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ABSTRACT

Procedures for Eliciting Time Preferences*

We study three procedures to elicit attitudes towards delayed payments: the Becker-DeGroot-Marschak procedure; the second price auction; and the multiple price list. The payment mechanisms associated with these methods are widely considered as incentive compatible, thus if preferences satisfy Procedure Invariance, which is also widely (and often implicitly) assumed, they should yield identical time preference distributions. We find instead that the monetary discount rates elicited using the Becker-DeGroot-Marschak procedure are significantly lower than those elicited with a multiple price list. We show that the behavior we observe is consistent with an existing psychological explanation of preference reversals.

JEL Classification: C91, D9

Keywords: time preferences, elicitation methods, Becker-DeGroot-Marschak procedure, auctions, multiple price list

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1 Introduction

Incentivized experiments that study choices among delayed rewards have been widely used to measure and test hypotheses about time preferences. Several elicitation methods have been viewed as "incentive compatible" means of eliciting precise information about time preferences. Three such procedures have become workhorse methods in experimental economics, psychology, and neuroeconomics: the multiple price list (MPL), the Becker, DeGroot, and Marschak [3] procedure (BDM), and the second price auction (SPA).[1]

We study the MPL, the BDM, and the SPA as procedures for eliciting preferences over delayed payments. The MPL is a *choice task*, in that subjects have to choose between a smaller-sooner and larger-later pair of outcomes. BDM and SPA are instead both instances of *matching tasks*, in which subjects name a 'sooner' amount they regard as indifferent to a later fixed reward. Regardless of these aspects, if the payment mechanism associated with each method is incentive compatible and subjects have preferences over delayed rewards that are invariant to the procedure by which they are elicited, we ought to recover the same distribution of time preferences from each method. With few exceptions, economic experiments using these three methods draw an interpretation of subjects' behavior that implicitly assumes *Incentive Compatibility* of the payment mechanism and *Procedure Invariance* of subject preferences. In this paper we instead treat these assumptions as testable, and we test their implications using a between-subject design.

Previous work in experimental economics has noted systematic differences in the rankings of lotteries inferred from their monetary valuations elicited using the BDM as compared to direct choices in choice tasks (e.g. Grether and Plott [13]). However, this literature on 'preference reversals' has focused on choice under risk. To the best of our knowledge, there is no existing incentivized study that indicates whether analogous preference reversals occur in intertemporal choice. A leading economic explanation of preference reversals under risk is based on the interaction between the random component of the payment mechanism, the risky alternatives, and a failure of the Independence Axiom (e.g. Karni and Safra [20]). But such an explanation is highly specific to choice under risk: there is no compelling reason to expect analogous preference reversals in intertemporal choice. On the other hand, existing work that compares different experimental techniques

[1] The MPL has been used extensively in economics experiments, for example, Coller and Williams[5], Harrison et al. [15], Dohmen et al. [8], and Filiz-Ozbay et al. [9]. The BDM has been used extensively in economics, psychology, and neuroeconomics; examples include Ifcher and Zarghamee [17], Weber et al. [29], and Cooper et al. [6]. The SPA has been used in economics and psychology; examples include Horowitz [16] and Kirby [21].

for studying time preferences does not use any incentives (Tversky et al. [28] Study 2; Read and Roelofsma [24]; Hardisty et al. [14]), and thus do not offer direct information about economic choices.

We find a significant difference in subject responses between the MPL and BDM. This is in spite of an implementation ensuring that a subject in each procedure faced exactly the same economic incentives. The direction of this effect is consistent with Tversky et al.'s [27] scale compatibility hypothesis, which hypothesizes that a subject responding with a monetary amount in a matching task like BDM will put more weight on monetary outcomes than in a comparable choice task like the MPL.

The paper is organized as follows. Section 2 describes our experimental design. In Section 3 we lay out Incentive Compatibility and Procedure Invariance as testable assumptions, we discuss their implications for our experiment, and we review the predictions of existing economic and psychological explanations of preference reversals for our experiment. We present our results in Section 4 and we discuss them in Section 5.

2 Experimental design

Our experiment implements a between-subjects design to study three procedures – the MPL, BDM, and SPA – for eliciting each subject's preferences between sooner payments and a fixed later payment.

We ran four sessions for each of the three treatments, with 16 inexperienced subjects per session between June 2012 and March 2013. Subjects for each session were recruited from the CEEL database at Università di Trento. All subjects received a €5 participation payment at the end of the session on top of any payments based on their choices. Each subject could only participate in one treatment of the experiment. An average session lasted less than 45 minutes, and the average subject payment was €14.40.

The subjects were given instructions that explained the task they would face and how they would be paid based on their choices. Then they completed a comprehension test on the instructions.[2] In each treatment, we use a single elicitation procedure (MPL, BDM, or SPA) to elicit the monetary amount paid tomorrow that would be indifferent to the receipt of a €20 at each of three possible delays (1, 2 and 4 months) for each subject. We implemented this by presenting subjects with a screen with three buttons,

[2] 20 participants were recruited for each session; to reduce the possibility of subject misunderstanding of the experiment driving our results, we only retained the first 16 subjects to correctly complete the comprehension test. The remaining four subjects in each session were paid a show-up fee and dropped from the session.

each corresponding to one of the time horizons. Subjects could enter money amounts in €0.50 increments in all treatments. To avoid any order effects, subjects were free to choose the order in which to tackle each task. After completing each choice task, subjects were sent back to this screen with the buttons corresponding to the time horizons already completed appearing greyed out.

In order to incentivize subjects to report their economic preferences, 50% of the subjects in each group were drawn at random to receive a payment based on their choices. At the end of the experiment we drew from a uniform distribution which 8 subjects (out of 16 participants in each computerized session) would receive a payment in addition to the show up fee; which screen (1 month, 2 months or 4 month delay) would 'count', and, in the case of the MPL or BDM elicitation method, which row or monetary amount would be drawn to determine their payment.

In the second part of the experiment, we test the subjects' awareness of the interest rates implied by their previous choices[3] and measure their personality traits. This part of the experiment was common across all treatments; we discuss these results in the Appendix.

2.1 Multiple Price List

In each row of our MPL, a subject chooses between Option A – an amount paid tomorrow that varies between €20 in the first row and decreases to €0.50 in the last row – and Option B, which gives €20 at the later date corresponding to the task. In our implementation of the MPL, we enforce a single switching line in each list by having the subject move a slider down the screen to indicate the rows in which she chooses Option A.

