Intertemporal Planning with Subjective Uncertainty,

or 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 opts for 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 might be considered suboptimal, compared to 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.

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1. 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. 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 cancelled 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 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 cancelling 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.

An important question is whether the attempts to exploit the potential for people to be tempted by certain options, in the sense that an option that is monetarily attractive may have characteristics different from a less monetarily attractive option that make it less likely that one will actually be better off for having chosen it. 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 (for example, 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.

Although the paper is primarily concerned with uncovering the determinants of choices between alternative future choice menus, we also investigate, in a small follow-up experiment, choice questions in which individuals choose between an immediate monetary payment and a future payment of the sort already described above. In light of the discussion above, it should be obvious that we would consider an "earlier" and a "later" payment option in this case to differ in more than simply the monetary and time dimensions. Opting for an immediate payment avoids tangible costs of returning to collect a payment, as well as uncertainty

about one's ability to return to collect a payment. 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 two weeks and a day to one apple in two weeks has been used to motivate the idea of hyperbolic discounting. Thaler (1981), Benzion et al (1989), Mischel (1966, 1974) Mischel and Ebbenson (1970) and Ainslie and Haendel (1983), which all employed only hypothetical payoffs, all emphasize stationarity violations (among other things). But careful incentivized studies by Holcomb and Nelson (1992) and Sopher and 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.

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 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.

2. A Model of Intertemporal Planning with Temptation

Ex Ante Choice

We consider, as in section 5 of Fishburn and 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. Call the set of such lotteries (P,t) conditional on t. 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, 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. Normalize $U(0,t)= \rho(t)u(p)$. Assuming impatience, $\rho(t)$ is decreasing.

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 one hour window of time one to eight weeks from the date of the experiment in the lab 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.) that 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 supposing that $r_i = x_i$, that is, 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 don't 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 example, 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 dollars today over 11 dollars in on 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 one 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, G. and V. Haendel (1983), Benabou and Pycia (2002), Chatterjee and Krishna (2005), Fudenberg and 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.

3. 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 inter-temporal choice, e.g., Sopher and 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, if you can pick up $20 in either 1 week, 2 weeks, 3 weeks, or 4 weeks, as in Option B below, that 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 4 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

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

collect. For example, one might be required to complete a questionnaire which 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.

The choice questions we use are all pair-wise comparisons, giving subjects a choice between 2 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 4 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 four weeks, but a lot more (about two-thirds of subjects) choose B over C when B pays $20 in either of four 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 contain 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 two 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 pair-wise 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, conducted during February of 2011 at Rutgers University-New Brunswick. Subject responded to 72 questions 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 the table. Each subject responded the same questions, but they were presented in a random order, independently determined for each subject. The same set of 36 questions were 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 non-trivial 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 approximately $X, including those people who only received the show up fee. The experiment took approximately one half hour to complete in the lab.

4. Experimental Results

Regression Analysis

Table 2 contains regression results which summarize the experimental data. The regression is a linear probability model, estimated with a random effects error specification to account for the repeated cross-sectional nature of the data. Choices are coded as a 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. The default category is the B vs. C choice in Set 1 with the shortest time delay until the first possible payment. Regressors include dummy variables for the A vs. C choice ("type2"), the A vs. B choice ("type3"), the other "set categories of option ("set2", "set3" and "set4"), whether the choices involved "delayed" options ("time2" and "time3" for the second and third row matrices from Table 1), and cross effects of the "type" variables with the "set" variables. Cross effects for the "type" variables with the "time" variables and cross effects for the "set" variables with the "time" 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.

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. 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 sub-section we analyze 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 Set 3 and 4 (where all payoffs are doubled) as for Set 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 week 1, 2, 3 or 4). 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 lab 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 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: 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

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 0's and 1's. 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, 111111 represents a pattern in which the dominant option is always chosen, and 110111 represents the "average" choice pattern discussed in the previous subsection.

Table 5 contains the frequency distribution of the observed patterns, aggregated over all 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 x 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, 110101, and 000010. Note that the average choice pattern, 110111, implied by the averages from Table 3, is only the 5th most frequently observed choice pattern, occurring 6% of the time. However, this pattern, along with patterns 110100 and 110101, which only differ by one choice from it, together account for 20% of all choices patterns, so it is likely 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, approximately 72% of the observed choice patterns can be attributed to 6 different choice patterns. We take the view, however, that there are really three "core" patterns of choice, (000011, 110101 and 111111), 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 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 lab 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 example, the A vs. B. choice in Set 1 (assuming 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 $p < .41$, 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 available is always chosen. For this pattern, a value of $p<.41$ is sufficient. But the other most prominent pattern of choice, 000011, and other observed choice patterns, are not rationalizable with a single parameter.

