000010, together, account for another 26% of the choice patterns. In summary, ~72% of the observed choice patterns can be attributed to six different choice patterns. We take the view, however, that there are really three 'core' patterns of choice, (000011, 110 101 and 111 111), that account for fully 53% of the choice patterns and that most other patterns should be thought of as small deviations from these core patterns. Table 6 contains information on the relative frequency of the three core patterns, disaggregated by two-set/time delay, and by the first and second asking of the questions (which are denoted by 'a' and 'b' in the table). There is some variation across the different pattern distributions and between early and later questioning, but nothing that is obviously systematic.

Determination of subjective no-show probabilities consistent with observed choice behavior

As outlined in Section 2, we consider a practical and, in principle, observable implementation of the dual self-idea to be the subjective probability or belief that one holds about one's ability to follow through on a future plan. In the context of the experiment, this probability would correspond to the chances that one will not be able to make it back to the laboratory one or more weeks later and/or will not be able to correctly complete the associated trivia quiz, to collect a payment. The simplest version of this idea is to suppose that there is a single probability, p, that one will not be able to show up to pick up a payment in any given period. Thus, for instance, the A vs. B. choice in Set 1 (assuming as we do risk neutrality) depends on comparing (1-p)10 to (1-p^4)6. Evidently, if p is such that (1-p)/(1- p^4) > 3/5, or $p < 0.41$, then A should be chosen; otherwise, B should be chosen. Continuing in this fashion, one can consider all of the choices made within a given choice pattern and determine what conditions on p would be consistent with the choice pattern. It turns out that such an approach is not feasible, though, in the sense that a single parameter cannot account for anything other than the 'dominant' pattern of choice in which the option with the highest possible monetary payoff is always chosen. For this pattern, a value of $p < 0.41$ is sufficient. But the other most prominent pattern of choice, 000011, and other observed choice patterns, cannot be rationalized with a single parameter.

Table 5. Frequency distributions of choice patterns

1, 2 and 3 refer to the choice patterns derived from the 'early', 'middle' and 'late' delay questions, respectively, for Set 1 and Set 2. 4, 5 and 6 refer to the choice patterns derived from the 'early', 'middle' and 'late' delay questions, respectively, for Set 3 and Set 4. An 'a' always refers to the first asking, the 'b' to the second asking of the questions. See Table 1 for definitions of the question options.

Pattern	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	Row total (ave. # in parens)	Overall % (total divided by 708)
000000	0	1	1	3	1	1	0	0	1	0	0	0	8 (0.67)	1%
000010	5	3	5	11	4	6	5	4	4	5	1	5	58 (4.83)	8%
000011	9	9	10	2	10	11	11	12	13	13	15	12	127 (10.58)	18%
000101	0	1	0	0	0	0	1	0	0	0	0	0	2 (0.17)	0% *
000110	0	0	0	0	0	1	0	0	0	0	0	0	1 (0.08)	0% *
000111	0	0	0	0	1	0	1	0	0	0	0	2	4 (0.33)	0% *
001000	0	0	0	0	0	0	0	0	0	1	0	0	1 (0.08)	0% *
001010	0	0	0	0	0	0	0	0	0	1	0	0	1 (0.08)	0% *
001011	4	1	3	1	3	2	1	1	0	0	1	2	19 (1.58)	3%
010000	1	3	2	1	1	2	3	2	2	3	2	3	25 (2.08)	4%
010001	0	1	0	6	1	0	0	2	1	0	0	0	11 (0.92)	2%
010010	2	3	2	0	1	2	4	5	3	4	3	0	29 (2.42)	4%
010011	2	2	0	1	0	1	1	2	1	1	1	0	12 (1.00)	2%
010100	1	0	2	2	0	0	1	0	0	2	0	1	9 (0.75)	1%
010101	0	0	1	1	1	1	0	1	0	0	0	0	5 (0.42)	1%
010110	1	0	0	0	1	0	0	0	0	1	2	2	7 (0.58)	1%
010111	0	2	1	0	3	2	1	1	0	0	2	2	14 (1.17)	2%
011011	0	0	0	1	0	0	0	0	0	0	0	1	2 (0.17)	0% *
100 000	0	0	0	0	0	0	0	0	0	0	0	1	1 (0.08)	0% *
100 010	0	0	0	1	0	0	0	0	1	0	0	0	2 (17)	0% *
100 011	0	2	0	1	0	0	0	0	0	0	0	0	3 (0.25)	0% *
100 100	1	0	0	0	0	0	0	0	0	0	0	0	1 (0.08)	0% *
100 110	0	0	0	0	0	1	0	0	0	0	0	0	1 (0.08)	0% *
100 111	0	1	0	0	0	0	0	0	1	0	0	0	2 (0.17)	0% *
101 100	0	0	0	0	0	0	0	0	0	0	1	0	1 (0.08)	0% *
101 111	0	0	0	1	0	0	1	0	0	0	0	0	2 (0.17)	0% *
110 000	1	0	0	0	0	0	1	0	0	0	0	0	2 (0.17)	0% *
110 001	0	0	2	1	0	0	0	0	1	0	0	0	4 (0.33)	1%
110 010	1	2	0	1	0	0	0	0	1	0	0	0	5 (0.42)	1%
110 011	0	1	0	2	0	2	1	0	0	1	0	0	7 (0.58)	1%
110 100	2	4	2	3	3	3	2	3	3	1	2	4	32 (2.67)	5%
110 101	8	4	4	6	7	5	3	3	7	5	5	4	61 (5.08)	9%
110 110	2	0	0	0	0	1	0	1	0	0	0	1	5 (0.42)	1%
110 111	0	4	7	1	4	4	4	8	1	4	4	5	46 (3.83)	6%
111 001	0	0	0	0	0	0	0	0	1	0	0	0	1 (0.08)	0% *
111 011	1	0	0	1	0	1	0	0	0	1	0	0	4 (0.33)	1%
111 101	1	0	1	0	1	0	0	1	0	0	1	0	5 (0.42)	1%
111 110	0	0	0	0	0	0	0	0	0	0	1	0	1 (0.08)	0% *
111 111	17	15	16	12	17	13	18	13	18	16	17	15	187 (15.58)	26%
Totals	59	59	59	59	59	59	59	59	59	59	59	59	708 (59) **	99 ***

