DISSERTATION

EXPERIMENTAL ELICITATION OF TIME PREFERENCE:
MYTHS AND REALITY

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This dissertation is dedicated to my Mom.
Chapter 1

Introduction

This dissertation conducts an investigation into the experimental treatment of time preference. The approach taken here is to address experimental research in time preference from a methodological point of view. My aim is to abstract from theoretical modelling for a moment to explore the implications of the experimental results.

Time preference is a very complicated phenomenon. Little or no consensus exists in the field of economic modelling on what the sources of time discounting are and how it functions. While the history of economic thought counts on dozens of models of intertemporal choice (Frederick et al (2002)), most of these models are of difficult empirical validation or do not have general application. Probably this difficulty in merely defining the phenomenon has made the simple and straightforward model proposed by Samuelson (1937) so attractive to the whole academic world and this has helped it to gain it’s leading position. All discussions on the causes and origins of time preference have been reduced to exploring the maximization of additive among periods utility function with one simple parameter, the discount rate, which necessarily has to be constant over time to guarantee the desired properties. While such strict assumptions may be justified for some particular research purposes, this model fails to account for many empirical facts and regularities observed in real life. From this inadequacy of the dominating model compared to real life behavior and from a lack of agreement on what actually time preference is, an explosion of experimental studies has been ignited that puts exploration of time preference into the debating
area. Thus, most experimental studies attack the assumption of the constant discount rate while retaining the simplified assumptions of a discounted utility model. The evidence that emerges from this research is surprisingly divergent. There has been a lot of theorization to be able to account for various results and that has lead to new divergences again, but little attempt has been made to explore the causes of the divergent behavior. Thus, while current experimental research continues to discuss whether the discounting is hyperbolic or exponential I propose to look at what actually gets measured in time preference experiments and how.

Chapter 2 of the present work is concerned with investigation of how a particular elicitation method influences the elicited discount rate. The chapter starts with an introduction of the discounted utility model. It proceeds with a discussion of experimental results that contradict the discounted utility model. Regardless a plethora of experimental studies that demonstrate flaws of the discounted utility model, divergence of discount rates and as well as a multiplicity of biases observed in the experiments raise doubts about the validity of experimental results in time preference.

Subsequently, I discuss objections that have been voiced against experiments in intertemporal choice both from a theoretical and a methodological point of view. I show that being able to account for these objections does not necessarily solve the problem of discount rate divergence. I suggest an alternative explanation of the results observed in experiments, thus clarifying how a particular elicitation procedure affects the final elicited discount rate. I present a taxonomy of experimental literature in time preference that connects reported experiment results to elicitation procedures, response mode and other variables that capture and guide the subjects’ attention during the experiment.

I propose a behavioral model of choice which is applied to the experimental evidence in time preference. I propose a generalized behavioral decisional model of choice. In this model a set of simple heuristics are set in motion by the attributes which attract subjects attention during the experiment. These attributes play the most important role in the making up the subjects’ representation of the task and of the problem he/she is faced with. Thus, a limited choice set is defined. Then, based on the constructed choice set and guided by heuristics evoked by the elicitation procedure and response mode, the threshold value that guarantees a satisfactory level in the decision is defined. The choice is made out of the restricted choice set based on the defined
threshold value.

I conclude that the elicitation procedures, and in particular one dimension of the task to which subjects’ attention is attracted during the experiment, define the entity of the final elicited discount rate in a predictable way.

Chapters 3 and 4 build on the results obtained in Chapter 2. Chapter 3 considers a particular elicitation method which is choice task in the multiple price list format implemented by Harrison et al, 2002, and explores the hypothesis of whether the constant discounting normally observed in studies that implement this elicitation method is due to an artefact of the elicitation method, the so-called ”middle table effect”. The results of the experiment in Chapter 3 do not confirm the middle table effect hypothesis. However, and unexpectedly, it is demonstrated that the choice task presented in the multiple price list format leads to elicitation of different discount rates compared to discount rates elicited by a matching task among the same subjects.

On the basis of these findings, I focus on an investigation of the interplay between matching task and choice task as the main procedures for eliciting time preference. In particular, I show how a simple model of decision making can explain the different results observed in the area of intertemporal choice research related to the functional form of discounting, i.e. the debate between hyperbolic and exponential discounting. Harrison and Lau (2005) attack the hyperbolic discounting evidence on the grounds of incorrect experimental procedures and claim that adjusting for this undermines the evidence for hyperbolic discounting. At the same time, studies exist that apply the “correct” procedures but nevertheless observe hyperbolic evidence. Based on experimental results I demonstrate that elicitation procedure, and the nature of the limits it imposes on possible observable discount rates, are alone sufficient to “produce” evidence of hyperbolic or exponential discounting.

Chapter 4 studies the analysis presented in Chapter 3 in more depth and compares the three most frequently used elicitation procedures in experimental elicitation of discount rates: choice task in nominal multiple price list format, choice task in multiple price list format with interest rate structure and matching tasks. It is demonstrated that the three tasks evoke different decision rules that are responsible for the elicitation of differing discount rates. In Experiment I, it is demonstrated that the three methods lead to observation of different discount rates. Experiment II shows that the three elicitation procedures lead to observation of different forms of discount
function. It is demonstrated how different decision rules influence the formation of different forms of discount functions.

Chapter 5 builds on the analysis carried out in Chapter 4 and compares the performance of the decision rules discussed in the latter chapter in elicitation with choice task in multiple price list format with nominal and interest rate structures. This chapter follows the study by Gode and Sunder, 1993 which uses computer simulations with artificial agents to demonstrate that simple constraints, such as the budget constraint, can lead to emergence of market equilibrium. In a similar fashion I show that the choice of elicitation method together with the structure of this method play a decisive role in establishing the magnitude of the discount rate that will be elicited and the form of discount function that is observed.

The key interest of the present work is the fact that preferences observed in experiments are highly sensitive to the experimental methods used to elicit them. I show that apparently robust evidence of hyperbolic discounting is largely a result of the methods and procedures used in the elicitation of time preferences. From this point of view hyperbolic discounting and other well known biases of time preference can be seen as myths. The reality seems to be even less comforting. Rationality failure of experimental subjects goes far beyond time inconsistency. Results presented in the dissertation discredit the discounted utility model itself.

Thus, the ongoing debate on whether time discounting is exponential or is present biased can be answered in the following way: it can be both of these or even something different (like negative time preference) depending on the elicitation task.

This conclusion raises obvious doubts regarding the external validity of experiments on intertemporal choice. While some elicitation procedures used in experiments and considered here are highly artificial and are unlikely to be encountered in real life, (in particular, the multiple price list method or methods used to demonstrate time preference reversal), some of the methods developed in the discipline are based on real life situations (simple choice tasks and rarely, matching tasks). Studying situations that individuals may plausibly encounter in real life will improve our knowledge of decision processes in time preference permitting development of better models.