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, $(1-p^k)$ 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 $(1-q^k)$ 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 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.

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 two most common "core" choice patterns identified in the preceding analysis. Table 8 reports on the values of a single parameter that would rationalize the three core patterns. More specifically, Figures 1, 2 and 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, .02, …, .99) X Q=(.01, .02, …, .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 .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 Figure 1 or 2 occupy much less volume

than the "tent" provided by the Insurance Choice graph in Figure 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 one 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.

The Fine Structure of the Parameters: Further Testing

We recently conducted an additional experiment (with sessions dating from Summer 2017 through January of 2018) in order to directly address some of the suppositions we have made in constructing our model of subjective probabilities as constraints on future planning. If we suppose that having more opportunities to collect will be viewed as an advantage to some decision makers, then reducing the number of collection opportunities should shift choices in a predictable way. If having to complete a quiz is a negative thing, then removing quizzes should shift choices. Finally, if having payment opportunities further in the future is a disadvantage, then shifting them closer to the present should shift choices in predicable fashion as well. We also consider choice questions in which subjects have a choice between an immediate payoff and a future payoff. These results provide some evidence in favor of a rethinking of earlier studies in which stationarity violations are taken as prima fascia evidence for non-constant discounting. Tables 9 through 11 summarize some of the main results from this new experiment (full analysis of these data is not complete at this time). The options A, B, C, D, E and F are all the same as in the original experiment, except as noted. All options involve payment only in the next four weeks (there is no shifting into the future as in the original experiment).

Table 9 compares aggregate choice frequency for pairs of options, where a quiz is sometimes included as a condition for one option, as in the original experiment (left column) vs the same options, but with the quiz requirement removed. The notation A^Q means option A with a quiz requirement, whereas A with no Q superscript means the same option with the quiz requirement removed. The comparisons all indicate a moderate increase in the fraction of subjects choosing an option without a quiz, vs. with a quiz attached as a condition of payment.

Table 10 compares aggregate choice frequencies for pairs of options, where sometimes there are 4 opportunities to collect (left column) and sometimes there are two opportunities to collect (right column). The notation B^4 means option B with four opportunities to collect $6, whereas B^2 means option B with two opportunities to collect. In each comparison, the fraction choosing the option with two opportunities to collect is either the same, or slightly less, than the fraction choosing the option with four opportunities to collect.

Table 11 compares aggregate choice frequencies for pairs of options, where sometimes there is an early payment option (14, 14, 2, 2) over four weeks, and sometimes there is a late payment option (2, 2, 14, 14) over four weeks. This is a manipulation of the original C or F option in the original experiment (2, 14, 2, 14) over four weeks. C^E means the earlier payment option, and C^F the later payment option. The results in Table 11 indicates a general tendency for the choice of C (or F) later to be less frequent, but the B vs. C comparison in the second row of the table goes in the opposite direction, suggesting that these comparisons may be more complex.

Table 12 contains what are the most interesting results from the new experiment, in the immediate vs. future payoff choices. The highlighted lines in the table show instances where the immediate payment grows large enough, relative to the future payment, for a substantial fraction

of subjects to switch to choosing the immediate payoff over the larger, later payoff. According to our model of decision making, these three choices are roughly equivalent, in the sense that for a given subjective probability weighting on the later payment (which would be (1-f)(1-p), as there is no quiz involved), the immediate payment should be chosen on all three if (1-f)(1-p) <.8, and the later option should be chosen otherwise. Of course, the same thing could be argued for a discount factor as well, but due to our argument in analogy with Rabin's result on attributing choices under small stakes to risk aversion, we reject that conclusion (one might say that we *discount* that argument). We can push the analysis a step further here: In fact, in having the immediate payment available, one also is able to avoid the inevitable fixed opportunity cost of going to collect a payment. Thus, even with a given (1-f)(1-p), we actually should expect subjects to be more likely to opt for the immediate option, the smaller the sakes. For example, if the opportunity cost is c, a constant, then the relevant comparisons are:

Opt for \$8 immediately if 8> (1-f)(1-p)(10-c)

Opt for \$16 immediately if 16>(1-f)(1-p)(20-c)

and Opt for \$32 immediately if 32>(1-f)(1-p)(40-c).

There are values of f, p and c such that one would choose \$8 immediately, but wait to collect \$20 or \$40. It would be premature to draw very strong conclusions from this snap shot of a result, but the fact that a larger fraction of subjects opt for an immediate \$8 and the immediate \$16 or \$32 is consistent with this analysis.