2.2 Becker-DeGroot-Marshack

Participants in the BDM treatment were asked in each of the three tasks to state the lowest amount L that they would prefer to receive tomorrow instead of receiving €20 at the later date corresponding to that task. For each of the three time horizons, if the value declared was not larger than a value drawn from a uniform distribution with support

[3]After all values have been elicited, subjects are asked to state the three annual (non-compound) interest rates that correspond to their choices in each time horizon. For instance, a declaration of €19 in the four month horizon question would have implied an annual interest rate of 15.75%. Subjects were instructed that they would be remunerated at €2 or €1 depending on whether the answer was within a 5% or 10% margin, respectively, of the true rate. We note that a software error affected the payments from this phase to 9 subjects, 4 of whom were paid more than they were entitled to.

on $\{€0.5, €1, \ldots, €20\}$, then the subject would receive a payment equal to the number drawn the following day; otherwise she would get the full amount $€L$ with delay.

2.3 Second Price Auction

As in the BDM treatment, participants in the SPA treatment were asked in each of the three tasks to state the lowest amount L for which they would prefer to receive tomorrow instead of receiving €20 at the later date corresponding to that task. For each of the three time horizons, when a subject was paid based on that auction task, if they had the lowest bid they received tomorrow the second-lowest stated amount stated by all subjects; otherwise they received €20 at the later date. The outcome of each auction was not revealed before the next auction was played, as in our other treatments.

3 Eliciting Time Preferences: Theory

3.1 Payment Mechanisms, Procedure Invariance, and Eventwise Monotonicity

For a subject who makes a single pairwise choice, the interpretation of this choice is uncontroversial from the perspective of standard economic theory: it defines her preference between two options. However, a single pairwise choice only provides limited information about a subject's preferences.

For this reason, past work has used the MPL, BDM, and SPA procedures to elicit finer information about the entire preference relation on the domain of interest. However, the validity of each method for eliciting preferences relies on some crucial assumptions.

First, preferences cannot depend on economically irrelevant features of the procedure that is used to elicit them – this is the Procedure Invariance assumption. While such an invariance is almost universally assumed, often implicitly so, it is testable. Second, any experiment that attempts to make multiple observations of a subject's preference relation must decide how multiple choices (that is, preference statements) determine a payment at the end of the experiment. Depending on how a subject's payment is determined from her portfolio of implied preference statements, she may or may not wish to report her true preferences. Which is the case will be driven by her preference over portfolios, given the experiment's payment mechanism.

To be more precise, let $M = \{€0.50, \ldots, €20\}$ denote a set of monetary payments and let $T = \{1 \text{ day}, 1 \text{ month}, 2 \text{ months}, 4 \text{ months}\}$ denote a set of payment dates. In the standard economic approach to decision-making (e.g. Fishburn and Rubinstein [10]), a subject has a single transitive preference relation $\succsim$ over dated rewards in $M \times T$, and this preference is procedure invariant, as explained above. The *Monetary Monotonicity* property requires that subjects prefer more money to less given a fixed horizon. Formally, $\succsim$ satisfies Monetary Monotonicity if for any $m, m' \in M$, $m > m'$ implies $(m, t) \succ (m', t)$ for any $t \in T$.

In our implementation of the MPL, such a subject makes a choice in each row of the MPL, which determines a smallest value $m^{MPL} \in M$ for which the subject picks $\left(m^{MPL,t}, 1 \text{ day}\right)$ over $(€20, t)$. In our implementations of the BDM and SPA, a subject is asked to state an amount $m^{i,t}$ ($i \in \{\text{BDM}, \text{SPA}\}$) for each of $t = 1\text{m}, 2\text{m}, 4\text{m}$. With $\emptyset$ denoting exclusion from payment, the payment mechanism corresponding to procedure i picks a state $\omega \in M \times \{1\text{m}, 2\text{m}, 4\text{m}\} \cup \{\emptyset\}$ that determines a subject's payment given her announcements $\{m^{i,1\text{m}}, m^{i,2\text{m}}, m^{i,4\text{m}}\}$. When the mechanism determines state ω, a subject in procedure i declaring $\{m^{i,1\text{m}}, m^{i,2\text{m}}, m^{i,4\text{m}}\}$ receives a payment determined by $\phi^i : \Omega \to M \times T \cup \{(0, \text{now})\}$ given by

$$\phi^i(\omega) = \begin{cases} (0, \text{now}) & \text{if } \omega = \emptyset \\ (m, 1 \text{ day}) & \text{if } \omega = (m, t) \text{ and } m \geq m^{i,t} \\ (€20, t) & \text{if } \omega = (m, t) \text{ and } m < m^{i,t} \end{cases}$$

for all $i \in \{\text{MPL}, \text{BDM}, \text{SPA}\}$. Each payment mechanism is a Savage act[4] ϕ^i over delayed payments in $M \times T$.

We wish to interpret a report of $m^{i,t}$ as implying the preference statements $(m, t) \succ (€20, t) \succ (m', t)$ for any $m, m' \in M$ satisfying $m > m^{i,t} > m'$. Since our payment mechanism is a Savage act, whether a subject's report admits such an interpretation depends on her preferences over acts. As shown in Azrieli et al. [1], such an interpretation will be appropriate if the subject has transitive preferences over $M \times T$ that satisfy Monetary Monotonicity and an additional property called *Eventwise Monotonicity*. Intuitively, Eventwise Monotonicity holds whenever an act that yields more preferred dated rewards in each state as compared to another is also ranked higher by the preference over Savage acts. Formally, given a subject's transitive preference relation over dated rewards $\succsim$, a subject's preference relation $\succsim^\star$ on Savage acts satisfies Eventwise Monotonicity if, for any two acts f and g, $f(\omega) \succsim g(\omega)$ for all $\omega \in \Omega$ implies that $f \succsim^\star g$, and if $f(\omega) \succsim g(\omega)$

[4] A Savage act is a map from states of the world into consequences, see Savage [26].

for all $\omega \in \Omega$ and $f(\omega) \succ g(\omega)$ for at least one $\omega \in \Omega$, then $f \succ^\star g$.[5]
Our discussion of the implications of properties of preferences for the incentive compatibility of experimental methods is summarized in the observation below.