1Myth -an idea or explanation which is widely held but untrue or unproven (Collins Essential English Dictionary, 2006).
The experiments analysed in the present dissertation show that, instead of maximizing discounted utility, subjects use rules of thumb that permit simplification of their decision making. The findings in the present work pose doubts about the descriptive validity of the discounted utility model. While the model is simple and has useful properties for application in economic modelling, it is too difficult and artificial to be applied by individuals, even those trained to do so. Although it can certainly be implemented in certain areas of research it should be replaced by more realistic models for situations where prediction of individual behavior is of great importance. This process has already started (see Leland (2002), Rubinstein and Salant (2006), Salant and Rubinstein (2007). The model developed here contributes to this research.
Chapter 2

Problematic issues of experimental treatment of time preference

2.1 Introduction

Time preference is a theoretical concept that establishes preference relations between present and future outcomes. In economic research, time preference is usually assumed to be positive. This means that the outcome consumed on today provides more immediate utility compared to immediate utility associated with its consumption on a later day. The considerations of time are involved in many economic decisions. Not surprisingly applications of time preference in economics research ranges from problems of self-control to savings and consumption decisions. The importance of this theoretical construct in economic theory is emphasized by a plethora of theoretical models that aim to explain time preference. These models provide the whole spectrum of sources of time preference. The motives included in time preference range from social factors, like the propensity of a nation to savings (John Rae, 1834), to strictly personal factors, like self-control (Fisher, 1930). Finally, time preference is seen as a result of the interaction of market
forces, i.e. of demand and supply of capital (Bohm-Bawerk, 1889). In this later treatment, time preference is seen as a rate of substitution between present and future consumption. A whole set of social and psychological factors that influence decisions over time is compressed into a single parameter – the discount factor (Samuelson, 1937). In addition, the discount factor is assumed to be constant among varying periods. The discounted utility model has become a leading theory extensively used in applications to economic problems.

Being a subjective construct time preference does not provide an objective measure that permits us to establish a measure of robustness for elicited values. Theoretical research into time preference goes back to the mid 18th century (Loewenstein 1991). Despite numerous attempts to develop general and tractable treatment of causes and consequences of time preference little success had been achieved before Samuelson (1937) proposed the discounted utility model as an alternative theoretical measure to budgetary studies of utility. The chapter starts with a brief overview of the discounted utility model.

I then provide an overview of experimental results in time preference. Most reviews that consider experimental evidence in time preference present frequently observed evidence of hyperbolic discounting, the fact that discount rates elicited experimentally tend to decrease with the increase of the length of the interval over which they were elicited.

Research in time preference is controversial. While some researchers dealing with intertemporal choice have readily accepted evidence of hyperbolic discounting, there are many researchers that consider this evidence an artefact created in experiments. The latter researchers criticize experiments in time preference for being too simple and using too many assumptions to measure discount rates. I discuss a list of critics which are against experimental research in time preference. I dedicate particular attention to the issues of linear utility function and implementation of real payoffs. I show that although these issues are important, accounting for them does not necessarily solve the problems of divergent and contradictory results.

I conclude the chapter with a descriptive choice model in time preference experiments. This model builds upon results observed in experiments in time preference. Opposed to the existing work on this subject, I present a study of attempts to uncover and describe simple psychological biases that are introduced by researchers and that can be responsible for the observed results. This unusual approach to the interpretation of experimental results was motivated by the attempt
to provide an explanation for the highly variable results observed in literature.

In the effort to develop the model of choice I analyze a vast quantity of literature on experimental research on time preference. Rather than reporting all experiments on time preference reported in experimental literature my goal in the present paper is to consider the experimental designs most frequently adapted in studies and show under which conditions specific results may be observed and should be expected.

2.2 Discounted utility model

Out of the complete range of intertemporal choice models the discounted utility model is of particular significance. According to this model the decision maker maximizes the utility function that is a sum of discounted to present utilities associated with future consumption (Ramsey, 1928). The rate at which the decision maker discounts future utilities is equal to the rate of substitution between present and future consumption.

A special form of discounted utility model was developed by Samuelson in *Note on measurement of utility* (Samuelson, 1937). The purpose of this work is to provide a method for measuring marginal utility from income based on budgetary studies and market behavior. Samuelson assumes that the individual faces fixed prices and maintains invariant tastes over time. This work analyzes the theoretical relation between income expenditure over time, an observable variable, and the marginal utility of monetary income. His goal is to characterize a uniquely defined, cardinal, utility index of income. The model is based on the following assumptions (p.156):”...

1. The utility is uniquely measurable

2. During any specified time, the individual behaves so as to maximize the sum of all future utilities, they being reduced to comparable magnitude by suitable time discounting

3. The individual discounts future utilities in some regular fashion which is known to us. For simplicity we assume in the first instance that the rate of discount of future utilities is a constant.”

These assumptions allow us to define utility index as:

---

1 for a comprehensive review of theoretical research in time preference see Frederick et al (2002).
\[ U = \int u_t(x)e^{-\pi t}dt \]

where \( u_t \) is the utility associated with the individual’s instantaneous consumption in period \( t \). This definition corresponds to a unique measure of utility of money income.

The main feature of this model is the assumption of constant discounting. Samuelson pointed out that the assumption of constant discounting is arbitrary and may be of scarce applicability for empirical purposes. Nevertheless, the simplicity and mathematical elegance of this formulation has promoted fast and wide-ranging implementation of the discounted utility model in theoretical research involving time preference. Its successive axiomatization by Koopmans (1960) and later by Fishburn and Rubinstein (1982) affirmed the predominance of the discounted utility model.

The main implication of the constant discounting model is time consistency of intertemporal choice\(^2\). The individual whose preferences are described by this utility function will choose the same consumption stream regardless of the date on which the choice is made. In other words, the choice of the optimal plan does not depend on the date when this choice is made. Time consistency has became a synonym of individual rationality applied to intertemporal choice.

### 2.3 Experimental measuring of time discounting

The assumption of constant discounting is very restrictive from an empirical point of view. Thaler (1981) conducts the first study to demonstrate that this assumption is not justified by data. He carried out a survey in which subjects were asked to specify how much they would require to be paid to make waiting for a payoff as attractive as receiving a payoff immediately. From the obtained indifference points he calculated corresponding discount rates. Consequent experimental studies have built upon this methodology.

