Risk Preferences Are Not Time Preferences

James Andreoni and Charles Sprenger

Web Appendix

A Appendix Tables

Table A1: Non-Parametric Estimates of DEU Violations

	Comparison		
	$(p_1, p_2) = (1, 1)$ vs. $(0.5, 0.5)$	$(p_1, p_2) = (1, 0.8)$ vs. $(0.5, 0.4)$	$(p_1, p_2) = (0.8, 1)$ vs. $(0.4, 0.5)$
Dependent Variable:	c_t Allocations		
Risk Conditions			
Condition $(p_1, p_2) = (1, 1)$	3.350***		
	(0.772)		
Condition $(p_1, p_2) = (1, 0.8)$		4.418***	
		(0.558)	
Condition $(p_1, p_2) = (0.8, 1)$			-3.537***
			(0.684)
Interest Rate x Delay Length Categories			
$(1 + r, k) = (1.00, 28)$	-	-	-
$(1 + r, k) = (1.05, 28)$	-5.318***	-1.651***	-0.967*
	(0.829)	(0.316)	(0.452)
$(1 + r, k) = (1.11, 28)$	-6.294***	-2.818***	-1.382**
	(0.812)	(0.434)	(0.454)
$(1 + r, k) = (1.18, 28)$	-6.921***	-4.140***	-1.851***
	(0.780)	(0.490)	(0.455)
$(1 + r, k) = (1.25, 28)$	-7.438***	-5.449***	-2.222***
	(0.755)	(0.544)	(0.488)
$(1 + r, k) = (1.33, 28)$	-8.187***	-7.139***	-2.742***
	(0.721)	(0.668)	(0.496)
$(1 + r, k) = (1.43, 28)$	-9.039***	-8.164***	-3.126***
	(0.677)	(0.658)	(0.503)
$(1 + r, k) = (1.00, 56)$	0.193	0.073	0.873*
	(0.192)	(0.211)	(0.395)
$(1 + r, k) = (1.05, 56)$	-4.600***	-1.290***	-0.352
	(0.791)	(0.336)	(0.442)
$(1 + r, k) = (1.11, 56)$	-5.409***	-2.582***	-0.923
	(0.805)	(0.331)	(0.515)
$(1 + r, k) = (1.18, 56)$	-6.462***	-3.685***	-1.451**
	(0.796)	(0.480)	(0.513)
$(1 + r, k) = (1.25, 56)$	-7.436***	-5.227***	-1.812***
	(0.758)	(0.544)	(0.512)
$(1 + r, k) = (1.33, 56)$	-8.118***	-6.979***	-2.532***
	(0.740)	(0.652)	(0.493)
$(1 + r, k) = (1.43, 56)$	-8.775***	-7.882***	-2.833***
	(0.713)	(0.656)	(0.477)
Risk Condition Interactions: Relevant Risk Condition x			
$(1 + r, k) = (1.05, 28)$	-6.148***	-1.544*	0.134
	(1.111)	(0.602)	(0.421)
$(1 + r, k) = (1.11, 28)$	-6.493***	-1.574**	0.498
	(1.048)	(0.573)	(0.446)
$(1 + r, k) = (1.18, 28)$	-6.597***	-2.131**	0.849
	(0.981)	(0.708)	(0.463)
$(1 + r, k) = (1.25, 28)$	-6.666***	-2.584**	0.920
	(0.971)	(0.762)	(0.576)
$(1 + r, k) = (1.33, 28)$	-6.425***	-2.136**	1.319*
	(0.917)	(0.764)	(0.601)
$(1 + r, k) = (1.43, 28)$	-5.683***	-2.170**	1.443*
	(0.880)	(0.728)	(0.623)
$(1 + r, k) = (1.00, 56)$	0.192	-0.180	0.107
	(0.450)	(0.243)	(0.602)
$(1 + r, k) = (1.05, 56)$	-5.540***	-1.646**	0.156
	(1.088)	(0.616)	(0.557)
$(1 + r, k) = (1.11, 56)$	-6.734***	-1.781**	0.511
	(1.093)	(0.588)	(0.521)
$(1 + r, k) = (1.18, 56)$	-6.450***	-2.471***	0.747
	(1.040)	(0.719)	(0.644)
$(1 + r, k) = (1.25, 56)$	-6.006***	-2.576***	0.994
	(0.975)	(0.714)	(0.636)
$(1 + r, k) = (1.33, 56)$	-5.911***	-2.286**	1.604**
	(0.974)	(0.781)	(0.587)
$(1 + r, k) = (1.43, 56)$	-5.574***	-2.618***	1.639*
	(0.936)	(0.702)	(0.654)
Constant (Omitted Category)	12.537***	14.455***	5.950***
	(0.464)	(0.424)	(0.554)
H_0: Zero Condition Slopes	$F_{14,79} = 6.07$	$F_{14,79} = 7.69$	$F_{14,79} = 5.46$
	$(p < 0.01)$	$(p < 0.01)$	$(p < 0.01)$
# Observations	2240	2240	2240
# Clusters	80	80	80
R^2	0.429	0.360	0.173