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 lab session 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 which 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. As we pointed out in the last part of the previous subsection, the actual fixed cost of returning to make a payment is relevant in considering whether to take an action immediately or not. In the case of the options in the original experiment, which is what we are concerned with here, all payments require one to return to the lab to collect. Thus, 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 further analysis, we intend to analyze this question more carefully.

5. 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 a 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.

In a smaller follow up experiment we have seen some vindication of the proposed decision making model through direct manipulation of the factors posited in the model. Subjects

are more less likely to choose dominated options when there are fewer opportunities to collect; they are more likely to choose any given option when there is no requirement to complete a trivia quiz as a condition of payment; and subjects are less likely to choose a given option when the payment opportunities for that option are shifted into the future, all else equal. Finally, we have analyzed some choices between immediate and future payments, and find behavior consistent with the proposed model, with the additional fact that opportunity costs of future payments should be explicitly included in the analysis when one of the payment options is immediate.

Analysis of actual collection behavior from the original experiment, not yet completed, will incorporate information characterizing the choice behavior of the decision makers in the *ex ante* choice part of the experiment, as a control for the fact that certain types of decision makers will be more likely to choose dominated options. We hope in this way to be able determine whether the larger rate of non-collection among those who have dominated options to collect on vs those who have dominant options to collect on is due to them being more constrained, in the sense of the model we propose, or whether it is due to the lower likelihood of a smaller amount being collected because of fixed opportunity costs (regardless of other constraints).

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.

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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

Table 1 (continued): Future Payment Choice Options in the Experiment

Options (Set 3)

"Early"

t	A	B	C
1	20	12	4
2	0	12	28
3	0	12	4
4	0	12	28
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0

"Middle"

	A	B	C
1	0	0	0
2	0	0	0
3	20	12	4
4	0	12	28
5	0	12	4
6	0	12	28
7	0	0	0
8	0	0	0

"Late"

	A	B	C
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	20	12	4
6	0	12	28
7	0	12	4
8	0	12	28

Options (Set 4)

"Early"

t	D	E	F
1	40	20	4
2	0	20	28
3	0	20	4
4	0	20	28
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0

"Middle"

	D	E	F
1	0	0	0
2	0	0	0
3	40	20	4
4	0	20	28
5	0	20	4
6	0	20	28
7	0	0	0
8	0	0	0

"Late"

	D	E	F
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	40	20	4
6	0	20	28
7	0	20	4
8	0	20	28

Table 2: Regression: Probability of Choosing the Payoff-Dominant Option

Random-effects GLS Regression, N=4248, Number of Subjects=59, Choices/subject=72

Wald Chi-square(39) =727.84, Prob.> Chi. Sq. =0.00

Variable	Coefficient	Std. Error	z-stat.	Prob.>z
Constant	.75	.07	10.73	.00
Type2	-.01	.04	-.16	.88
Type3	-.19	.04	-4.30	.00
Set2	-.42	.03	-12.82	.00
Set3	-.02	.03	-.52	.61
Set4	-.43	.03	-13.08	.00
Type2/Set2	.35	.06	6.22	.00
Type2/Set3	.05	.06	0.95	.34
Type2/Set4	.36	.06	6.27	.00
Type3/Set2	.45	.06	7.87	.00
Type3/Set3	-.01	.06	-.10	.92
Type3/Set4	.38	.06	6.72	.00
Time2	.01	.03	0.37	.71
Time3	.03	.03	1.17	.24

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	.73	.73	.54	Set 2	.31	.65	.96
Set 3 (doubled)	.73	.73	.54	Set 4 (doubled)	.31	.64	.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.		

Table 5: Frequency Distributions of Choice Patterns

Pattern Frequency by Set-Pairs/Rows (a indicates first asking, b indicates second asking)														
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 (.17)**	**0%***
000110	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1 (.08)**	**0%***
000111	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**4 (.33)**	**0%***
001000	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1 (.08)**	**0%***
001010	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1 (.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 (.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 (.75)**	**1%**
010101	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**5 (.42)**	**1%**
010110	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**7 (.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 (.17)**	**0%***
100000	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1 (.08)**	**0%***
100010	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2 (17)**	**0%***

Table 5: Frequency Distributions of Choice (continued)