Therefore, to measure the discount rate most studies collect data on the indifference point between two payoffs available on two different dates. Usually these indifference points consist of a smaller payoff that is available on a sooner date (sooner smaller payoff – the SS outcome) and a larger payoff that is available on a later date (later larger payoff – the LL outcome). The

\(^2\)For a complete review of the implications of the assumptions in Samuelson (1937) see for example Frederick et al. (2002).
difference between the date on which the SS payoff is available and the present date is called front-end-delay (FED). In most of the early experimental studies in time preference, FED was set at zero meaning that the SS payoff was available immediately\(^3\). The date on which the LL payoff is available is referred to as back-end delay (BED) (Holcomb and Nelson, 1992). The difference between the FED and the BED is called the elicitation interval . For example, it can be elicited that the subject is indifferent about receiving $100 in 1 year or $150 in 3 years.

Given indifference between sooner smaller and later larger payoffs, the implicit discount rate is computed using net present value calculation from the discounted utility model:

\[
u(SS)D(t_{ss}) = u(LL)D(t_{LL})
\]

where \(u(x)\) is immediate utility associated with outcome, is assumed to be linear and \(D(t)\) is the discount function that is assumed to be exponential. Therefore,

\[
\vartheta = \frac{t_{LL} - t_{ss}}{\sqrt{LL \cdot SS}}
\]

where \(\vartheta\) is the discount factor that relates to the discount rate, \(r\), as

\[
\vartheta = \frac{1}{1 + r}
\]

For instance, if the individual is indifferent between $100 today and $120 in 1 year his corresponding implicit annual discount rate is of 20%. This computation is based on the equation:

\[
100 = \frac{120}{(1 + r)^{t_{LL} - t_{ss}}},
\]

where \(\rho\) is the implied discount rate and \(t\) is the length of its elicitation period.

A typical time preference study elicits several discount rates corresponding to several elicitation intervals, several elicitation amounts or both.

Therefore, elicitation of time preference consists of finding the indifference point between a sooner smaller option and later larger option. In a typical experiment of time preference

\(^3\)The role of FED in experimental elicitation of time preference will be discussed later in the Chapter.
elicitation there are two dimensions of choice – time and payoff. Each dimension takes on two values. The time dimension is defined by a front-end delay, the date when the soonest payoff is available, and a back-end delay, the date when the later payoff is available. Consequently there are two payoffs: the payoff associated with FED and the payoff associated with BED. In the experiment the researcher defines three of these values and the interest of the experiment is in the elicitation of the fourth value. Therefore, the experiment can be designed in four following ways:

1. Given FED, BED and SS value, the value associated with the LL option is elicited;
2. Given FED, BED and LL value, the value associated with the SS option is elicited;
3. Given, FED, SS and LL options, the corresponding BED is elicited;
4. Given, BED, SS and LL options, the corresponding FED is elicited.

When the SS value or the FED are elicited we are talking about the speed-up frame of elicitation, while if LL option or BED are being elicited experiment it is said to be in the delay frame. In situations 1 and 2 the interval of elicitation remains fixed while one of the two payoffs vary. In situation 3 and 4 the two payoffs remain fixed while the length of the interval is elicited.

In matching task subjects will be faced with given values and will be asked to fill in the blank space associated with the missing value. In the choice task subjects are given a list of choice questions in which all the four values are given, but the three values that are defined by the experimenter are fixed, and remain the same throughout the whole list of choice questions while the attribute that is being elicited can take on values decided by the experimenter. Subjects are expected to choose the SS option for some corresponding values of the LL option and switch the choice to the LL option. A missing value, the purpose of our elicitation, is defined as the midpoint of interval in which the subject switches the choice.

There are two main ways in which the missing value can be presented with the choice task: the multiple price list (Green et al., 1997, Coller and Williams, 1999, etc.) and the titration mechanism (Kirby and Herrnstein, 1995, Read and Roelofsma, 2003, etc.). The multiple price

\[\text{Eventually there can be a third dimension, corresponding to the SS and LL pair interest rate with all the problems associated with this representation discussed earlier.}\]
list (MPL) refers to a list of values corresponding to the value that is being elicited defined by the researcher before the experiment. These values can be constructed by the experimenter by departing from the given, fixed, corresponding value and increasing (decreasing) it by some regular or irregular amounts. For example, in Green et al. (1997) subjects were asked to choose between a fixed delayed value of $100 and immediate values of $99, $97.5, ..., $2.5, $1. These values remained the same for all intervals of elicitation considered in the experiment. In the present study, this elicitation method is referred to as choice task in multiple price list format with nominal structure ($-MPL) to underline that it has a payoff structure fixed in nominal terms. In Coller and Williams (1999) however, a corresponding missing value is constructed in a way to guarantee a certain level of return related to a SS-LL pair. In this case a list of choices between SS-LL outcomes corresponds to a list of annual returns on a given option, usually SS payoff. While for elicitation over a single interval there is little difference between this method and the $-MPL SS-LL considered earlier, when elicitation has been completed for more than one period, the present method is distinguished as it maintains the structure of annual returns associated to each choice pair regardless of the length of the interval. Therefore, subjects are actually called to choose from a list of interest rates that remains the same for all considered elicitation intervals. For the remainder of this study this elicitation method is called choice task in multiple price list format with interest rate structure (%-MPL) to emphasize that it has a fixed interest rate structure.

Choice task in the MPL method can be presented to a subject in a table form in which subjects have to express their choice for each question (Coller and Williams, 1999, Harrison et al., 2002, etc.) or can indicate the question, row of the table, where they prefer to switch their choice from choosing option A to option B (Andersen et al., 2006, Manzini et al., 2008, etc.). Subjects can also be presented with a single question at a time in increasing/decreasing order of the varying value, value being elicited, (Green et al., 1994, Green et al., 1997, etc.) or in random order (Experiment I in Chapter 3, Experiment I in Chapter 4 in present dissertation). The subsequent chapters of this dissertation provide a very detailed discussion of $-MPL and %-MPL choice tasks.

In the titration mechanism subjects are faced with a first choice pair arbitrarily defined by the experimenter. Depending on the value that was chosen, the varying value is adjusted by the
titration mechanism to elicit the indifference point. For example, in Read and Roelofsma (2003)
subjects were first faced with a choice between £500 on Sept. 28, 2001 and £1000, Sept. 27,
2002. If the fixed amount was LL, SS was increased following a choice of LL and then decreased
following a choice of SS. If the fixed amount was SS, LL was decreased following a choice of
LL and increased following a choice of SS. In this case the experimenter should decide on the
value to be presented in the first choice and on the amount of adjustment. This mechanism
is similar to $-MPL in that it maintains its nominal values when elicitation is performed over
different intervals. Although it is not identical to $-MPL: in $-MPL subjects are faced with a
fixed number of choices while in the titration mechanism they are given choice questions unless
the indifference value is found or the limiting value for the task is reached.