Observation. 1. If a subject has Procedure Invariant preferences $\succsim^\star$ on Savage acts over $M \times T$ that satisfy Eventwise Monotonicity, then each subject would announce the same value $m^{i,t}$ in each procedure $i \in \{\text{MPL}, \text{BDM}, \text{SPA}\}$ given the horizon $t \in \{1 \text{ month}, 2 \text{ months}, 4 \text{ months}\}$. If a subject's preferences $\succsim$ on $M \times T$ also satisfy Monetary Monotonicity, then for any horizon $t \in \{1 \text{ month}, 2 \text{ months}, 4 \text{ months}\}$, procedure $i \in \{\text{MPL}, \text{BDM}, \text{SPA}\}$, and amounts $m, m' \in M$ with $m > m^{i,t} > m'$, we have $(m, t) \succ (€20, t) \succ (m', t)$.

2. If a subject would announce different values $m^{\text{BDM},t} \neq m^{\text{MPL},t}$ for some horizon $t \in \{1 \text{ month}, 2 \text{ months}, 4 \text{ months}\}$, then this subject cannot have Procedure Invariant preferences on Savage acts over $M \times T$. If a subject would announce values $m^{\text{SPA},t} \neq m^{\text{MPL},t}$ or $m^{\text{SPA},t} \neq m^{\text{BDM},t}$ for some horizon $t \in \{1 \text{ month}, 2 \text{ months}, 4 \text{ months}\}$, then this subject cannot have preferences on Savage acts over $M \times T$ that satisfy both Procedure Invariance and Eventwise Monotonicity.

3.2 Alternative Hypotheses

Incentives. Economic theories that maintain the existence of procedure invariant economic preferences have posited that the payment mechanism could be responsible for preference reversals in BDM in the domain of choice under risk (Karni and Safra [20]), violating Eventwise Monotonicity.[6] Karni and Safra's theory relies on the fact that in choice under risk, a subject's choices combined with a random problem selection mechanism with objectively given probabilities determines a compound lottery; a subject who reduces compound lotteries will only want to report their preferences over lotteries if she has expected utility preferences. In the domain of delayed payments, none of our payment mechanisms forms a compound lottery and there is no obvious analogue of reduction. Thus we see no compelling reason why incentives ought to generate differences across treatments according to Karni's and Safra's theory. Moreover, since the exact same objectively-given randomization process is used in MPL and BDM mechanisms, according

[5]The mechanisms we study fall into the class of Random Problem Selection mechanisms in Azrieli et al. [1]. They show that Eventwise Monotonicity is a sufficient, and 'almost' necessary condition for each Random Problem Selection mechanism to correctly elicit $\succsim$ – or in other words, to be incentive compatible. The discussion leading to their Theorem 1 provides details.

[6]These theories have received mixed support empirically (Cox and Epstein [7]; Tversky et al. [28]).

to this theory there is no possibility of incentive-driven preference reversals between the MPL and BDM treatments.

Response mode. The MPL has a subject respond with her row-by-row choices (a choice task), while the BDM and SPA ask a subject to state a monetary amount to a later payment that would make her indifferent between the sooner monetary amount and a €20 later payment (matching tasks). Tversky et al. [27] argue that the response mode can affect the weight that a decision-maker places on each of multiple attributes, which is inconsistent with procedure invariant economic preferences. Their scale compatibility hypothesis posits that subjects in matching tasks will put more weight on the matched attribute - in our case, the monetary payment. This hypothesis can correctly predict the pattern of commonly observed preference reversals over risk following Grether and Plott. Tversky et al. [27] find some evidence to support their hypothesis when comparing choice and matching tasks involving purely hypothetical delayed rewards. Their hypothesis predicts that $m^{MPL,t} < m^{BDM,t} = m^{SPA,t}$ for any subject.

Confusion in BDM. Cason and Plott [4] hypothesize that many subjects incorrectly believe that they will receive the payment stated in the BDM should a "winning" number be drawn; akin to misperceiving that $\phi^{BDM}((m,t)) = \left(m^{BDM,t}, t\right)$ whenever $m \geq m^{BDM,t}$.[7] If preference $\succsim^{\star}$ satisfies Eventwise Monotonicity but a subject misperceives ϕ^{BDM} as such, she would pick $m^{BDM,t} > m^{MPL,t}$. However, Cason and Plott are silent on how subjects would behave in a SPA against human bidders with nearly identical instructions.

Biases in Auctions. Previous research has documented a bias towards overbidding one's value in second price auctions with induced private values (Kagel and Levin [18]) and also with private homegrown values (as compared to bids in BDM; Rutström [25]). One hypothesis is that this arises due to a desire to win in a competitive environment. In our experiment, this would lead to lower bids in the SPA treatment.

[7]That is, they confuse the BDM, which is effectively a second-price auction against a single mechanical random bidder, for a first-price auction against a mechanical random bidder.

4 Results

We find that subjects' responses are consistently the lowest in the MPL and highest in the BDM (Table 1, Figure 1).

		MPL	BDM	SPA
One month	Mean	14.77	16.83	16.39
	Median	15.00	18.00	18.00
Two months	Mean	14.17	16.30	15.23
	Median	15.00	17.25	16.50
Four months	Mean	13.58	15.03	13.79
	Median	14.50	15.00	15.00
	Sample size	64	64	64

Table 1: Elicited values by treatment

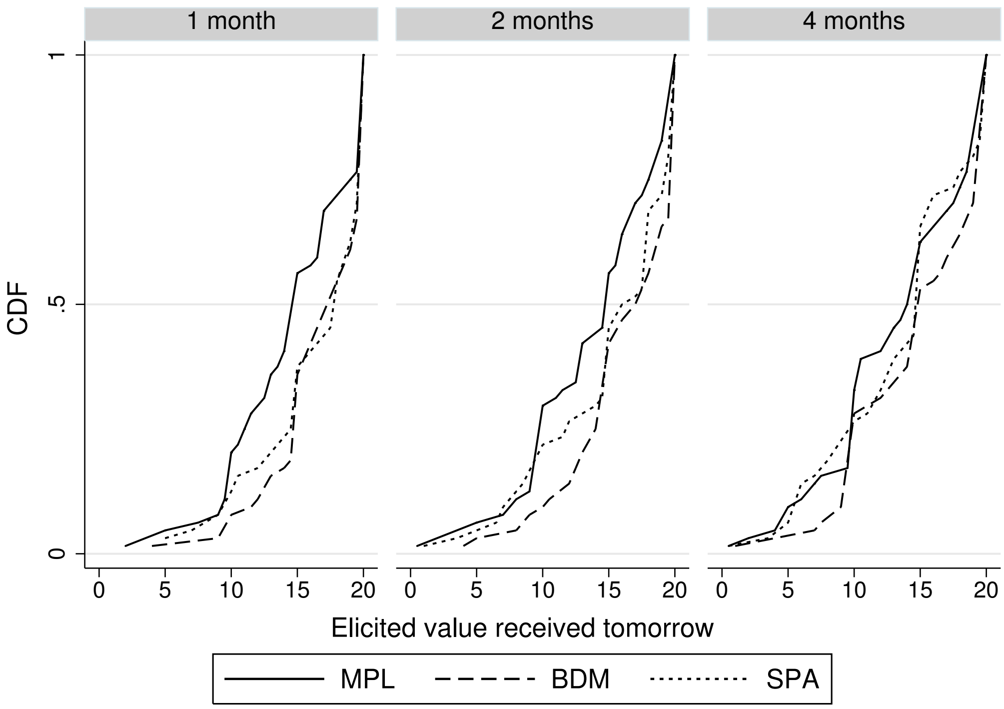

Figure 1: Distribution of elicited values by treatment

We use rank-sum tests to test whether subjects' responses differ systematically by procedure. The difference between responses in the MPL and BDM is significant in two