Pattern Frequency by Set-Pairs/Rows (a indicates first asking, b indicates second asking)

pattern	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	Row total (ave. # in parens)	Overall % (total divided by 708)
100011	0	2	0	1	0	0	0	0	0	0	0	0	3 (.25)	0%*
100100	1	0	0	0	0	0	0	0	0	0	0	0	1 (.08)	0%*
100110	0	0	0	0	0	1	0	0	0	0	0	0	1 (.08)	0%*
100111	0	1	0	0	0	0	0	0	1	0	0	0	2 (.17)	0%*
101100	0	0	0	0	0	0	0	0	0	0	1	0	1 (.08)	0%*
101111	0	0	0	1	0	0	1	0	0	0	0	0	2 (.17)	0%*
110000	1	0	0	0	0	0	1	0	0	0	0	0	2 (.17)	0%*
110001	0	0	2	1	0	0	0	0	1	0	0	0	4 (.33)	1%
110010	1	2	0	1	0	0	0	0	1	0	0	0	5 (.42)	1%
110011	0	1	0	2	0	2	1	0	0	1	0	0	7 (.58)	1%
110100	2	4	2	3	3	3	2	3	3	1	2	4	32 (2.67)	5%
110101	8	4	4	6	7	5	3	3	7	5	5	4	61 (5.08)	9%
110110	2	0	0	0	0	1	0	1	0	0	0	1	5 (.42)	1%
110111	0	4	7	1	4	4	4	8	1	4	4	5	46 (3.83)	6%
111001	0	0	0	0	0	0	0	0	1	0	0	0	1 (.08)	0%*
111011	1	0	0	1	0	1	0	0	0	1	0	0	4 (.33)	1%
111101	1	0	1	0	1	0	0	1	0	0	1	0	5 (.42)	1%
111110	0	0	0	0	0	0	0	0	0	0	1	0	1 (.08)	0%*
111111	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 .5%. **Column may not adds 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: 110101	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%*

Table 7: Conditions on No-Show Probability as a Function of p, q and f Consistent with Dominance Violations

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 (2^{nd} 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 (3^{rd} 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 (4^{th} 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 (5^{th} 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)

Table 8: Parameters Consistent with Main Choice Patterns

Pattern #	Pattern	C1	C2	C3	C4*	C5*	C6	Single parameter (p)	Three paramters (p, q, f)
I (dominant)	111111							p<.41	See Figure 1
II (quiz-avoiding)	000011	x	x	x	x			p >.64 and increasing with time delay	See Figure 2
III (insurance)	110101			x		x		p>.55 and increasing with time delay	See Figure 3

*C4 and C5 both require a p that is increasing with the time delay from the present. Absolute number given comes from other conditions where a constant p is sufficient. Some (earlier) values of p may be smaller than this number (needs to be checked more carefully)