Notes: Clustered standard errors in parentheses. $F_{14,79}$ statistics correspond to hypothesis tests of zero slopes for risk condition regressor and 13 risk condition interactions.

B Estimating Preference Parameters

In this appendix we discuss structural estimation of intertemporal preference parameters. We document that a common set of DEU parameters cannot simultaneously rationalize the $(p_1, p_2) = (0.5, 0.5)$ and $(p_1, p_2) = (1, 1)$ data, providing structural support for the claim that risk preferences are not time preferences. Additionally, the parameter estimates are used out of sample to predict behavior both in Figure 6 and in Figure A2. The evidence indicates that away from certainty the data adhere closely to DEU parameters estimated from $(p_1, p_2) = (0.5, 0.5)$, but are far from those estimated from $(p_1, p_2) = (1, 1)$.

Given structural assumptions, the design allows us to estimate utility parameters, following methodology developed in Andreoni and Sprenger (Forthcoming). We assume an exponentially discounted CRRA utility function,

$$U = p_1\delta^t(c_t - \omega)^\alpha + p_2\delta^{t+k}(c_{t+k} - \omega)^\alpha,$$

where δ represents exponential discounting, α represents utility function curvature and ω is a background parameter that could be interpreted as a Stone-Geary minimum.[24] We posit an exponential discounting function because for timing and transaction cost reasons no present payments were provided. This precludes direct analysis of present-biased or quasi-hyperbolic time preferences (Strotz, 1956; Phelps and Pollak, 1968; Laibson, 1997; O'Donoghue and Rabin, 1999). Under this formulation, the DEU solution function, c_t^*, can be written as

$$c_t^*(p_1/p_2, t, k, 1{+}r, m) = \frac{[1 - (\frac{p_2}{p_1}(1+r)\delta^k)^{\frac{1}{\alpha-1}}]}{[1 + (1+r)(\frac{p_2}{p_1}(1+r)\delta^k)^{\frac{1}{\alpha-1}}]}\omega + \frac{[(\frac{p_2}{p_1}(1+r)\delta^k)^{\frac{1}{\alpha-1}}]}{[1 + (1+r)(\frac{p_2}{p_1}(1+r)\delta^k)^{\frac{1}{\alpha-1}}]}m,$$

or

$$c_t^*(\theta, t, k, 1+r, m) = \frac{[1 - (\theta\delta^k)^{\frac{1}{\alpha-1}}]}{[1 + (1+r)(\theta\delta^k)^{\frac{1}{\alpha-1}}]}\omega + \frac{[(\theta\delta^k)^{\frac{1}{\alpha-1}}]}{[1 + (1+r)(\theta\delta^k)^{\frac{1}{\alpha-1}}]}m. \quad (1)$$

We estimate the parameters of this function via non-linear least squares with standard errors clustered on the individual level to obtain $\hat{\alpha}$, $\hat{\delta}$, and $\hat{\omega}$. An estimate of the annual discount rate is generated as $1/\hat{\delta}^{365} - 1$, with corresponding standard error obtained via the delta method.

Table A2 presents discounting and curvature parameters estimated from the two conditions $(p_1, p_2) = (1, 1)$ and $(p_1, p_2) = (0.5, 0.5)$. In column (1), we estimate a baseline model where discounting, curvature, and background parameters are restricted to be equal across the two risk conditions. The aggregate discount rate is estimated to

[24] The ω terms could be also be interpreted as intertemporal reference points or background consumption. Frequently in the time preference literature, the simplification $\omega = 0$ is imposed or ω is interpreted as *minus* background consumption (Andersen et al., 2008) and calculated from an external data source. In Andreoni and Sprenger (Forthcoming) we provide methodology for estimating the background parameters and employ this methodology here. Detailed discussions of sensitivity and censored data issues are provided in Andreoni and Sprenger (Forthcoming) who show that accounting for censoring issues has little influence on estimates.

be around 27 percent per year and aggregate curvature is estimated to be 0.98. The background parameter, $\hat{\omega}$ is estimated to be 3.61.