2.4 Anomalies of discounted utility

Experimental research in psychology and economics has documented a long list of behavioral
anomalies of the constant discounted model. In what follows I discuss the main anomalies
observed in the literature.

There is no doubt that the main finding of experimental research in time preference is that
the discount rates decrease with any increase in the elicitation interval, hyperbolic discounting.
Experimental evidence in support of hyperbolic discounting was first presented by Thaler (1981).
This study opened a new area of experimental research including numerous consecutive studies
which addressed the question of whether time discounting is hyperbolic or not. Two approaches
to this question can be distinguished in the literature.

The first approach is focused on the experimental derivation of the correct functional form
of discounting. The first studies within this approach elicited discount rates and graphically
demonstrated that these discount rates decrease with the increase in the elicitation interval
(Thaler, 1981, Benzion et al., 1989, etc.). Later studies applied more or less sophisticated econo-
metric techniques to fit possible functional forms proposed by theoretical research like exponen-
tial (Samuelson, 1937) or quasi-hyperbolic (Laibson, 1997) discounting or based on empirical
observations, like simple hyperbolic (Mazur, 1984) or generalized hyperbolic (Lowenstein and
Prelec, 1992). Earlier studies that applied econometric techniques argued in support of hyperbolic discounting confirming their statements with more matching functional forms of hyperbolic discounting compared to the standard exponential (Green et al., 1997, Kirby and Marakovic, 1995, Kirby, 1997, etc.). Based on these studies hyperbolic discounting has gradually become considered as a robust experimental phenomenon.

Another approach to dealing with hyperbolic discounting is to test the behavioral implications of hyperbolic discounting. The main behavioral implication of hyperbolic discounting is the famous time preference reversal. Time preference reversal, or delay effect, describes a situation in which an individual prefers $10 today to $15 tomorrow, but chooses $15 in 1 year and 1 day over $10 in 1 year. This kind of choice violates the time consistency that is required by exponential discounting. Experiments that observe time preference phenomenon use the above example to construct a series of choices in which subjects reverse their choices. These experiments were conducted both with monetary (Ainslie and Haendel, 1983, and others) and non-monetary outcomes like sips of juice or water (McClure et al., 2007). The generally accepted opinion is that the majority of subjects in these experiments reverse their choice in line with predictions of hyperbolic discounting (Kirby and Herrnstein, 1995, Green et al., 1994, McClure et al., 2004 and McClure et al. 2007). Evidence of time preference reversal reinforces the arguments of hyperbolic discounting.

Special attention should be given to studies by Read (2001) and Read and Roelofsma (2003) that explain the hyperbolic effect observed in data by subadditive discounting. The idea is that subjects require more compensation for waiting a shorter period of time compared to waiting a longer period of time. To test this hypothesis in a series of experiments, the discount rate over a long temporal interval and shorter intervals were elicited, where the long interval were split up. An interesting point in this elicitation is that only long and one of the short intervals started immediately, while the rest of the short intervals started when the preceding intervals were ending. Thus, if the discount rate over 24 months was compared to 8-month periods, discount rates over 24 months starting immediately, 8 months starting immediately, 8 months starting in 8 months and 8 months starting in 16 months were elicited. It was observed that as expected the discount rate over a shorter interval was higher than the one over a longer interval. This data supports hyperbolic discounting.
Another widely observed result in time preference experiments is the dependence of the discount rate on the magnitude of the reward through which it was elicited. This evidence has been called the *magnitude effect* and describes decreasing discount rates with the increase in size of the elicitation reward. This result was first observed in Thaler (1981) and confirmed by consequent studies by Benzion et al. (1989), Benhabib et al. (2006) and many others.

Chapman and Winquist (1998) look for possible origins of this effect. They hypothesize that the magnitude effect is common to other tasks that require quantitative evaluations of monetary rewards meaning that it is a property of monetary utility function\(^5\) rather than a demonstration of pure time discounting. They conduct a study in which they compare the magnitude effect observed in situations involving discounting and tipping. Subjects in this study were asked to provide monetary payoffs to be received in the future that make the future receipt as attractive as immediate payoff. Different sizes of reward were offered. The same subjects were simultaneously asked to provide the amount that they would leave as a tip on a given bill, where the monetary magnitude of the bill corresponded to the magnitude of the rewards in the time preference task. The magnitude effect was observed in both tasks. This study contributes to the discussion of the form of the underlying utility function associated with monetary payoffs and provides support to the nonlinear specification of the monetary utility function.

*Sign effect* – discrepancy between discount rates elicited over gains and losses - is another well-documented anomaly of intertemporal choice. According to this effect discount rates elicited in domains of gains are higher than discount rates elicited in domain of losses. This effect is explained by the prospect theory (Kahneman and Tversky, 1979).

Moreover, it has been noted that the way the elicitation question is posed in each sign domain influences the behavior of the discount rates (Loewenstein, 1988). Subjects tend to require a higher premium to postpone the receipt of the given immediate payoff compared to the premium they accept to pay to anticipate the receipt of a given future reward. This bias is called *delay-speed up asymmetry*. Loewenstein (1988) explains this systematical divergence in discount rates by a simple psychological mechanism: the available payoff is perceived as a reference point and the task is evaluated compared to this reference point. For example, if the subject is asked to state a payoff that makes him/her indifferent to either receiving the given payoff immediately

\(^5\)This study was based on the assumptions of the model by Loewenstein and Prelec (1992).
or waiting till some future date, waiting for a future date will be perceived as a loss compared to the initial situation of an immediately available gain. Consequently, a higher premium for waiting will be required by the subject. Instead, if the subject is given a payoff on a future date and is asked to state the immediate payoff that will make him/her indifferent to receiving either a future or an immediate payoff, he/she will perceive an anticipation of the future payoff as a gain compared to the reference point, which would be to receive a payoff on a future date. A lower premium is thus required to make the subject indifferent. A similar but opposite in sign asymmetry is observed for the loss domain: subjects are less inclined to pay for postponing the payment of a loss but are willing to pay more to anticipate this payment.

Although the sign effect has received extensive experimental treatment (Shelley, 1994, Benhabib et al., 2005, etc.) its existence in theoretical research in time preference is mostly neglected.