*Less than 0.5%. **Column may not add to 59 due to rounding error. ***Column does not add to 100 due to rounding error.

Table 6. Relative frequencies of across (set choice patterns)

Pattern	Early Sets 1–2	Middle Sets 1–2	Late Sets 1–2	Early Sets 3–4	Middle Sets 3–4	Late Sets 3–4	Ave. % (pattern)
I: 111111	a: 29% b: 25%	a: 27% b: 20%	a: 29% b: 22%	a: 31% b: 22%	a: 31% b: 27%	a: 29% b: 28%	a: 29% b: 24%
II: 000011	a: 15% b: 15%	a: 17% b: 19%	a: 17% b: 19%	a: 19% b: 20%	a: 22% b: 22%	a: 25% b: 20%	a: 19% b: 19%
III: 110 101	a: 14% b: 7%	a: 7% b: 10%	a: 12% b: 8%	a: 5% b: 5%	a: 12% b: 8%	a: 8% b: 7%	a: 10% b: 8%
Ave. % (Col.)	a: 58% b: 47%	a: 51% b: 49%	a: 58% b: 49%	a: 55% b: 48%	a: 65% b: 57%	a: 62% b: 55%	*a*: 57% *b*: 51%

As the choice options vary in the number of chances to collect, whether or not a quiz is required as a condition of collection, and in the location in time of the possible collection opportunities, we propose to parameterize the 'no-show' probability as being a function of three separate factors. Let p now stand for the probability that one is not able to make a collection on a given date. In general, $(1\text{-}p^k)$ is the probability that one will manage to collect if there are $k > 0$ opportunities to collect. Let q stand for the probability that one is not able to correctly complete a quiz that is required to collect a payment and bring it along when collecting. Then $(1\text{-}q^k)$ is the probability that one will correctly complete a quiz and bring it along when there are $k > 0$ opportunities to collect. Finally, let f stand for the per-period rate at which one will forget that there is a collection opportunity that can be

Table 7. Conditions on no-show probability as a function of p, q and f

Choice #	Dominant choice	Dominated choice condition
C1(Leftmost)	F preferred to E ($14 > 10)	$(1 - p^4)10(1-f)^{2.5} > (1-p^2)(1-q^2)14(1-f)^3$(to choose E)
C2(2nd from Left)	D preferred to F ($20 > $14)	$(1-p^2)(1-q^2)14(1-f)^3 > (1-p)20(1-f)$(to choose F)
C3(3rd from Left)	D preferred to E ($20 > $10)	$(1 - p^4)10(1-f)^{2.5} > (1-p)20(1-f)$(to choose E)
C4(4th from Left)	C preferred to B ($14 > $6)	$(1 - p^4)6(1-f)^{2.5} > (1-p^2)(1-q^2)14(1-f)^3$(to choose B)
C5(5th from Left)	C preferred to A ($14 > 10)	$(1 - p)10(1-f) > (1-p^2)(1-q^2)14(1-f)^3$(to choose A)
C6(Rightmost)	A preferred to B ($10 > $6)	$(1 - p^4)6(1-f)^{2.5} > (1-p)10(1-f)$(to choose B)

Consistent with dominance violations.