	MPL vs. BDM	MPL vs. SPA	SPA vs. BDM
One month	.009	.039	.671
Two months	.008	.159	.210
Four months	.161	.876	.150

Two-sided p-values for rank-sum test of equality of distribution.

Table 2: Tests of equality of responses across treatments

of the three horizons at the 5% significance level (Table 2). The responses between the SPA and BDM do not statistically differ on any horizon (at the 10% level), and only on the one month horizon do the distribution of responses in the SPA and MPL differ statistically at the 5% significance level. Figure 1 shows that differences across treatments are systematic across horizons and throughout the distribution.

We use regression techniques to conveniently summarize how inferred monetary discount rates differ across treatments.[8] We wish to estimate the regression equation:

$$r_{it} = \rho_M MPL_i + \rho_B BDM_i + \rho_A SPA_i + X_{it}\beta + \epsilon_{it}$$

The variable r_{it} denotes the monthly monetary discount rate inferred (under the assumptions of Monetary Monotonicity and Eventwise Monotonicity) from subject i's behavior in horizon t, MPL, BDM, SPA are treatment dummies, X_{it} denotes additional controls, and ϵ denotes an error term. However, even under these assumptions our treatments only measure an interval for r_{it} given i's response in horizon t. In specifications 3 and 4 (Table 3), we use interval regressions to account for this under the assumption that the ϵ_{it} are independently and normally distributed. Specification 3 includes no control variables in X, while specification 4 includes time horizon dummies to account for the possibility of non-constant discounting over monetary amounts. We assume that discount rates are weakly positive; thus values of r_{it} are bounded below by 0 and the empirical distribution of r_{it} is rightly skewed with a mode close to 0. For this reason, the normality assumption embedded in the interval regression is highly inappropriate for our data.[9] In specifications 1, 2, 5, and 6 we use least squares estimators with the minimum of the inferred interval

[8]Our inferred monetary discount rates measure do not account for the possibility that individuals discount their utility of payments and have a curved utility-for-money function. A subject's utility-for-money function is not separately identified from her discount rate on our domain, even if we assumed power utility-for-money functions. This mechanically implies that the inferred discount rates here will exceed that of studies that work with a curved utility-for-money function.

[9]We note that an application of interval regression based on an asymmetric distribution for ϵ_{it} might be feasible, but would be difficult to interpret.

	Inferred Discount Rate					
	OLS		Interval Regression		Random Effects	
	(1)	(2)	(3)	(4)	(5)	(6)
MPL	.362	.231	.380	.243	.362	.231
	(.063)	(.050)	(.066)	(.052)	(.063)	(.050)
BDM	.179	.048	.192	.055	.179	.048
	(.036)	(.036)	(.038)	(.038)	(.036)	(.036)
SPA	.249	.119	.266	.129	.249	.119
	(.042)	(.041)	(.045)	(.043)	(.042)	(.041)
1 month	-	.287	-	.304	-	.287
		(.062)		(.063)		(.062)
2 months	-	.103	-	.107	-	.103
		(.026)		(.025)		(.026)

Robust standard errors clustered at the subject level in brackets.

Random effects coefficients and standard errors computed using lincom in Stata.

Table 3: Inferred discount rates by treatment

of discount rates as the left-hand side variable as checks on the robustness of the interval regression.[10] We use ordinary least squares to estimate in specifications 1 and 2 to estimate the same regression equations as 3 and 4. To account for individual heterogeneity, we add an individual-specific dummy to specifications 1 and 2, and estimate the resulting model using a generalized least squares random effects estimator (specifications 5 and 6).

We obtain similar results across specifications (Table 3). Focusing on our results from the interval regression (specification 3), the inferred monetary discount rate is highest in the MPL (.380), lowest in the BDM (.192), and intermediate in the SPA (.266). The difference between the MPL and BDM is statistically significant ($p = .01$) but the difference between the MPL and SPA is not ($p = .15$), nor is the difference between the BDM and SPA ($p = .20$). We obtain qualitatively and quantitatively similar results using both ordinary least squares and generalized least squares random effects with the minimum of the inferred interval of discount rates as the left-hand side variable, and also if we include time horizon dummy variables to account for non-constant monetary discount rates. In each specification in Table 3, the inferred discount rate is on average .18-.19 higher in the

[10]There were only three times when a subject chose €0.50 tomorrow over the more delayed €20, but since these observations are potentially consistent with an infinite discount rate, the above methods except for interval regression can be sensitive to how these outliers are coded. For this reason, we used the lowest discount rate consistent with a choice as the left-hand side variable, and note that this ought to lead to a slight downward bias in estimated discount rates.

MPL than in the BDM, a significant difference at the 5% level, while the inferred average discount rates in the SPA treatments do not significantly differ from either of the other two treatments.

5 Discussion

We found evidence of a substantial difference in the discount rates inferred from subjects in the MPL as compared to the BDM. Since these elicitation schemes have the same incentive structure, this difference violates Procedure Invariance. The direction of this bias – towards more inferred patience in the BDM – is consistent with Tversky et al.'s [27] scale compatibility hypothesis. It is also consistent with Cason and Plott's [4] conjecture that many subjects systematically misperceive the BDM, and believe that they receive their stated amount should the BDM draw an amount that exceeds it.

Since there are systematic albeit statistically insignificant differences between behavior in the SPA and the other two methods, we view these differences as merely suggestive. We note that Cason and Plott do not state whether an analogous mistake ought to occur in an SPA setting with multiple human bidders. In our context we see such an extension as natural. Such a mistake, however, would (counterfactually) predict underbidding in private value SPAs. In contrast, the conjunction of the scale compatibility hypothesis and a previously documented bias towards making winning bids in auctions could explain why bids in the SPA tend to be higher than in those in the BDM.