Experiments involving choice among sequences of outcomes constitute a separate line of research in time preference. Accepting a prevailing view in behavioral economics, such as hyperbolic discounting, the individual with present bias preferences will prefer a sequence that offers larger gains immediately and postpones smaller gains to the future. Contrary to this intuition, in experiments, a majority of subjects choose increasing sequences. Meaning that being able to choose between sequences of future payoffs that offer the same cumulative nominal value but differ in distribution of this value over time, subjects prefer options that offer an increasing sequence of payoffs compared to a decreasing one. Note that a decreasing sequence in this case corresponds to the lowest discounted value. For example, in a survey by Loewenstein and Sicherman (1991) on wage profiles, the majority of individuals chose an increasing wage profile over constant or decreasing, even if each wage profile was giving the same general income. Preference for improvement is a widely observed phenomenon not only in a monetary domain (Varey and Kahneman (1992) for discomfort levels, Lowenstein and Prelec (1990) for dinner choice). Not only is this evidence contrary to the widely accepted hyperbolic discounting view but it also negates the existence of positive discounting in general. Lowenstein and Prelec (1991) state that the sequence is perceived differently compared to a simple outcome. A standard explanation of anomalous choice over sequences is to be searched in models with a reference point and a habit formation. In this case an additional assumption is made. This assumption is that a subject consumes a corresponding income immediately without saving anything for the future period.
When a subject is faced with a task of choosing a future wage profile he/she perceives an increasing sequence as associated with increasing wellbeing. The subject anticipates he/she will get used to a higher income level and will want in the future period at least as good an income as was received in the present. Thus, an increasing sequence is chosen even at a cost of choosing a cash flow with a lower present value.

On the other hand, Loewenstein and Prelec (1990) notice that for some sequences, like deciding where to spend free time or choosing dinner at a restaurant, rather than habit formation there is a preference for spreading pleasant experiences over time.

Experimental research in time preference has discovered many behavioral anomalies of constant discounted utility model tested empirically. The most important result of this research is that the idea of hyperbolic discounting has become widely accepted, at least by experimental and behavioral economists. Evidence of hyperbolic discounting is considered to be robust and unconditional. However, experimental evidence in time preference is not homogeneous. Big differences are observed in the magnitude of discount rates observed in different studies. As Frederick et al. (2002) put it ”... in contrast to estimates of physical phenomena like speed of light, there is no methodological progress; the range of estimates is not shrinking over time” (p.377). This variability of results between studies poses doubts on the reliability of obtained evidence.

For these reasons experimental studies that observe evidence of hyperbolic discounting have been extensively criticized. This critic addresses features of the theoretical assumptions that are made in experimental studies in time preference as well as the methodology used in the experiments. The goal of this critic is to explain the variability between the estimated discount rates in studies and the evidence of hyperbolic discounting as opposed to predicted exponential discounting. The next section presents the critique that addresses theoretical assumptions of experimental studies. A separate section is dedicated to the discussion of the problems related to experimental procedures.

### 2.5 Problematic issues from a theoretical point of view

The elicitation procedure described in section 2.3 is widespread in experimental literature. Although it is often not focused on, this approach relies on several additional assumptions (often
implicit), which may lead to confounding results.

Frederick et al. (2002) discuss several of these confounding factors. In the list of implicit assumptions, on which studies eliciting discount rates rely, the following concepts are included.

Consumption reallocation – it is assumed that an individual participating in an experiment, treats the task as an isolated event without considering his overall position. Moreover, it is assumed that the individual will not shift his consumption around over time, in anticipation of receiving the future reward or penalty. Andersen et al. (2008) is the only study so far that integrates the subjects’ income into the discount rate estimation model. This estimation, however, is based upon the model (by Fudenberg and Levine, 2006) and substitutes the subjects’ income by the average daily income of the Danish population.

Intertemporal arbitrage – in the presence of financial markets offering tradable payoffs in experiments, such as monetary outcomes, is open to opportunities of intertemporal arbitrage (Pender, 1996). If subjects have access to perfect financial markets, the discount rate should converge on the market interest rate. However, discount rates imputed from subjects’ choices in most of experiments not only do not converge on market interest rate but also are much higher. It suggests that subjects are neglecting capital markets or base their choices on some other considerations.

Diminishing marginal utility – while theoretical research assumes that immediate utility associated with payoffs is characterized by diminishing marginal increases, the experimental approach to the estimation of discount rates assumes this function to be linear.

Uncertainty – in experimental studies subjects are typically instructed to assume that delayed rewards will be delivered with certainty. It is not clear whether subjects accept this assumption in their decision-making since delay is normally associated with uncertainty.  

Inflation – it is assumed that $100 today and $100 in 10 years generate the same consumption stream. However, presence of inflation devalues monetary payoffs. If subjects anticipate inflation in their responses it would lead to upward bias in estimates of discount rates. Ostaszewsky et al. (1998) studied the influence of inflation on intertemporal choice. In their experiment subjects were asked to make a choice over time presented in zloty, a currency that at the moment of the experiment underwent high inflation, and dollars, a currency considered stable in terms

\[^6\text{This issue will be discussed more in detail in the next section.}\]
of inflation at that moment. They found that discount rates elicited in zloty were higher than
discount rates elicited with dollars. However, they also find that participants discounted larger
payoffs less steeply than small payoffs while inflation should have the same effect regardless of
the magnitude of the payoff. At the same time considerations of inflation did not influence de-
cisions over probabilistic payoffs. They conclude that although subjects are taking inflation into
consideration in their decision-making process they do not follow normative theory in doing so.

Expectation of changing utility – subjects can expect to have a high income in the future
(this expectation is rather common among the student population, which is the main subject
pool for experiments) therefore the marginal utility of the same $100 will be lower in the future
compared to it’s marginal utility today. This factor will lead to the overestimation of discount
rates.

Habit formation – the notion of a discount rate in the discounted utility model is based on the
assumption of separability of consumption between periods taken into consideration. Evidence
on intertemporal choice in sequences of outcomes pose serious doubts about the plausibility of
the assumption of separability of time preference over time- periods due to the habit formation
phenomenon. Although several models have been developed to deal with this problem (see
Frederick et al., 2002, for a review) the discounted utility model maintains its primacy, since it
assures a mathematical tractability of the problem.

Given that most experimental research was aimed at testing an intertemporal choice model
as defined by Samuelson (1937) only some of these confounding factors can be a direct criticism
of assumptions in experimental studies while others were explicitly assumed by the model. First
of all, Samuelson defines the model to measure a marginal utility from income expressed in
monetary terms. It is assumed that an individual’s tastes do not vary and that he faces fixed
prices. Uncertainty as well is excluded from the analysis. Thus, the questions of inflation,
uncertainty, habit formation and expectation of changing utility would rather undermine the
original model than the experiments. Nevertheless, it remains true that experiments testing
the model should ensure necessary experimental conditions required by the model. All of these
conditions together with assumption of constant discounting are required elements to measure
marginal income utility in the model.