Figure 1: Parameters Consistent with the Dominant Choice Pattern

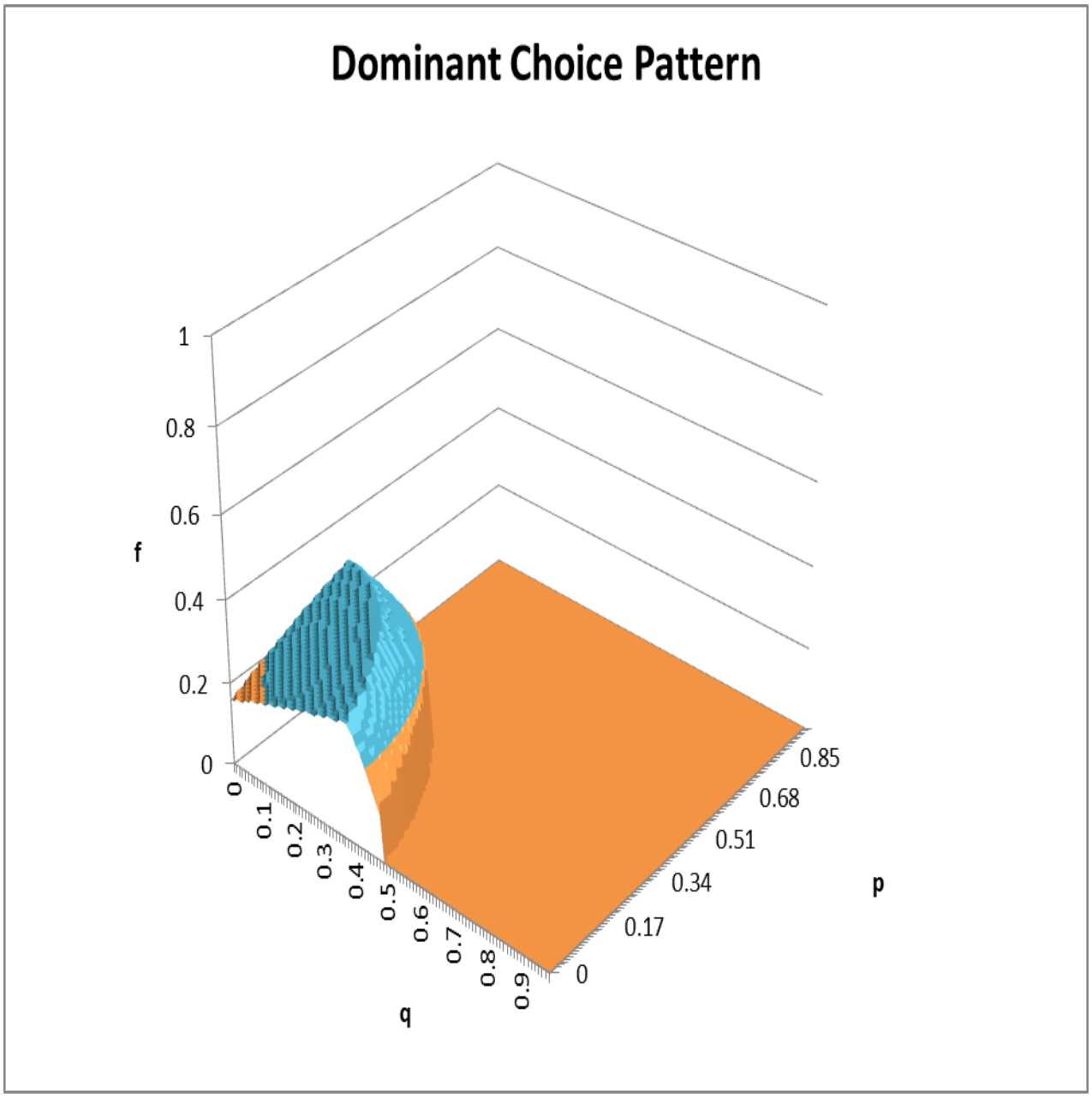

Figure 2: Parameters Consistent with the Quiz-Avoiding Choice Pattern

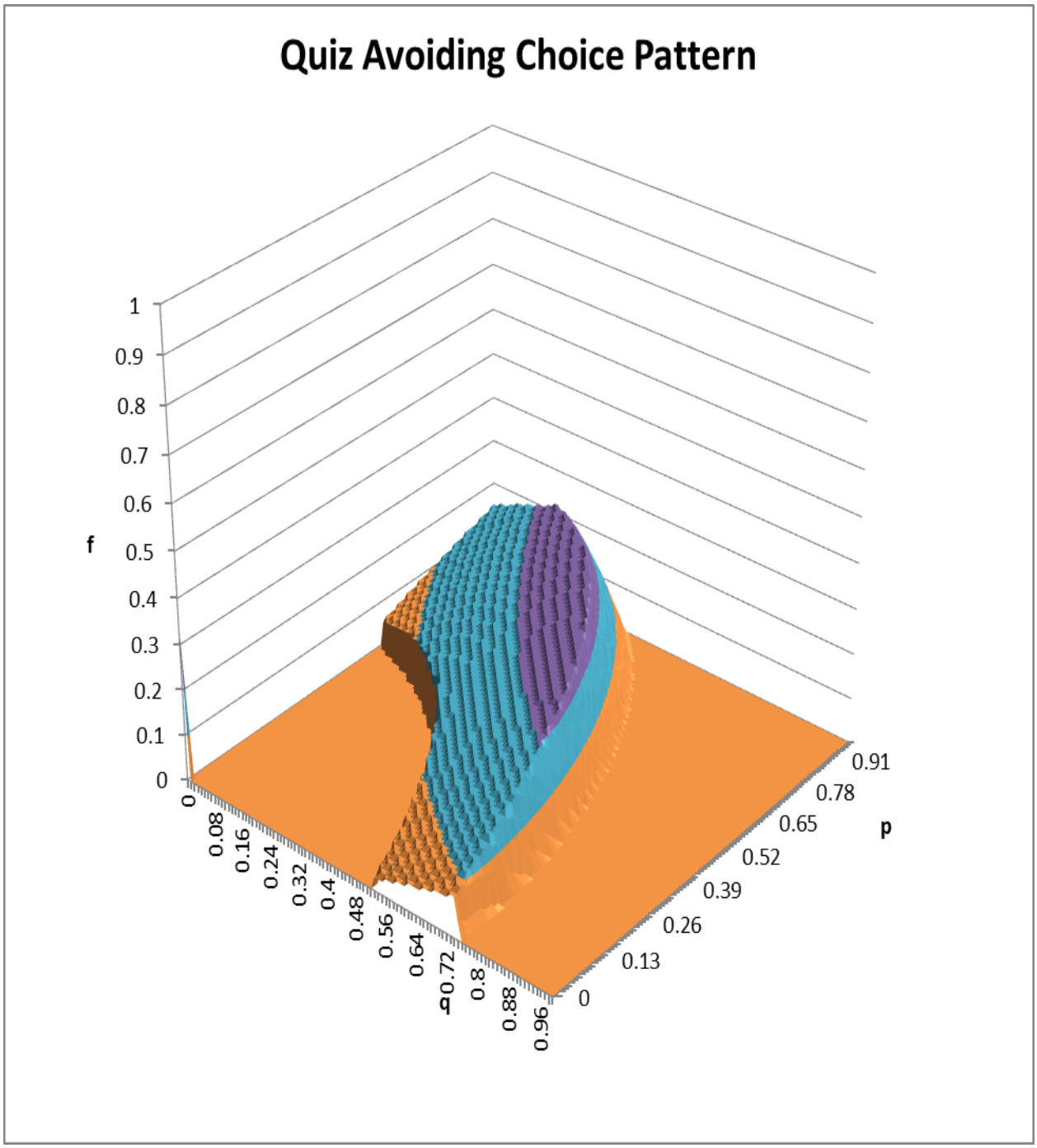

Figure 3: Parameters Consistent with Insurance Choice Pattern

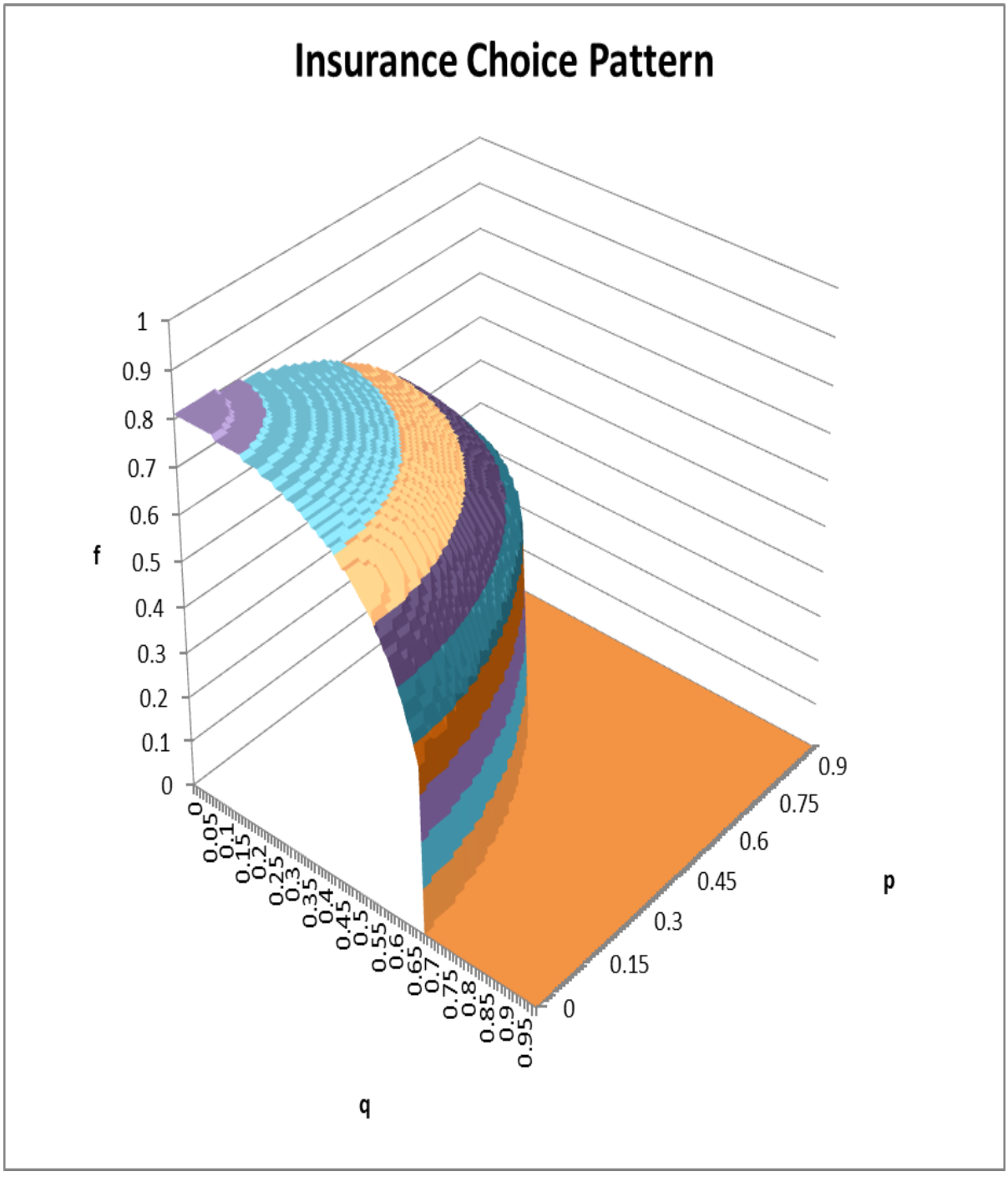

Table 9: Effect of Removing Quiz Requirement from Future Payment Options

Fraction Choosing option with Quiz	Fraction Choosing option with Quiz removed
A^Q vs. B: .80	A vs. B: .93
B vs. C^Q : .79	B vs. C: .90
D^Q vs. E: .88	D vs. E: .93
E vs. F^Q : .70	E vs. F: .78
N=40 subjects	

Table 10: Effect of Offering Few Collection Opportunities

Fraction Choosing option with Four Collection Times	Fraction Choosing option with Two Collection Times
A vs. B^4 : 1.0	A vs. B^2: 1.0
B^4 vs. C: .85	B^2 vs. C: .79
D vs E^4: 1.0	D vs E^2 1.0
E^4 vs. F: .46	E^2 vs. F: .44
N=39 subjects	

Table 11: Effect of Earlier vs. Later Opportunities to Collect

Fraction Choosing option with Four Collection Times	Fraction Choosing option with Two Collection Times
A vs. C^E : .58	A vs. C^L: .35
B vs. C^E: .67	B vs. C^L: .78
D vs F^E: .95	D vs F^L: .88
E vs. F^E: .35	E vs. F^L: .23
N=40 subjects	

Table 12: Immediate vs. Future Payments

Immediate Payoff	Payoff in One Week	Fraction Choosing Later Option (Dominant)
$4	$10	0.97
$8	$10	0.59
$4	$20	1.00
$8	$20	0.97
$12	$20	0.97
$16	$20	0.74
$8	$40	1.00
$16	$40	0.97
$24	$40	0.92
$32	$40	0.67
N=40 subjects		

Appendix A: Instructions for the Experiment

Introduction