Our discussion has taken the MPL as a benchmark. Findings from past intertemporal choice experiments that use the MPL have not provided evidence of any inconsistency with the combination of Eventwise Monotonicity and Procedure Invariance (Andersen et al. [2]). The existing evidence from choice under risk that is inconsistent with the combination of Eventwise Monotonicity and Procedure Invariance can be explained by the incentive scheme (i.e. a failure of Eventwise Monotonicity; Freeman et al. [12]) – unlike the results here.

Subjects' inferred discount rates in our experiment are an order of magnitude larger than market interest rates in Italy. In the absence of an Italian student debt crisis, we might view the results from all treatments as prima facie evidence against the existence of procedure invariant economic preferences. Our experimental findings are not unusual in this regard: the discount rates inferred from past incentivized experiments span from negative to infinite (Table 1 in Frederick et al. [11]). We also note extreme variance in market interest rates across settings: for example, daily interest rates in the 10-30% range for informal loans in Bangalore, India (Kalkod [19]) and annualized interest rates in the 279-1199% range on payday loans in British Columbia, Canada.[11]

We believe that the evidence we have provided demonstrates the potential value of incorporating context-dependence into economic theories of intertemporal choice (like that of Tversky et al. [27]). Such models could be particularly valuable for analyzing the results of economic experiments. We submit that, if our goal is to use economic experiments to better understand real world decisions, future experimental work on the elicitation of "time preferences" should treat context-dependence as a variable of interest rather than an issue to be ignored or treated as a confound.

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Appendices

A Instructions

The translation of the original instructions (in Italian) follows below (we omit the comprehension test for space reasons - it showed three screens, one for each time horizon, as filled by an hypothetical participants. On each screen two simple questions asked about what payment would the hypothetical participant received if drawn or not drawn. Links to screenshots and our experimental software is available **here**.

A.1 Sheet 1 (common to all treatments)

This experiment studies choice over time. Please read carefully the instructions that follow while an assistant also reads them aloud. You will be given a fixed participation fee at the end of the experiment. Moreover you may be able to receive an additional sum on top of the participation fee. This additional amount will depend on your choices and on a random draw. More precisely, you will have one chance in two to be drawn to receive the additional payment.

At the end of the experiment we will ask you to complete a questionnaire. The information collected will be used solely for research purposes. The information collected will be kept completely anonymously.

Click 'NEXT' to continue.

A.2 Sheet 2

A.2.1 MPL

TAKING PART IN THE EXPERIMENT

By participating in this experiment you have one chance in two of being drawn to receive a monetary amount. We will ask you shortly to make some choices between monetary rewards payable at different points in time. All the choices, presented in a table, are between two options: option "A" or option "B". Each option consists of an amount of money which you could receive, and each row in the table corresponds to a different pair A and B For each row you will have to choose between a smaller amount payable tomorrow (option A) or a larger amount payable later (option B) Option B is the same in all rows, and corresponds to the receipt of €20, payable with some weeks delay.

Option A instead is different on all rows, and varies between a minimum of €0.50 and a maximum of €20. Careful! You must make a choice in each row. To do so you will have to use the cursor in the middle of the screen: you can scroll it using the mouse to select the option that you prefer in each row. You will see three tables in total, differing from one another only for the delay with which the €20 of option B are payable.

Three random draws will take place at the end of the experiment. The first will draw one of the three screens, the second will draw one of the forty rows from that screen, and the third will draw the participants which will receive the additional payment, corresponding to the choice made in the row drawn. This means that if you are drawn to receive a payment, the amount of money you will receive will be that corresponding to the option (A or B) that you chose in the row drawn. This means that each choice you will make in each of the three tables may be rewarded.

Click 'NEXT' to continue

A.2.2 BDM

TAKING PART IN THE EXPERIMENT

By participating in this experiment you have one chance in two of being drawn to receive €20, which will be payable with a delay of some weeks. However you will have the opportunity to anticipate receipt to tomorrow. In this case you will have to give up part of the total amount. Very shortly you will see a screen where you will be able to declare the minimum amount you are prepared to receive in place of the full €20 to receive your payment tomorrow, entering a value between €0.50 and €20 in €0.50 steps. After your choice a number between €0.50 and €20 in €0.50 increments will be drawn at random. Every value between €0.50 and €20 in €0.50 increments has the same probability of being drawn

How much is the early payment?

If you are drawn for payment:

1) if your declared value smaller or equal to the one drawn, you will be entitled to receive tomorrow an amount of money equal to the number drawn.

2) if your declared value is larger than the one drawn, you will be entitled to the full €20 but with delay.

How much to declare?

If you think about it, you will see that the best option for you is to declare the amount that makes you indifferent between receiving such amount tomorrow or the whole €20 with delay. Consider for instance the two extreme values, namely €0.50 and €20. If you declare €0.50, you will be sure that, if drawn for payment, you will receive your payment tomorrow, but you could earn as little as €0.50 in case the number drawn is €0.50. If you declare €20 you will be sure that, if drawn for payment, you will receive the whole €20 albeit with delay: the exception is if €20 is drawn, in which you would receive €20 tomorrow. Yet even in this case if the declaration which makes you indifferent is less than €20, by declaring such value you would receive €20 tomorrow anyway.

You will be shown three screens in total, which differ only for the delay with which the full €20 are payable.

Three random draws will take place at the end of the experiment. The first will draw one of the three screens, the second will draw a number between €0.50 and €20 in €0.50 increments, and the third will draw the participants who will receive a payment corresponding to the choices made. This means that if you are drawn to receive a payment, the amount of money you will receive will be based on the choice you made in the screen drawn. This means that each choice you will make in each of the three screens may be rewarded.

Click 'NEXT' to continue

A.2.3 SPA

TAKING PART IN THE EXPERIMENT

By participating in this experiment you have one chance in two of being drawn to receive €20, which will be payable with a delay of some weeks. However you will have the opportunity to anticipate receipt to tomorrow. In this case you will have to give up part of the total amount. Very shortly you will see a screen where you will be able to take part in an auction to anticipate the payment to tomorrow. As the other participants, you will have to declare the minimum amount you are prepared to receive in place of the full €20 to receive your payment tomorrow, entering a value between €0.50 and €20 in €0.50 steps. The participant declaring the lowest value will acquire the right to receive the payment earlier. If two or more participants have inserted the same minimum value, all of these participants will acquire the right to receive the payment earlier.

How much is the early payment?