Under conditions and assumptions defined by the model in Samuelson (1937) intertemporal
utility, as Samuelson puts it, is not a general index of utility, one out of many, but a particular, *unique measure* of utility. Samuelson’s aim was to identify one measure of utility that uniquely defines preferences in the market as a contrast to an infinite number of utility indexes that might have given rise to observed preference relations. In these terms immediate utility of money is defined as a *cardinal concept*, it is invariant except for a linear transformation. Just like the von Neumann-Morgenstern utility function for risky outcomes. Discounting is, therefore, cardinal by assumption. It is from comparisons of the individual discount rate to the market interest rate that conclusions on the form of marginal monetary utility are drawn. Cardinality of intertemporal utility function is implied by axiomatic derivation in Koopmans (1960).

Cardinality of the intertemporal utility function as defined in Samuelson (1937) is of great importance for empirical studies in experimental economics. It implies that both the discounting function and the immediate utility function are uniquely defined. Hence, the incorrect choice of functional form will lead to misspecification and incorrect estimation. Thus, if the model is being tested empirically there is a need to identify these two functions in a unique way. Correct specification of functional forms together with assurance of conditions and assumptions required by the model, permit treatment of the discount rate as a cardinal concept making it comparable to the magnitude of market interest rate (as is normally done in studies to show biases in intertemporal choice compared to the model).

Two main conclusions are usually drawn from results of intertemporal choice experiments that report elicited discount rates. One of them is that elicited discount rates are not constant in time. The other one refers to the fact that discount rates are significantly higher than market interest rates prevailing in the period of elicitation in the field. Although each condition and assumption imposed by the model of intertemporal choice discussed above are important for obtaining intertemporal utility function, the main criticism towards these results lies in the assumption of linear form of immediate utility function. Recent interest in the role of functional form of the immediate utility function in elicitation of discount rate (Andersen et al., 2008) makes its discussion here only more pertinent.

When linear utility is assumed the original concavity of utility function that is characterized by diminishing marginal increases will be included in the discounting function altering observed discount rates. Discount rates calculated with assumption of diminishing marginal utility are
lower than discount rates calculated with assumption of linear utility:

\[
\sqrt{\frac{u(x_t)}{u(x_0)}} \leq \sqrt{\frac{x_t}{x_0}},
\]

by Jensen’s inequality. Therefore, the fact that discount rates observed in experimental studies are significantly higher than corresponding market interest rates faced by subjects in the field, can be explained by misspecification of immediate utility function. Moreover, assumption of diminishing marginal utility can, at least in theory, counterbalance the diminishing pattern of hyperbolic discounting. Last but not least, the concave utility function can account for the magnitude effect, another frequently observed violation of intertemporal choice (Loewenstein and Prelec, 1992).

Supporters of linearity of the utility function base their arguments on Rabin’s calibration theorem (Rabin, 2000). Rabin shows that, under assumption of constant risk aversion, refusing a 50/50 gamble of losing $10/gaining $11 that results in risk aversion for small stakes, leads to the refusal of good bets like 50/50 losing $20,000/winning any sum that any normal person would accept. By this counterexample it is demonstrated that for small stakes a decision maker should be roughly risk-neutral. While these arguments seem hardly refutable for small stakes that are adopted in experiments, in general the stakes that are considered in experiments in intertemporal choice often are far from being small. Moreover, experimental evidence about behavior under risk suggests that subjects are risk averse even for low stakes (Starmer, 2000). Therefore, necessity to account for the form of the utility function takes an important place in this area of research.

Several methods have been used in literature to demonstrate this accountability. For example, Chapman (1996) separately elicited utility function for monetary payoffs from preference relations between money and health. The observed utility function was strongly concave over the monetary amounts. She then calculated the discount rates for monetary and health payoffs accounting for this concavity of utility function. Discount rates calculated in this form came out as substantially lower than those calculated under assumption of linear utility. Moreover, the magnitude effect for discount rates calculated in this way was less pronounced than for discount rates calculated assuming linear utility function. At the same time low correlation between
discount rates in health and monetary domain was observed.

Another approach sometimes adopted in literature is to derive, by means of mathematical manipulation, forms of discount rates without any assumption about the form of the utility function being necessary. One example of such work is Attema et al. (2006). Instead of eliciting monetary payoffs that make subjects indifferent between receiving a certain payoff sooner or later, they elicit a temporal interval that makes the subject indifferent to receiving a certain payoff on a given date or alternately to receiving a larger payoff after a delay that has been specified by the subject. In other words, sequences of willingness to wait to receive larger amount when a smaller amount is available on a given date are elicited. Based on the notions of diminishing impatience (Prelec, 2004) they prove that these trade-off sequences define the form of discounting. The conclusion about the form of discounting does not require any specific assumption about the form of the immediate utility function. A strong heterogeneity of results was observed: About one third of subjects presented behavior that is compatible with constant discounting, another one third behaved according to hyperbolic discounting and the rest exhibited negative discounting. Although the present method is convenient as it does not rely on assumptions about the form of utility function, it has been demonstrated that subjects behave differently when asked to perform a task where the response in a monetary dimension is required compared to a temporal dimension (Loewenstein, 1988).

Chesson and Viscusi (2000) jointly elicit time and risk preferences. They construct a lottery that attributes with a toss of a coin whether the same prize will be paid sooner or later; the availability of this same prize is also guaranteed on a date that lies in between the two dates used in the lottery. After the choice between the lottery and the certain option is made, subjects are asked to report the time horizon that will make them indifferent between trying the lottery or accepting the sure option. They demonstrate that under assumption of expected utility from this indifference, it is possible to derive the value of the pure discount rate. Elicited in this way discount rates have presented the same dependence on the length of a considered time horizon as in studies where discount rates were calculated assuming linear utility function. Although this method provides discount rate estimates without assumptions about the utility function, it only holds up under the assumption of expected utility for risky choice. However, long research in risky choice provides consistent evidence that assumption of expected utility is not necessarily
true (Starmer, 2000).

Andersen et al. (2008) perform joint estimation of risk and time preference. As in the previous study it is assumed that utility function over monetary payoffs is the same for risky and intertemporal choice. However, while in Chesson and Viscusi (2000) lotteries, and therefore risky choice, are defined over time, in the present study risky preferences are observed in present and time preferences are elicited over payoffs that are seen as certainty equivalents from the risky choice perspective. It means that in Andersen et al. (2008) risk preferences and time preferences are elicited in separate tasks. They estimate the utility function over monetary payoffs from risky choice under the assumption of expected utility and then transfer this utility function into an estimation of time preference. Discount rates estimated under assumption of the concave utility function found in risky choice are lower than those estimated under assumption of the linear utility function.

Andersen et al. (2008), underline that the monetary utility function that appears in the intertemporal utility specification should be the same as the one that enters the expected utility definition. In this way, if subjects are risk averse in the risky choice task, concavity of the utility function recovered from this data will be transferred to time preference. While subjects in the study were risk averse in general risky choice allows subjects to be risk prone. The assumption of the convex utility function in the Samuelson model will lead to an individual that constantly prefers the future to the present. This individual will not consume in the present, thus postponing consumption to a future period – a rather absurd conclusion from an intuitive point of view.