Table 8. Parameters consistent with main choice patterns

Pattern #	Pattern	C1	C2	C3	C4*	C5*	C6	Single parameter (p)	Three parameters (p, q, f)
I (dominant)	111 111							p < 0.41	See Fig. 1
II (quiz-avoiding)	000011	x	x	x	x			p > 0.64 and increasing with time delay	See Fig. 2
III (insurance)	110 101			x		x		p > 0.55 and increasing with time delay	See Fig. 3

*C4 and C5 both require a p that is increasing with the time delay from the present, so a single parameter is not sufficient to rationalize these patterns. For the three parameters, there are a multitude of feasible combinations that can rationalize the choices, which are illustrated in Figs 1–3. An 'x' indicates the conditions on which a dominance violation must occur for that pattern to be exhibited.

exercised. Thus, $(1-f)^t$ is the probability that one remembers a collection opportunity t periods from today. More generally, we let t stand for the average delay into the future that a choice option provides to collect a given monetary payoff, if $k > 1$ (so that there is more than one opportunity to collect). The overall subjective probability of collecting is the product of these three factors, and this product is used to weight the monetary payoff available for a given option with these characteristics, consistent with the discussion in Section 2. It bears emphasizing that these factors are really constraints on a decision-maker. They are not part of the decision-maker's preference structure, which we have assumed to be of the simplest form.

Table 7 contains the conditions on p, q and f that must be satisfied in order for the payoff-dominated option to be chosen in each of the six choice questions that the choice patterns entail. A choice pattern is thus a system of six inequalities, and a triple of parameter values that satisfies all six inequalities simultaneously is of interest. In general, a given choice pattern, aside from the 'all dominant option' pattern, requires that one or more of these conditions is binding, in the sense that the option with the lower monetary payoff is chosen. We only report on the three most common 'core' choice patterns identified in the preceding analysis. Table 8 reports on the values of the three parameters, p, q and f that would rationalize these three core patterns. More specifically, Figs 1–3 illustrate graphically the set of (p, q, f) values that rationalize the dominant choice pattern (111111), what we will term the Quiz-Avoiding Choice Pattern (000011), and what we will term the Insurance Choice Pattern, respectively. The graphs are the result of a systematic grid search in which we search for a positive value of f for each possible (p, q) pair in P = (.01, 0.02, . . . , 0.99) X Q = (.01, 0.02, . . . , 0.99). In particular, points in the (p,q) plane, with f = 0, are not points that satisfy the constraints. We only graph the largest value of f for a given (p,q) pair that satisfies all of the inequalities for a pattern. Thus, it is the illustrated surface, as well as points below the surface, which are consistent with the choice pattern.

Note that the first two core patterns are much more tightly constrained than the Insurance Choice Pattern. Neither pattern would allow a 'forgetting' parameter, f, much larger than 0.25, combined with (p, q) (scheduling and quiz parameters) that one must trade-off between in rationalizing the choice pattern. Either of the graphs in Figs 1 and 2 occupies much less volume than the

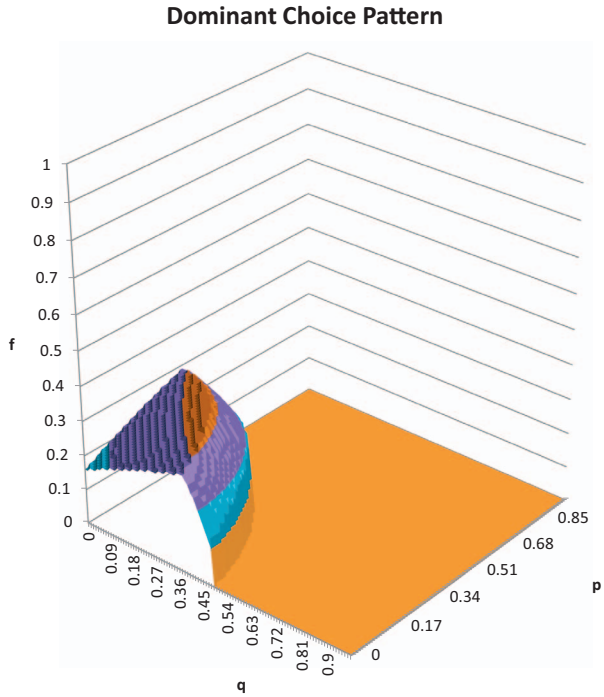

Figure 1. Parameters consistent with the dominant choice pattern

'tent' provided by the Insurance Choice graph in Fig. 3. We have done some investigation of possible parameters that would rationalize other less frequently observed patterns of choice. Interestingly, although there are 64 possible patterns of choice that one might logically observe, the three core patterns are the only ones for which we have been able to find plausible parameters, or any parameters with positive values, consistent with the pattern. As mentioned before, we think it is likely that the other observed patterns of choice are likely to be rationalized only as slight deviations from these most frequent core patterns.