If you are drawn for payment:

1) if your declared value is the smallest, you will be entitled to receive tomorrow an amount of money equal to the lowest of all the other declarations excluding yours. Thus in case of a draw with one or more participants, such lowest value will be the same as the one you declared.

2) if your declared value is not the smallest, you will be entitled to the full €20 but with delay.

Suppose for instance that there are only two participants, Jane who declares €x and John who declares €y, and suppose that they are both drawn to receive payment. If €x is smaller than €y, Jane gets the right to early payment, and will receive €y tomorrow, while John will receive €20 with delay; if €x is larger than €y, Jane will receive €20 with delay while John gets the right to early payment, and will receive €x tomorrow; if €x and €y are the same, then both Jane and John will receive €x=€y tomorrow.

How much to declare?

If you think about it, you will see that the best option for you is to declare the amount that makes you indifferent between receiving such amount tomorrow or the whole €20 with delay. Consider for instance the two extreme values, namely €0.50 and €20. If you declare €0.50, you will be sure that, if drawn for payment, you will receive your payment tomorrow, but you could earn as little as €0.50 in case another participant has also declared €0.50. If you declare €20 you will be sure that, if drawn, you will receive the whole €20 albeit with delay: the exception is if everybody else has also declared €20, in which case everybody will have the right to early payment. Yet even in this case if the declaration which makes you indifferent is less than €20, by declaring such value you would be the only participant to get the right for early payment, and would receive €20 tomorrow anyway.

You will be shown three screens in total, which differ only for the delay with which the full €20 are payable.

Two random draws will take place at the end of the experiment. The first will draw one of the three screens, the second will draw the participants who will receive a payment corresponding to the choices made. This means that if you are drawn to receive a payment, the amount of money you will receive will be based on the choice you made in the screen drawn. This means that each choice you will make in each of the three screens may be rewarded.

Click 'NEXT' to continue

A.3 Sheet 4

A.3.1 MPL

INTEREST RATE PHASE

In the next screen you will have the possibility, if drawn, to earn additional money.

In each of the previous screens your choices have determined the last line (counting from the top) in which you have chosen option A over option B. On that row of course the value of option A would have been between €20 (if you chose option A only on the first line, the one at the top) and €0.50 (if you chose option A always, down to the bottom line). In the next screen we will ask you to enter the simple annual interest rate corresponding to the choice you made in the last line where you chose option A, in each of the three tables.

If drawn, your earnings will be determined as follows:

1. if the simple annual interest rate you entered for the table drawn is within ±5% of the simple annual interest rate corresponding to your choice, you will earn €2;

2. if the simple annual interest rate you entered for the table drawn differs more than ±5% but not more than ±10% from the simple annual interest rate corresponding to your choice, you will earn €1;

3. for larger differences, or if you do not enter any value, you will earn nothing.

Click on 'NEXT' to continue

A.3.2 BDM and SPA

INTEREST RATE PHASE

In the next screen you will have the possibility, if drawn, to earn additional money.

We will ask you to enter the three simple annual interest rates corresponding to the choices you made in the three preceding screens.

If drawn, your earnings will be determined as follows:

1. if the simple annual interest rate you entered for the version drawn is within ±5% of the simple annual interest rate corresponding to your choice, you will earn €2;

2. if the simple annual interest rate you entered for the version drawn differs more than ±5% but not more than ±10% from the simple annual interest rate corresponding to your choice, you will earn €1;

3. for larger differences, or if you do not enter any value, you will earn nothing.

Click on 'NEXT' to continue

A.4 Sample graphic interface

A.4.1 Interface to select between time horizons (common to all treatments)