Although the assumption of transferability of the monetary utility function from risky choice to time preference sounds plausible at first glance, there is no theoretical argument, except for common sense, to validate this. Moreover, the possibility that the monetary utility function in risky choice can be convex, creates problems for its application in time preference research. From a theoretical point of view no factor imposes the expected utility to continue to hold over time. It is possible that individual is seeking risk but shows impatience. As Strotz (1953), puts it "... there is no presumption that these two measures of utility are the same. Measurement is arbitrary and for different purposes different measures may be the most appropriate" (p. 397).

In the specific case of Andresen et al. (2008) it is enough that assumptions of expected utility hold within the period but not necessarily between periods where a time preference operates.
Decision in risky choice can be modeled with the help of the expected utility model:

\[ V(x, p) = \sum_i u(x_i) p_i \]

But any function that preserves the order defined by \( V \) which does not necessarily possess expected utility properties will represent risky preferences within the period in the choice between periods. The function in question can be any monotonic positive transformation of \( V \):

\[ U(x, p, t) = \sum_t f(V(x_{it}, p_i)) \delta^t \]

There exists a positive monotonic transformation that can even lead to observation, at least in theory, of the linear utility function in intertemporal choice and risk-averse, thus concave, utility function in risky choice (Strotz, 1953).

Obviously, these arguments are only theoretical in nature, further research is needed to identify whether cardinal utility associated with monetary payoffs in risky choice corresponds to the measure of immediate utility associated with monetary payoffs in intertemporal choice.

The theoretical concerns presented above throw doubts on the plausibility of the assumption of the transferability of the monetary utility function from risky choice to time preference choice and show that this assumption is very restrictive from a theoretical point of view. Without this assumption the question of the correct specification of the form of immediate utility function remains open. To deal with this problem one of the most promising approaches could be further research of methods that permit elicitation of time preference without imposing any assumption on utility function like the one in Attema et al. (2007). Another approach would be to find robust statistical methods that permit joint identification of pure time preference and immediate utility from observed choice.

In this section a list of concerns that can be found about experimental studies in time preference from a theoretical point of view is presented. Among these arguments, the most popular treatment was taken as more plausible the functional form of immediate utility function. Note that the aim of the model in Samuelson (1937) was to develop a method to measure utility from income empirically. Assumption about time discounting, among others, was needed to uniquely define the utility function. In turn, most experimental research in time preference, has been
concerned with the test of assumption of constant discounting. Interestingly enough, the conclusion of experimental research is that there is a need to impose some strict assumptions on the monetary utility function in order to be able to estimate discount rates. This situation remains a loop with no escape route.

Another problematic assumption of discounted utility that has received little attention is evidence about habit formation. This evidence contradicts the assumption of separability among time periods that is necessary for the definition of the discount rate itself.

The next section presents concerns with the experimental elicitation of time preference from the point of view of experimental methodology. Some of these concerns are closely related to theoretical issues but it was preferred to postpone this discussion to the coming section.

2.6 Problematic issues from the point of view of experimental methodology.

Out of the methodological issues related to the experimental elicitation in time preference the question of real payoffs is probably the most cumbersome. Economists believe that experimental subjects take an experimental task more seriously when they can earn money for performing well. Nowadays failure to implement real payoffs can be one of the decisive factors that prevent results of an economic experiment being published. However, the effect of incentives on human subjects’ behavior in experiments is an empirical question. A recent review of the effect of real incentives in experimental studies by Camerer and Hogarth (1999) shows that the implementation of real incentives lead to mixed and confusing evidence. There are many tasks in which enforcement of real payoffs leads to better performance measured by independent measures such as response times and pupil dilation. Among these, judgment tasks are seen as being important. Such incentives can improve recall of remembered items, reduce the effect of anchoring bias on judgment, improve some kinds of judgments and predictions as well as improve the ability to solve easy problems. This evidence surely highlights the necessity for the implementation of real payoffs in all experiments in individual decision making.

However, Camerer and Hogarth (1999) find that the most common result is that incentives
do not affect performance. This usually happens for tasks where it is either very easy to perform well, or very hard to improve performance.  

Based on the analysis of a 10-year sample of empirical studies, published in The Journal of Behavioral Decision Making (2001) Hertwig and Ortmann conclude that although real incentives do not guarantee that subjects will choose optimal decisions, in many cases the presence of real incentives leads to the observation of results close to normative model requirements and reduces the variability of results.  

Harrison and Rutström (2008) find, in their contingent evaluation studies review, evidence of a considerable hypothetical effect. This means that people declare that they are willing to pay much more to be environmentally friendly in a hypothetical context compared to what they actually pay in real life.  

The experimental task in the time preference study resembles the task of contingent evaluation: subjects are usually asked to provide their monetary evaluation of the cost of waiting to receive a certain amount of money or anticipate its receipt to an earlier date. Therefore, it is considered that the implementation of real payoffs in time preference is of great importance to avoid hypothetical response bias on one hand and to reduce variability of responses on the other (Harrison and Lau, 2005).  

Implementation of real payoffs in experiments in time preference presents researchers with additional issues that are not observed in other areas of experimental research. While budget concerns pose serious limitations on the enforcement of real payoffs in all experimental studies, time preference experiments require payment of delayed monetary payoffs. To make future payment of the delayed payoff credible to subjects appears to be a considerable challenge for experimental design for two reasons: One is related to the length of the elicitation interval, the other is concerned with the amount of elicitation.  

2.6.1 Length of the elicitation interval  

The length of the elicitation interval greatly depends on the choice of the incentive structure. Studies with hypothetical payoffs permit consideration of very long elicitation periods even reaching as far as horizons of 20 years. While analyzing discount rates, Frederick et al. (2002) reported
on more than 20 time preference studies, finding that discount rates elicited over intervals longer than one year do not present much variation over time. At the same time discount rates elicited over intervals shorter than one year present a strong declining effect. Harrison et al. (2002) obtain a similar result. This evidence suggests that there is a need to compare discount rates elicited over intervals that are shorter and longer than one year. This task is very hard if not impossible to achieve with real payoffs. When subjects are promised to be paid in several years, uncertainty associated with the collection of the future payoff increases, leading to the choice of the immediate option. This will impose a very high premium for waiting and as a consequence will lead to the overestimation of the discount rates. Given that most experiments in economics are performed with student subjects taking part in the experiments, payment horizons cannot exceed the length of the academic year. Therefore, a strong overestimation of the discount rates may be the outcome. The recent tendency in time preference experiments, however, is to conduct field experiments engaging subjects who are not students. Even in this case it is hard to convince subjects that the payment will be made in 10 years. Even from an administrative point of view, this promise is hard to keep for the experimenter. Thus, when introducing real payoffs in experimental elicitation of time preference, researchers have to take into consideration the length of the interval that is feasible with the subject pool they are dealing with.