Table A2: Discounting and Curvature Parameter Estimates

	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{\alpha}$	0.982		0.984			
	(0.002)		(0.002)			
$\hat{\alpha}_{(1,1)}$		0.987		0.987	0.988	0.988
		(0.002)		(0.002)	(0.002)	(0.002)
$\hat{\alpha}_{(0.5,0.5)}$		0.950		0.951	0.885	0.883
		(0.008)		(0.008)	(0.017)	(0.017)
Rate	0.274			0.285		0.284
	(0.035)			(0.036)		(0.037)
$\text{Rate}_{(1,1)}$		0.281	0.276		0.282	
		(0.036)	(0.039)		(0.036)	
$\text{Rate}_{(0.5,0.5)}$		0.321	0.269		0.315	
		(0.059)	(0.033)		(0.088)	
$\hat{\omega}$	3.608				2.417	2.414
	(0.339)				(0.418)	(0.418)
$\hat{\omega}_{(1,1)}$		2.281	2.106	2.285		
		(0.440)	(0.439)	(0.439)		
$\hat{\omega}_{(0.5,0.5)}$		4.397	5.260	4.427		
		(0.321)	(0.376)	(0.324)		
H_0: Equality		$F_{3,79} = 16.12$	$F_{2,79} = 30.47$	$F_{2,79} = 23.24$	$F_{2,79} = 37.97$	$F_{1,79} = 38.09$
		($p < 0.01$)	($p < 0.01$)	($p < 0.01$)	($p < 0.01$)	($p < 0.01$)
R^2	0.642	0.675	0.672	0.675	0.673	0.673
N	2240	2240	2240	2240	2240	2240
Clusters	80	80	80	80	80	80

Notes: NLS solution function estimators. Subscripts refer to (p_1, p_2) condition. Column (1) imposes the interchangeability, $v(\cdot) = u(\cdot)$. Column (2) allows different curvature, discounting and background parameters in each (p_1, p_2) condition. Column (3) restricts curvature to be equal across conditions. Column (4) restricts discounting to be equal across conditions. Column (5) restricts the background parameter ω to be equal across conditions. Column (6) restricts the background parameter ω and discounting to be equal across conditions. Clustered standard errors in parentheses. F statistics correspond to hypothesis tests of equality of parameters across conditions. Rate: Annual discount rate calculated as $(1/\hat{\delta})^{365} - 1$, standard errors calculated via the delta method.

In column (2), we estimate separate discounting, curvature and background parameters for the two risk conditions. That is, we estimate a certain $v(\cdot)$ and an uncertain $u(\cdot)$. Discounting is found to be similar across the conditions, around 30 percent per year ($F_{1,79} = 0.69,\ p = 0.41$).[25] In the certain condition, $(p_1, p_2) = (1, 1)$, we find almost linear utility while in the uncertain condition, $(p_1, p_2) = (0.5, 0.5)$, we estimate

[25]For comparison, using similar methodology without uncertainty Andreoni and Sprenger (Forth-