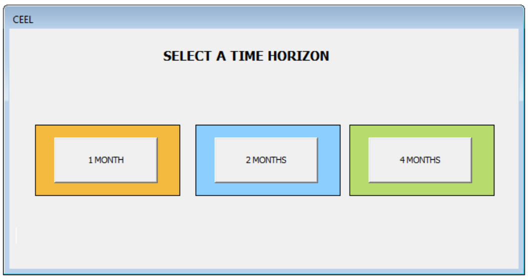

Figure 2: Selecting a version

A.4.2 Sample choice problem - MPL

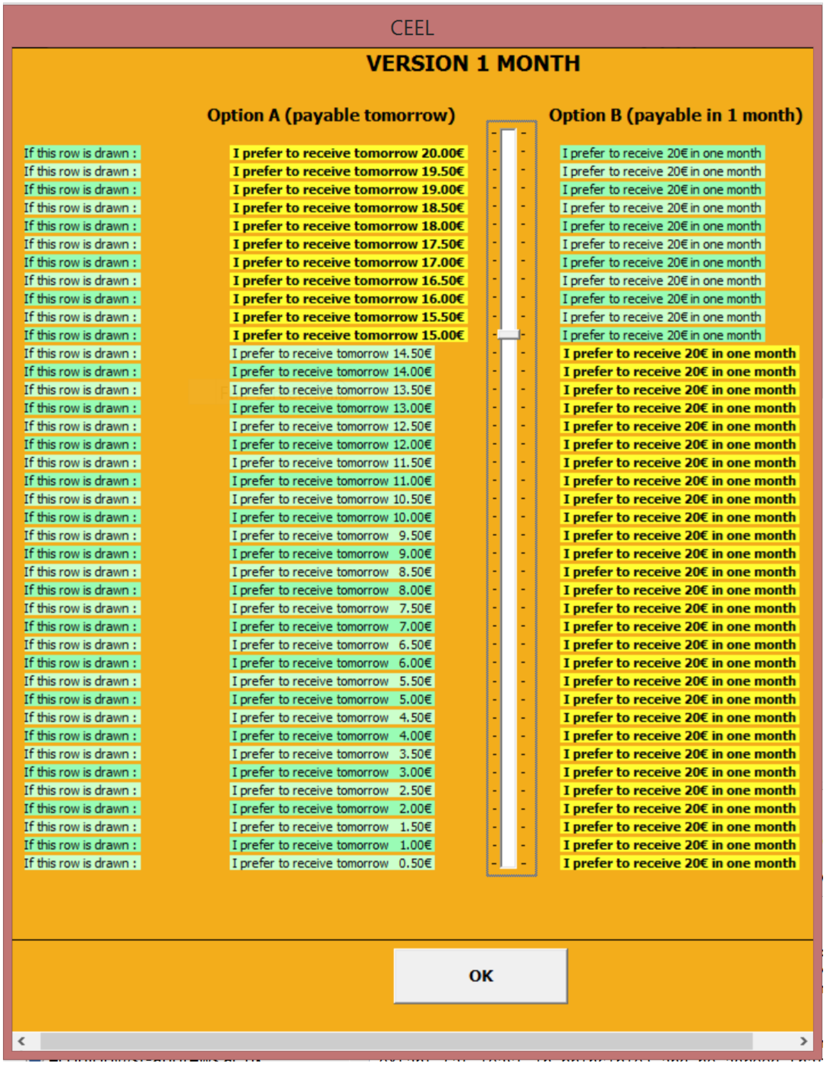

Figure 3: Sample Screenshot for MPL elicitation method

A.4.3 Sample choice problem - BDM

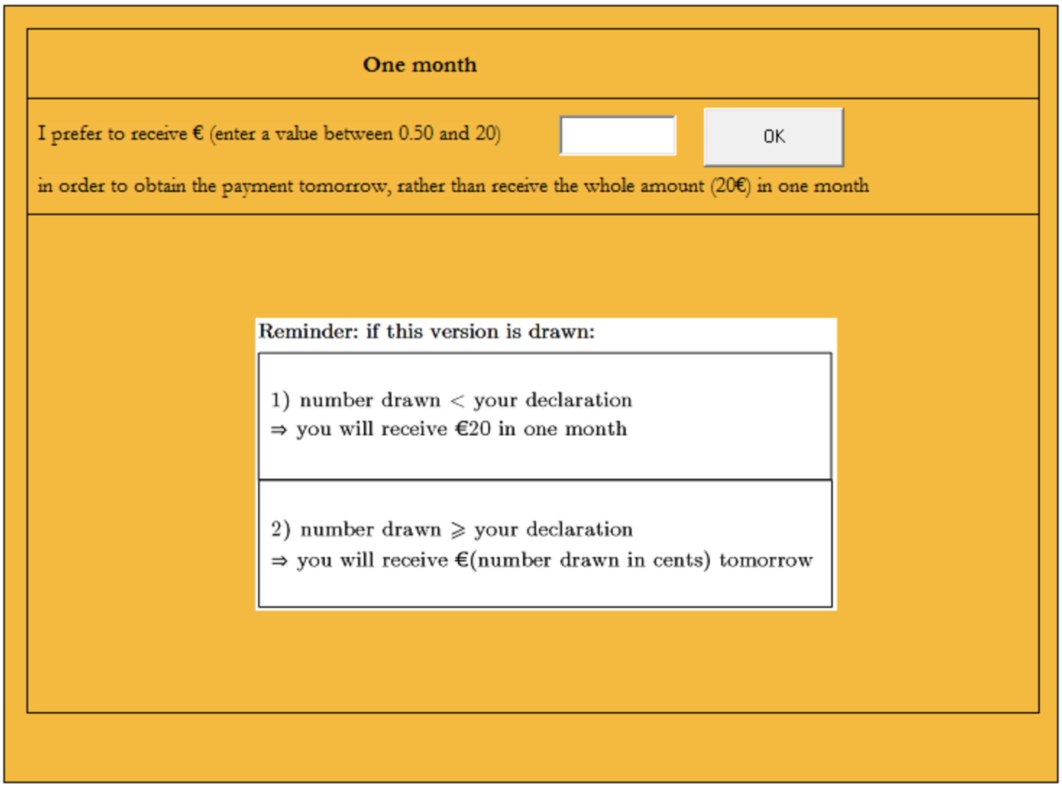

Figure 4: Sample screenshot for the BDM elicitation method, two month version

A.4.4 Sample choice problem - SPA

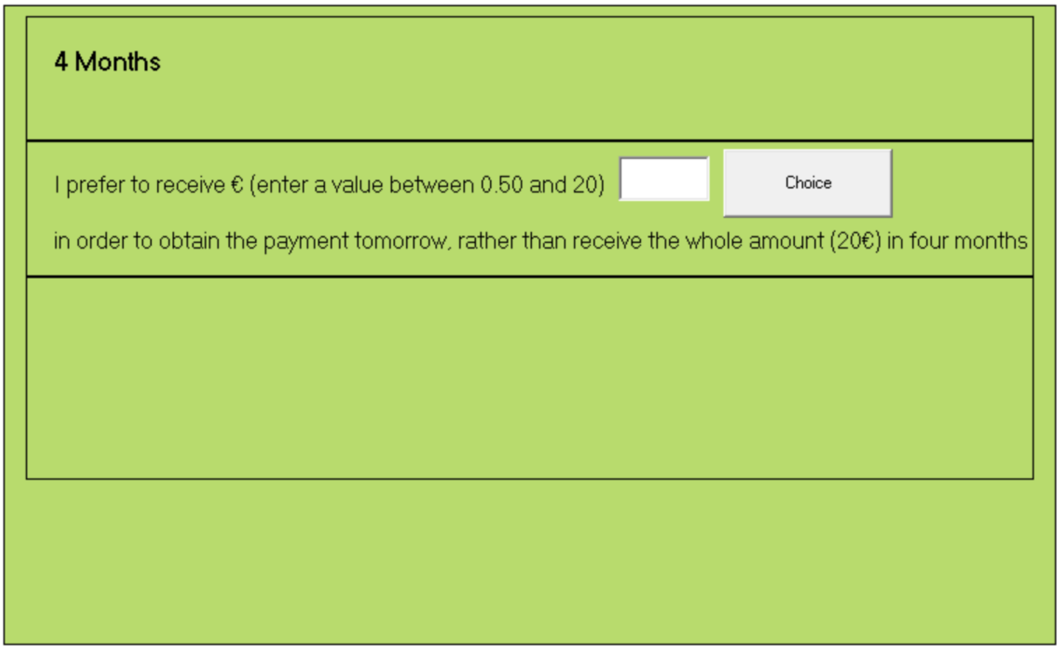

Figure 5: Sample screenshot with the elicitation question for the auction method

B Predictions of Discount Rates Implied by Choices

In the last phase of the experiment, we verified (in an incentived way) subjects' perceptions of the interest rates implied by their choices, as was indicated to subjects in the instructions. The elicitation method seems to have no effect on subject prediction errors. In Table 4, we show the distribution of prediction errors by time horizon.