Are choices consistent with actual collection behavior?

This is a natural point to transition to the question of how subjects go about collecting actual payments, once the laboratory session

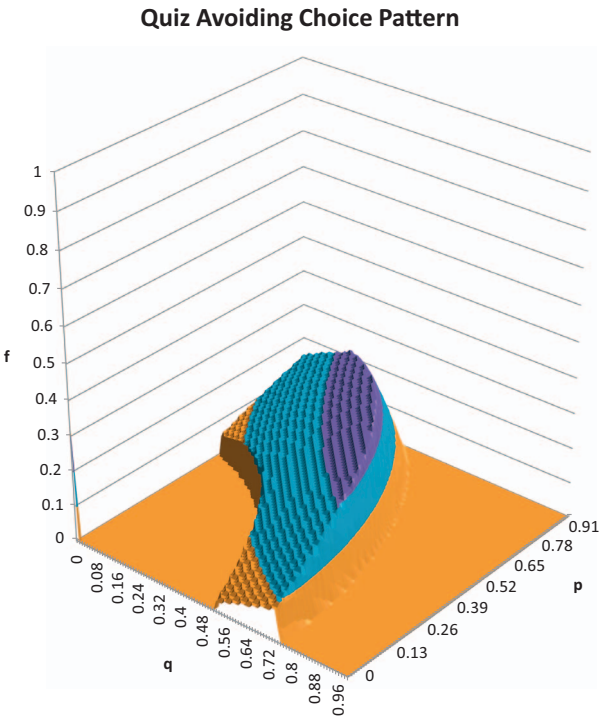

Figure 2. Parameters consistent with the quiz-avoiding choice pattern

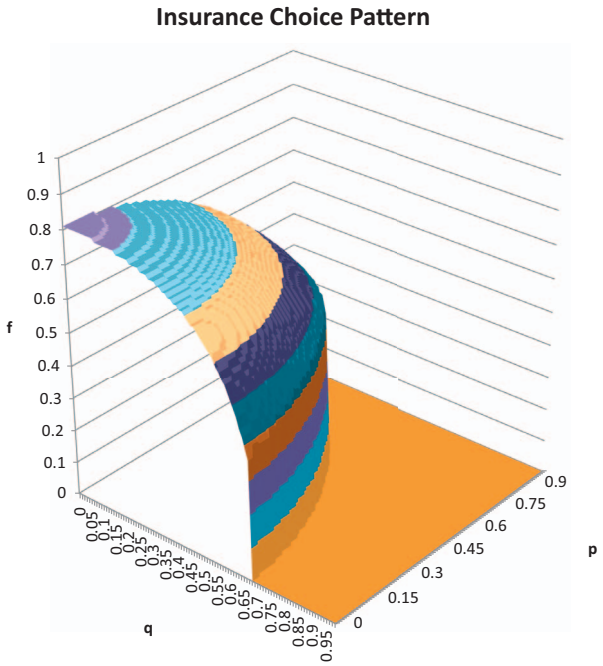

Figure 3. Parameters consistent with insurance choice pattern

is over and they have their specific payment options selected. One advantage of our design is that the actual behavior of subjects in collecting their payments is relevant to the testing of our model of decision-making, as in the just considered question of immediate vs. future payoffs. We have attributed choices of dominated options and, more generally, choice patterns that include some choices of dominated options, to subjective uncertainty about one's ability to collect in the future. If this really is the reason for these choices, then we would hope to be able to observe differences in the frequency with which subjects who chose dominated options collect and the frequency with which subject who chose the dominant options collected. Since we randomly selected a single question to determine subjects' earnings, we do not have nearly as much data here—just one choice per subject—but it is revealing nonetheless. In the original experiment, when the subject had chosen the dominant option on the question chosen to determined payoffs, 20% of subjects did not manage to collect their payment. When the subject had chosen the dominated option on the selected question, 45% of subjects did not manage to collect. The actual fixed cost of returning to make a payment would be relevant in considering whether to take up an immediately available payment or not. But as all payments in our experiment require one to return to the laboratory to collect, smaller amounts are less likely to be collected, all else equal and dominated options do have smaller payments. Thus, the higher rate of non-collection for smaller payments is not necessarily due to the subjects being more constrained, in the sense of the subjective probability of not being able to collect. In other words, to be more specific, even if a subject does not feel constrained by worries of not being able to collect, when it comes time to collect that subject may still not find it is worth the cost of coming to collect the payment.