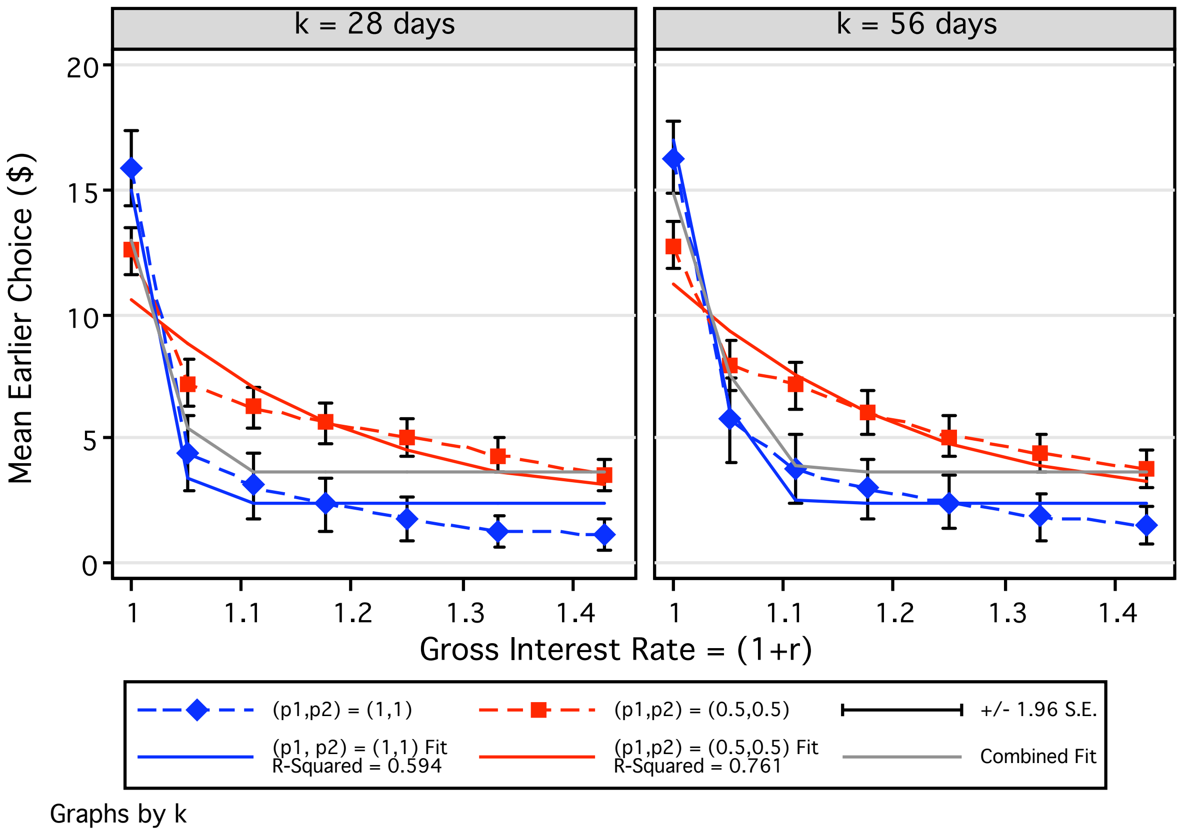
utility to be significantly more concave ($F_{1,79} = 24.09,\ p < 0.01$). In the certain condition, $(p_1, p_2) = (1, 1)$, we estimate a background parameter $\hat{\omega}_{1,1}$ of 2.28 while in the uncertain condition the background parameter is significantly higher at 4.40 ($F_{1,79} = 25.53,\ p < 0.01$). A hypothesis test of equal utility parameter estimates across conditions is rejected ($F_{3,79} = 16.12,\ p < 0.01$).

In Table A2, columns (3) through (6) we estimate utility parameters with various imposed restrictions. In column (3), we restrict curvature to be equal across conditions and obtain very similar discounting estimates, but a larger difference in estimated background parameters. In column (4), we restrict discounting to be equal across conditions and obtain a result almost identical to column (2). In column (5), we restrict background parameters to be equal and obtain very similar discounting estimates, but a larger difference in curvature. This finding is repeated in column (6) where discounting is restricted to be the same. Across specifications, hypothesis tests of equality of utility parameters are rejected.

To illustrate how well these estimates fit the data, Figure A1 displays solid lines with predicted behavior from the most restricted regression, column (6) and the common regression of column (1). The general pattern of aggregate responses is well matched by the column (6) estimates. Figure A1 reports separate R^2 values for the two conditions: $R^2_{1,1} = 0.594$; $R^2_{0.5,0.5} = 0.761$, and the model fits are substantially better than the combined model of column (1). For comparison a simple linear regression of c_t on the levels of interest rates, delay lengths and their interaction in each condition would produce $\tilde{R}^2$ values of $\tilde{R}^2_{1,1} = 0.443$; $\tilde{R}^2_{0.5,0.5} = 0.346$. The least restricted regression, column (2) creates very similar predicted values with R^2 values of 0.595 and 0.766. As the estimates show predicting either condition's responses from the other would lead to substantially worse fit. When using the $(p_1, p_2) = (0.5, 0.5)$ estimates of column (2) as a model for the $(p_1, p_2) = (1, 1)$ data, the R^2 value reduces to 0.466. And, when using the $(p_1, p_2) = (1, 1)$ estimates of column (2) as a model for the $(p_1, p_2) = (0.5, 0.5)$ data, the R^2 value reduces to 0.629.