You are about to participate in an experiment in the economics of decision making. Various research foundations have provided the funding for this research. The research is designed to study how people make decisions when facing uncertainty and how people make decisions that take place over time. At the end of the experiment you will be paid for your participation, as outlined in the following instructions.

General Instructions

In this experiment you will have the opportunity to make a series of decisions by indicating , on a series of questions, which of two alternative ways of receiving different sums of money at different points in time you would prefer. Each alternative will specify one or more weeks in which, on a particular day, you can receive a specified monetary payment. The monetary amount may be the same in every period, or they may differ over the different periods. No matter the configuration of the possible payments over the possible periods, you will only have the option to collect a single one of the payments for the alternative that you choose. Some of the alternatives will involve *simple* payments, which means that to collect a payment you will only need to show up on the day, time and place specified to collect your payment. Other alternatives will involve *conditional* payments, which means that to collect a payment you will need to show up on the day, time and place specified, as for simple payments, but you will also need to satisfy certain *conditions.* The details of what sorts of payment alternatives are possible, when the payment collections days will be, and what kind of conditions will need to be satisfied in order to collect conditional payments, will be explained in turn below.

Payment alternatives

A typical choice question that you will be presented with in the experiment will be of the following sort:

Question: Which of the following alternatives would you prefer?

Alternative I : You may receive a payment of $10 one week from today, $10 two weeks from today, or $10 eight weeks from today.

Alternative II: You may receive a payment of $15 five weeks from today. The condition for this alternative is that you complete a trivia quiz with a score of 100%.

Alternative I is a simple alternative. If you chose this alternative, then you could come to collect your payment of $10 either in one week, in two weeks, or in eight weeks. Alternative II is a conditional alternative. In order to collect the payment of $15, you would need to show up in five weeks, but you would also need to bring with you a completed trivia quiz with all of the answers correct.

The Full Questionnaire

In all, there will be 72 questions, each presenting you with two different alternatives. Once you have finished answering all of the questions, one of the questions will be selected at random, and the alternative that you chose for that question will determine your payoffs for the experiment. You will receive $5 simply for having shown up to participate today, plus an additional payment, which will depend upon the alternative you selected, and on which of the options for payment, if any, you choose to exercise.