		Number of subjects
One month	Don't know	34
	Error >10%	125
	5%<Error≤10 %	2
	Error ≤5%	31
Two months	Don't know	37
	Error >10%	132
	5%<Error≤10 %	3
	Error ≤5%	20
Four months	Don't know	33
	Error >10%	140
	5%<Error≤10 %	2
	Error ≤5%	17

Table 4: Frequency of prediction errors, by time horizon

C The HEXACO personality inventory

The conventional 'Big Five' personality traits (CANOE: Conscientiousness, Agreableness, Neuroticism, Openness, Extraversion) have been found to be unsatisfactory when used to assess personality traits in non anglophone populations (see e.g. Lee and Ahston [22]). For this reason we have instead relied on the HEXACO personality inventory, which concentrates on six personality traits: Honest, Emotionality, eXtraversion, Agreableness, Conscientiousness and Openness to experience. Each trait has five subtraits. Subjects were asked a total of 60 personality questions, with each group of 10 assessing a different trait. Given that we 'only' have 192 subjects overall, we do not have enough data for a proper analysis using these traits as regressors. For this reason, we do not discuss personality measures in the body of the paper.

We report below some summary statistics to show that the subjects in each treatment were fairly homogeneous in terms of personality traits. We present these summary statistics both by treatment in Table 5.

		Mean	Median	Mode	Maximum	Minimum	St. Dev.
Honesty	Auctions	3.48	3.40	3.40	5.00	2.00	.65
	BDM	3.41	3.25	3.20	4.70	1.90	.61
	MPL	3.47	3.50	3.30	4.80	1.50	.70
Emotionality	Auctions	3.01	3.00	2.80	4.70	1.70	.56
	BDM	3.19	3.20	2.90	4.50	1.90	.59
	MPL	3.10	3.20	3.30	4.30	1.80	.59
Extraversion	Auctions	3.50	3.55	3.70	4.40	1.90	.54
	BDM	3.46	3.45	3.30	4.50	2.50	.49
	MPL	3.50	3.55	3.60	4.90	2.30	.52
Agreeableness	Auctions	3.08	3.00	2.80	5.00	1.90	.65
	BDM	2.88	2.90	2.70	3.90	1.40	.57
	MPL	2.98	3.00	3.00	4.30	1.80	.58
Conscientiousness	Auctions	3.55	3.70	3.70	4.90	1.00	.75
	BDM	3.63	3.80	3.80	5.00	1.90	.70
	MPL	3.61	3.60	3.60	4.90	2.10	.61
Openness	Auctions	3.50	3.60	4.00	5.00	2.00	.64
	BDM	3.43	3.55	3.70	4.70	2.10	.66
	MPL	3.59	3.60	4.00	4.80	2.30	.65

Table 5: HEXACO personality traits - summary statistics by treatment

To evaluate whether any of the differences across treatments are statistically significant, we regress the measure of each trait above on treatment dummies. None of our tests for equality of treatment dummy coefficients reject the null hypothesis of equality in that personality trait in each treatment at the 5% significance level.

C.1 HEXACO questions

The HEXACO personality inventory questions in the English version follow below (from Lee and Ashton [22]).

DIRECTIONS

On the following pages you will find a series of statements about you. Please read each statement and decide how much you agree or disagree with that statement. Then write your response in the space next to the statement using the following scale: 5 = strongly agree 4 = agree 3 = neutral (neither agree nor disagree) 2 = disagree 1 = strongly disagree

Please answer every statement, even if you are not completely sure of your response.

Please provide the following information about yourself.

Sex (circle): Female Male

Age: _______ years

(we also added indication of the discipline to which student participants belonged)

1. I would be quite bored by a visit to an art gallery.
2. I plan ahead and organize things, to avoid scrambling at the last minute.
3. I rarely hold a grudge, even against people who have badly wronged me.
4. I feel reasonably satisfied with myself overall.
5. I would feel afraid if I had to travel in bad weather conditions.
6. I wouldn't use flattery to get a raise or promotion at work, even if I thought it would succeed.
7. I'm interested in learning about the history and politics of other countries.
8. I often push myself very hard when trying to achieve a goal.
9. People sometimes tell me that I am too critical of others.
10. I rarely express my opinions in group meetings.
11. I sometimes can't help worrying about little things.
12. If I knew that I could never get caught, I would be willing to steal a million dollars.
13. I would enjoy creating a work of art, such as a novel, a song, or a painting.
14. When working on something, I don't pay much attention to small details.
15. People sometimes tell me that I'm too stubborn.
16. I prefer jobs that involve active social interaction to those that involve working alone.
17. When I suffer from a painful experience, I need someone to make me feel comfortable.

18. Having a lot of money is not especially important to me.

19. I think that paying attention to radical ideas is a waste of time.

20. I make decisions based on the feeling of the moment rather than on careful thought.

21. People think of me as someone who has a quick temper.

22. On most days, I feel cheerful and optimistic.

23. I feel like crying when I see other people crying.

24. I think that I am entitled to more respect than the average person is.

25. If I had the opportunity, I would like to attend a classical music concert.

26. When working, I sometimes have difficulties due to being disorganized.

27. My attitude toward people who have treated me badly is "forgive and forget".

28. I feel that I am an unpopular person.

29. When it comes to physical danger, I am very fearful.

30. If I want something from someone, I will laugh at that person's worst jokes.

31. I've never really enjoyed looking through an encyclopedia.

32. I do only the minimum amount of work needed to get by.

33. I tend to be lenient in judging other people.

34. In social situations, I'm usually the one who makes the first move.

35. I worry a lot less than most people do.

36. I would never accept a bribe, even if it were very large.

37. People have often told me that I have a good imagination.

38. I always try to be accurate in my work, even at the expense of time.

39. I am usually quite flexible in my opinions when people disagree with me.

40. The first thing that I always do in a new place is to make friends.

41. I can handle difficult situations without needing emotional support from anyone else.
42. I would get a lot of pleasure from owning expensive luxury goods.
43. I like people who have unconventional views.
44. I make a lot of mistakes because I don't think before I act.
45. Most people tend to get angry more quickly than I do.
46. Most people are more upbeat and dynamic than I generally am.
47. I feel strong emotions when someone close to me is going away for a long time.
48. I want people to know that I am an important person of high status.
49. I don't think of myself as the artistic or creative type.
50. People often call me a perfectionist.
51. Even when people make a lot of mistakes, I rarely say anything negative.
52. I sometimes feel that I am a worthless person.
53. Even in an emergency I wouldn't feel like panicking.
54. I wouldn't pretend to like someone just to get that person to do favors for me.
55. I find it boring to discuss philosophy.
56. I prefer to do whatever comes to mind, rather than stick to a plan.
57. When people tell me that I'm wrong, my first reaction is to argue with them.
58. When I'm in a group of people, I'm often the one who speaks on behalf of the group.
59. I remain unemotional even in situations where most people get very sentimental.
60. I'd be tempted to use counterfeit money, if I were sure I could get away with it.