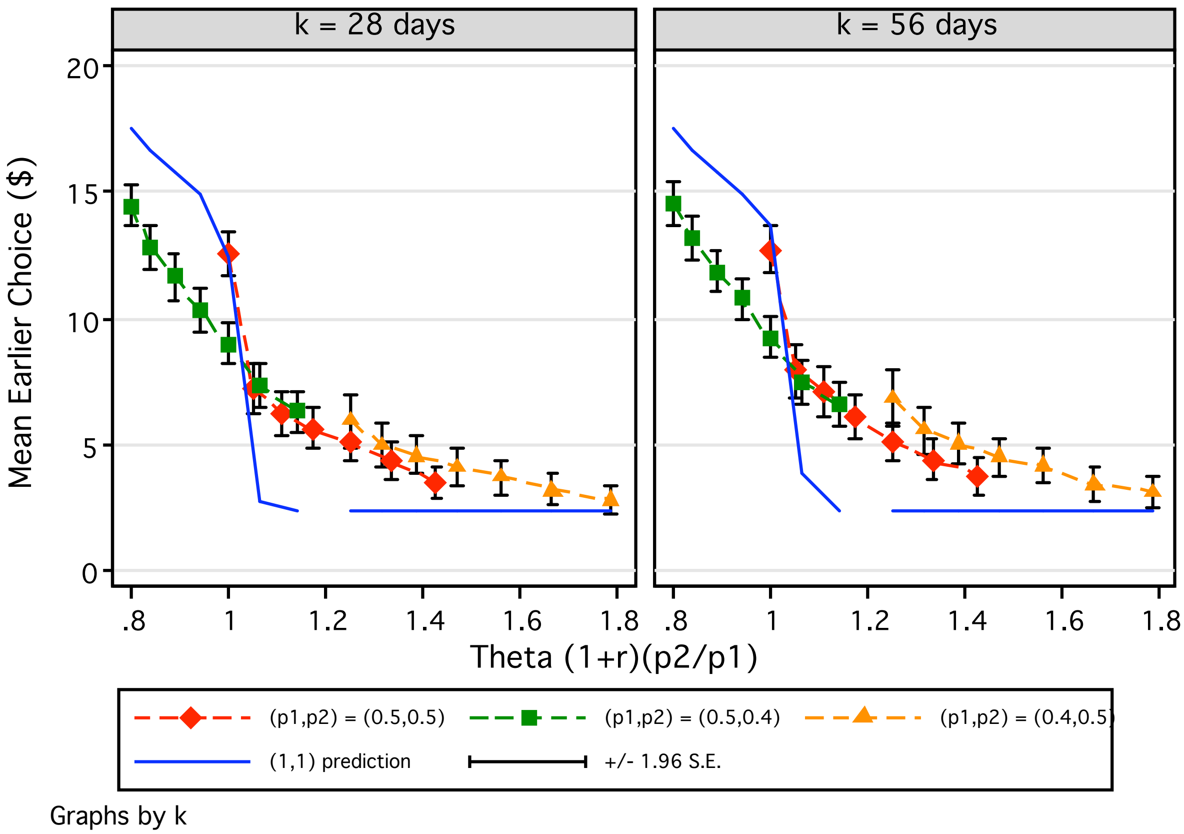
coming) find aggregate discount rate between 25-35 percent and aggregate curvature of around 0.92. These discount rates are lower than generally found in the time preference literature (Frederick, Loewenstein and O'Donoghue, 2002). Notable exceptions of similarly low or lower discount rates include Coller and Williams (1999), Harrison, Lau and Williams (2002), and Harrison et al. (2005) which all assume linear utility, and Andersen et al. (2008), which accounts for utility function curvature with Holt and Laury (2002) risk measures.

Figure A1: Aggregate Behavior Under Certainty and Uncertainty



Note: The figure presents aggregate behavior for $N = 80$ subjects under two conditions: $(p_1, p_2) = (1, 1)$, i.e. no risk, in blue; and $(p_1, p_2) = (0.5, 0.5)$, i.e. 50 percent chance sooner payment would be sent *and* 50 percent chance later payment would be sent, in red. $t = 7$ *days* in all cases, $k \in \{28, 56\}$ *days*. Error bars represent 95 percent confidence intervals, taken as $+/-1.96$ standard errors of the mean. Test of H_0 : Equality across conditions: $F_{14,79} = 6.07,\ p < .001$.