Conditions for Payment

If you opt for a conditional alternative, the condition will always be a trivia quiz of 20 questions which you must complete with correct answers. The questions on these quizzes will be questions where the answer may not be obvious to you, but a simple internet search will reveal the answer fairly quickly. The questions are intended to have a simple, clear answer, so you should not be concerned that you will not be able to find the answer. A typical question on the quiz would be something like, "Who was the 13th President of the United States?" You only need to be sure to allow yourself time to find the answers, and to bring the completed quiz with you when you come to collect your payment. If you forget the quiz, or fail to complete it correctly, you will not be able to collect your payment. You must bring the original quiz that you are given in order to collect your payment. Photocopies or other reproductions will not be accepted.

Payment Collection Days

The days on which you can pick up payments will always be on exactly the same day of the week that you are completing the experiment, at the same time that you are completing the experiment, and in the same place that you are completing the experiment. So if today is Tuesday and the session is taking place between 10 and 11am in the 107 Scott Hall Lab, then your collection day, time and place will always be a Tuesday, between 10 and 11am, in the 107 Scott Hall Lab. Payments in different alternatives will be one to eight weeks from today. If you do not show up in the specified period for the payment, you will not be able to collect a payment for that day.

What if You Are Not Able to Pick Up Your Payment?

If you are not able to collect a payment, either because you fail to show up at the date, time and place specified, or you show up but forget your quiz for a conditional payment or fail to have all of the questions answered correctly, then you cannot pick up a payment that day. If the alternative that you chose includes other dates in the future with payments, then you are still free to exercise one of those options. If you are not able to collect a payment because you have failed to complete a quiz correctly, you may still use the same quiz that you originally were given to complete.

Payoff

Your final earnings will be determined as follows. You will earn $5 for having shown up to the experiment today. You will receive one additional payment, which will depend upon the details of the alternative you chose on the question that was randomly selected from the full set of questions you answered. If you are unable to successfully pick up a second payment due to a failure to show up at the right date, time and place, or due to failing to bring a completed, correct quiz when one is required, your total payment will be $5. In other words, in order to collect a second payment, you must shown up at the date, time and place specified for one of the payment options in the alternative you chose, and you must also have a completed, correct quiz if the payment is a conditional payment.

If you have any questions at this time, please raise your hand and someone will come to answer your question.

Payment Coupon

Your name: _____ Location of today's session: _____

Today's date_____ Time of today's session: _____

Your options for payment: Date:

In one week: _____ _____

In two weeks _____ _____

In three weeks: _____ _____

In four weeks: _____ _____

In five weeks: _____ _____

In six weeks: _____ _____

In seven weeks: _____ _____

In eight weeks: _____ _____

You have chosen a simple alternative _____.

You have chosen a conditional alternative_____. If this line is checked, then you must complete

the attached trivia quiz correctly and bring it with you when you come to collect your payment, along with this payment coupon. For both simple and conditional alternatives, you must come to the same location where you completed the experiment on the same day of the week and in the same one hour time slot in which you completed the experiment, in order to collect your payment. You may only collect one time.

Appendix B: Sample of trivia questions used for quizzes on conditional questions.

What are the five European countries to have won soccer's World Cup?

Who was the first U.S. volleyball player to win three Olympic gold medals?

Prior to 2010, in how many World Series of baseball did the New York Yankees participate?

What baseball announcer's 1996 funeral was attended by Joe DiMaggio, Yogi Berra, Whitey Ford and Phil Rizzuto?

Who was the only soccer player to play on three World Cup-winning teams?

Who was known as "Tanya" after a 1974 San Francisco bank robbery?

What color were the "black boxes" on TWA Flight 800?

What secretary of defense admitted the Vietnam War was a "mistake" in 1995?

What was a ship called the *Ancon* the first to travel through, on August 15, 1914?

Who was the longest-reigning Arab ruler, through 1995?

What are the international registration letters of a vehicle from Estonia?

What is the weight of an Oscar Award?

When was the North Atlantic Treaty signed?(dd/mm/yy)

Who was the youngest person to ever receive an Oscar?

Who was the youngest person to be nominated and win Best Supporting Actress, for *Paper Moon* in 1974?

Who became the oldest person to win Best Actor for his performance as the grouchy retired college professor in *On Golden Pond* (1981)?

Who became the oldest woman to win Best Actress for her performance in *Driving Miss Daisy* (1989)?

Who has been editing Forbes magazine since 1999?

Which US city hosts the `Consumer Electronics Show` every year in January?

Who won the Nobel prize in Literature in 2006?