CONCLUSIONS

We have reported on an experiment designed to allow subjects to display choice behavior over multiple pairwise choices of alternative ways to receive a monetary payment in the future. This allowed us to observe heterogeneous choice patterns that can be rationalized as being the result of (different configurations of) three parameters that capture distinct dimensions of difficulty that rational but human decision-makers may experience in making future plans for collecting payments. Although the most common distinct pattern, which we call the 'Dominant' choice pattern, involved subjects always choosing the option that yielded the highest possible monetary payment, there were significant numbers of subjects choosing other patterns as well. In particular, the second most common observed pattern, which we termed the 'Quiz-Avoiding' choice pattern, involved choices in which subjects seemed to avoid dealing with the need to complete a trivia quiz as a condition of payment, provided the monetary cost of doing so was not too large. A third pattern, which we term the 'Insurance' choice pattern, involved subjects generally choosing options that offered more opportunities to collect their (single) monetary payment in the future. These three patterns, out of the 64 logically possible patterns of choice, are actually virtually the only patterns that admit of a plausible, or any, representation in terms of the proposed parametric structure.

Analysis of actual collection behavior from the original experiment is difficult, simply because there is only one possible choice question for each subject, but there are some things we can say. Mainly by 'typing' subjects based on their *ex-ante* choice behavior according to whether they are more or less likely to choose dominated options there, we can forecast that those that are more likely to choose dominated options will be more likely to have trouble actually coming to collect their payments *ex-post*, as the choice of dominated options *ex-post* suggests that these subjects are more likely to have the types of constraints that would prevent them from collecting. This, in a nutshell, is what we conclude.

Most importantly, we believe that our analysis shows that consideration of basic economic constraints can go a long way to explaining intertemporal choice behavior that heretofore has

been explained mainly as resulting from a non-constant rate of time discounting, such as hyperbolic discounting, or beta-delta discounting. A key part of this insight follows from incorporating Rabin's critique of risk aversion as an explanation of choice under uncertainty when stakes are small, and our own analogous critique of pure-time preference as an explanation of intertemporal choice with small stakes over short time periods. What the experiment shows, in our interpretation, is that to a very large degree subjects seem to act in a way that is consistent with trying to anticipate those factors that may present challenges to them in finally collecting the money they will have access to. This is evident from the fact that the most prominent individual choice patterns can be rationalized by three parameters that roughly capture the nature of the constraints that different types of questions impose, as well as from the fact that *ex-post* collection behavior, as far as we can tell, is also consistent with the 'types' of subjects, as demarcated by their *ex-ante* patterns of choice.

It should be added that we are not, of course, arguing that the specific constraints that weighed on the subjects in our experiment are universal factors in decision-making experiments. Rather, we are suggesting that it may be useful to think carefully about the interface between the laboratory and the life of subjects outside of the laboratory, particularly as it relates to being paid in an experiment. The vast majority of experiments in economics take place within the laboratory, with all payments occurring in the laboratory setting, and this is normal and appropriate. But when the theories under consideration in the experiment depend upon the fundamental question of how money wealth is evaluated in the face of subjective uncertainty, shifting the payment procedure outside the laboratory, paradoxically, gives one more control, in the sense that suppositions about the nature of risk aversion and discounting can actually be credible and not just assumptions. This is not to say that this solves the question of what the right theory of decision-making under uncertainty is. We maintained throughout our analysis the working assumption that subjects are, essentially, interested in maximizing their income, as a way of zeroing-in on the subjective uncertainty induced by the structure of the experiment (i.e. by the constraints on collection opportunities). It may well still be the case that 'wrinkles' in the structure of preferences may have a role to play in understanding choice behavior, but our results indicate that attention should be paid to constraints on decision making, quite apart from preference structure.

Acknowledgements

We have benefited from comments from previous seminar audiences at Oxford University, the University of Auckland, Monash University and the University of Queensland. We have been ably assisted by Callie Ellis, Shelby Rose Petro, Vinay Ravinder, Kendra Singh and Rachel Straub. We thank Revan Sopher, Ashton Sopher and James Baker for expert computer programming.

Funding

We acknowledge funding from the Rutgers University Research Council and the Center for Economic Behavior, Institutions and Design at Rutgers for this research.

Conflict Of Interest

None declared.

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