Figure A2: Aggregate Behavior Under Uncertainty with Predictions Based on Certainty



Note: The figure presents aggregate behavior for $N = 80$ subjects under three conditions: 1) $(p_1, p_2) = (0.5, 0.5)$, i.e. equal risk, in red; 2) $(p_1, p_2) = (0.5, 0.4)$, i.e. more risk later, in green; and 3) $(p_1, p_2) = (0.4, 0.5)$, i.e. more risk sooner, in orange. Error bars represent 95 percent confidence intervals, taken as $+/-1.96$ standard errors of the mean. Blue solid lines correspond to predicted behavior using certain utility estimates from $(p_1, p_2) = (1, 1)$ as estimated in Table A2, column (6).

C Welcome Text

Welcome and thank you for participating.

Eligibility for this study: To be in this study, you need to meet these criteria. You must have a campus mailing address of the form:

YOUR NAME

9450 GILMAN DR 92(MAILBOX NUMBER)

LA JOLLA CA 92092-(MAILBOX NUMBER)

Your mailbox must be a valid way for you to receive mail from now through the end of the Spring Quarter.

You must be willing to provide your name, campus mail box, email address, and student PID. This information will only be seen by Professor Andreoni and his assistants. After payment has been sent, this information will be destroyed. Your identity will not be a part of any subsequent data analysis.

You must be willing to receive your payment for this study by check, written to you by Professor James Andreoni, Director of the UCSD Economics Laboratory. The checks will be drawn on the USE Credit Union on campus. You may deposit or cash your check wherever you like. If you wish, you can cash your checks for free at the USE Credit Union any weekday from 9:00 am to 5:00 pm with valid identification (drivers license, passport, etc.).

The checks will be delivered to you at your campus mailbox at a date to be determined by your decisions in this study, and by chance. The latest you could receive payment is the last week of classes in the Spring Quarter.

If you do not meet all of these criteria, please inform us of this now.

D Instruction and Examples Script

Earning Money:

To begin, you will be given a \$10 minimum payment. You will receive this payment in two payments of \$5 each. The two \$5 minimum payments will come to you at two different times. These times will be determined in the way described below. Whatever you earn from the study today will be added to these minimum payments.

In this study, you will make 84 choices over how to allocate money between two points in time, one time is ‘earlier’ and one is ‘later’. Both the earlier and later times will vary across decisions. This means you could be receiving payments as early as one week from today, and as late as the last week of classes in the Spring Quarter, or possibly other dates in between.

It is important to note that the payments in this study involve chance. There is a chance that your earlier payment, your later payment or both will not be sent at all. For each decision, you will be fully informed of the chance involved for the sooner and later payments. Whether or not your payments will be sent will be determined at the END of the experiment today. If, by chance, one of your payments is not sent, you will receive only the \$5 minimum payment.

Once all 84 decisions have been made, we will randomly select one of the 84 decisions as the decision-that-counts. This will be done in three stages. First, we will pick a number from 1 to 84 at random to determine which is the decision-that-counts and the corresponding sooner and later payment dates. Then we will pick a second number at random from 1 to 10 to determine if the sooner payment will be sent. Then we will pick a third number at random from 1 to 10 to determine if the later payment will be sent. We will use the decision-that-counts to determine your actual earnings. Note, since all decisions are equally likely to be chosen, you should make each decision as if it will be the decision-that-counts. When calculating your earnings from the decision-that-counts, we will add to your earnings the two \$5 minimum payments.

Thus, you will always get paid at least \$5 at the chosen earlier time, and at least \$5 at the chosen later time.

IMPORTANT: All payments you receive will arrive to your campus mailbox. On the scheduled day of payment, a check will be placed for delivery in campus mail services by Professor Andreoni and his assistants. Campus mail services guarantees delivery of 100% of your payments by the following day.

As a reminder to you, the day before you are scheduled to receive one of your payments, we will send you an e-mail notifying you that the payment is coming. On your table is a business card for Professor Andreoni with his contact information. Please keep this in a safe place. If one of your payments is not received you should immediately contact Professor Andreoni, and we will hand-deliver payment to you.

Your Identity:

In order to receive payment, we will need to collect the following pieces of information from you: name, campus mail box, email address, and student PID. This information will only be seen by Professor Andreoni and his assistants. After all payments have been sent, this information will be destroyed. Your identity will not be a part of subsequent data analysis.

On your desk are two envelopes: one for the sooner payment and one for the later payment. Please take the time now to address them to yourself at your campus mail box.

How it Works:

In each decision you are asked to divide 100 tokens between two payments at two different dates: Payment A (which is sooner) and Payment B (which is later). Tokens will be exchanged for money. The tokens you allocate to Payment B (later) will always be worth at least as much as the tokens you allocate to Payment A (sooner). The process is best described by an example. Please examine the sample sheet in you packet marked SAMPLE.

The sample sheet provided is similar to the type of decision sheet you will fill out in the study. The sample sheet shows the choice to allocate 100 tokens between Payment A on April 17th and Payment B on May 1st. Note that today's date is highlighted in yellow on the calendar on the left hand side. The earlier date (April 17th) is marked in green and the later date (May 1st) is marked in blue. The earlier and later dates will always be marked green and blue in each decision you make. The dates are also indicated in the table on the right.

In this decision, each token you allocate to April 17th is worth \$0.10, while each token you allocate to May 1st is worth \$0.15. So, if you allocate all 100 tokens to April 17th, you would earn 100x\$0.10 = \$10 (+ \$5 minimum payment) on this date and nothing on May 1st (+ \$5 minimum payment). If you allocate all 100 tokens to May 1st, you would earn 100x\$0.15 = \$15 (+ \$5 minimum payment) on this date and nothing on April 17th (+ \$5 minimum payment). You may also choose to allocate some tokens to the earlier date and some to the later date. For instance, if you allocate 62 tokens to April 17th and 38 tokens to May 1st, then on April 17th you would earn 62x\$0.10 = \$6.20 (+ \$5 minimum payment) and on May 1st you would earn 38x\$0.15 = \$5.70 (+ \$5 minimum payment). In your packet is a Payoff Table showing some of the token-dollar exchange at all relevant token exchange rates.

REMINDER: Please make sure that the total tokens you allocate between Payment A and Payment B sum to exactly 100 tokens. Feel free to use the calculator provided in making your allocations and making sure your total tokens add to exactly 100 in each row.

Chance of Receiving Payments:

Each decision sheet also lists the chances that each payment is sent. In this example there is a 70% chance that Payment A will actually be sent and a 30% chance that Payment B will actually be sent. In each decision we will inform you of the chance that the payments will be sent. If this decision were chosen as the decision-that-counts we would determine the actual payments by throwing two ten sided die, one for Payment A and one for Payment B.

EXAMPLE: Let's consider the person who chose to allocate 62 tokens to April 17th and 38 tokens to May 1st. If this were the decision-that-counts we would then throw a ten-sided die for Payment A. If the die landed on 1,2,3,4,5,6,or 7, the person's Payment A would be sent and she would receive \$6.20 (+ \$5 minimum payment) on April 17th. If the die landed 8,9, or 10, the payment would not be sent and she would receive only the \$5 minimum payment on April 17th. Then we would throw a second ten-sided die for Payment B. If the die landed 1,2, or 3, the person's Payment B would be sent and she would receive \$5.70 (+ \$5 minimum payment) on May 1st. If the die landed 4,5,6,7,8,9, or 10, the payment would not be sent and she would receive only the \$5 minimum payment on May 1st.

Things to Remember:

- You will always be allocating exactly 100 tokens.

- Tokens you allocate to Payment A (sooner) and Payment B (later) will be exchanged for money at different rates. The tokens you allocate to Payment B will always be worth at least as much as those you allocate to Payment A.

- Payment A and Payment B will have varying degrees of chance. You will be fully informed of the chances.

- On each decision sheet you will be asked 7 questions. For each decision you will allocate 100 tokens. Allocate exactly 100 tokens for each decision row, no more, no less.

- At the end of the study a random number will be drawn to determine which is the decision-that-counts. Because each question is equally likely, you should treat each decision as if it were the one that determines your payments. Two more random numbers will be drawn by throwing two ten sided die to determine whether or not the payments you chose will actually be sent.

- You will get an e-mail reminder the day before your payment is scheduled to arrive.

- Your payment, by check, will be sent by campus mail to the mailbox number you provide.

- Campus mail guarantees 100% on-time delivery.

- You have received the business card for Professor James Andreoni. Keep this card in a safe place and contact Prof. Andreoni immediately if one of your payments is not received.