A separate but related question is how to make the promise of a future payment credible to subjects. One of the important issues to consider from this point of view is the fact that often experiments in time preference give subjects the choice of either immediate payoff or some delayed payoff. While the immediate payoff is normally collected the same day as the experiment, collection of the delayed payoff is related to uncertainty (whether the experimenter will maintain the promise) and the transaction costs of getting paid (coming back to the laboratory on a given day to actually receive the payment). Harrison and Lau (2005) describe this situation as comparing good apples with money today, and bad apples to delayed payment. According to their analysis this comparison is asymmetric by definition and leads to an overestimation of discount rates. The only way to overcome this bias is seen in delaying both smaller and larger payoffs. Therefore, it is necessary to incorporate front-end-delay at least equal to one day into the experimental design. Although this design feature prevents the experimenter from testing quasi-hyperbolic discounting and its effect extends only to the immediate future, it is considered
a necessary compromise to obtain credible estimates of the discount rates.

The effect of FED on elicited discount rates was studied by Coller and Williams, (1999) and Slonim et al., (2007). Coller and Williams in between subjects design compared the effect of FED of 1 month and an elicitation interval of two months among the student subject population. The median discount rate result between the two treatments is almost the same (position 11 of the multiple price list corresponding to the interval of the 20-25% discount rate was chosen in presence of FED, while position 12, corresponding to the interval of 25-35%, was chosen in the absence of FED\(^7\)). The coefficient corresponding to the FED effect in the regression performed throughout all treatments, is of low significance.

In their study of the effect of FED in within subjects design Slonim et al., (2007) obtain more significant estimates of coefficients corresponding to implementation of FED and demonstrate that FED leads to the elicitation of lower discount rates.

Another key question related to the delayed payments is how the experimenter enforces the promise of delayed payment. Typically in economic experiments subjects are paid after the experiment in cash or with a check. In a time preference experiment a promise to be paid in cash on a later day may not be perceived as a credible promise especially in places where the experimental laboratory does not have an established reputation or in a field study. To solve this situation and reduce transaction costs related with the collection of the delayed payoffs, subjects are provided with a check payable on a later date, gift certificates or credit vouchers. Some field experiments that are organized in cooperation with governmental institutions may use checks or certificates guaranteed by this institution (Harrison et al., 2002).

### 2.6.2 Magnitude of payoffs

The magnitude of the payoffs in experiments is another problematic question related to the controversy of real and hypothetical payoffs which is largely discussed in experimental research. The magnitude of the payoffs appears to be especially crucial in time preference experiments. In studies with hypothetical payoffs it has been demonstrated that discount rates diminish with the increase in the payoff through which they have been elicited – the magnitude effect.

\(^7\)Chapters 3, 4 and 5 are dedicated to the study of the multiple price list format of the elicitation task. It will become clear why this result is not to be considered significant.
Hypothetical payoffs permit us to analyze situations in which very large amounts of money, up to 1 million USD, are taken as stakes. At the same time it is not very clear whether subjects in experiments without real incentives take the task of evaluation (choice) seriously given that their choices are not influencing their payoff from the experiment\textsuperscript{8}. In this case there is no mechanism that ensures that subjects are providing their true responses to experimental questions instead of choosing randomly or using some simple heuristics.

Budget constraints, instead, pose significant limits on the magnitude of the payoffs possible for consideration in the experiment. Normally, considerably smaller amounts of money are involved in experiments with real incentives, from 10 to 500 USD.

Results from the experiments are then used for economic modeling to explain different real life situations that require optimization over time ranging from procrastination and diet to savings and retirement. To obtain data that can be considered ecologically valid, i.e. transferable to real life, this data should be collected through tasks that resemble real life situations to which the evidence will be applied. Thus, it is difficult to accept that people will treat 10 USD in the same way in an experimental setting to their savings in real life. Because savings in real life involve much larger amounts of money and expand over a long term planning horizon that is not possible to realize in experiments with real incentives, it is very difficult to justify the use of evidence from these experiments for modeling purposes that consider savings.

Theoretically the individual discount rate should be the same at least for the same individual and should be similar to the market interest rate that this individual is faced with. Discount rates elicited with smaller amounts of money appear to be much higher than those elicited with larger amounts. One of the explanations to this behavior, apart from the concavity of utility function discussed in the previous section, is mental accounting (Thaler, 1985). According to this theory small amounts of money are considered as money to spend now and a very high delay premium is requested to shift the receipt of the payment to the future. At the same time large amounts are seen as savings and treated accordingly.

Budget constraints of an experimental study put considerable limits on the number of subjects that can participate in the study especially if the objective is to elicit time preferences with

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\textsuperscript{8}Payoff for participation in the experiment in this case can be course credit, flat fee, entering the lottery, offering big prize.
large payoffs. To overcome this problem some studies propose that subjects enter a lottery in which some subjects will be given a prize while the others will receive a flat rate fee for participation. For example, in Coller and Williams (1999) one subject in a group of around 30 was randomly selected to receive a chosen option equivalent to $500. Andersen et al. (2008) gave subjects a 10% probability of being selected for winning DKK 3000 (around $500). Manzini et al. (2008) provided every second participant in the experiment with a payment of €20 or €50 depending on treatment. Although this procedure permits us to increase of the sample size there are some concerns that the lottery mechanism of assigning payoffs may create additional confusion in subjects (Manzini et al., 2008). However, Harrison and Rutström (2008) state that these additional biases are more than counterbalanced by the presence of real payoffs of high magnitude in risky choice experiments.

2.6.3 Enforcement of real payoffs with different elicitation tasks

Last but not least the implementation of real payoffs in experiments on time preference is influenced by the elicitation task chosen for the estimation of the discount rate. Time preference is normally elicited with one of the two main elicitation tasks: matching task and choice task. Although the consequent section and the rest of dissertation are dedicated mainly to the analysis of these elicitation methods, a short discussion of peculiarities each elicitation method involves in terms of implementation of real payoffs is appropriate here.

As was noted earlier, the main goal of the time preference experiment is to be able to determine the unchanging relationship between a payoff available sooner and the other payoff available later. One of the methods to establish this is to ask subject to give a delayed (sooner) evaluation of a sooner (delayed) outcome. This elicitation method is called a matching task. Alternatively, subjects may be asked to choose between a series of sooner smaller and later larger outcomes. In this case elicitation is performed with the choice task. While one question in the matching task format provides the point estimate of discount rate, to find discount rate with the choice task requires giving the subject a whole range of choice questions keeping one of the two payoffs fixed and changing the other until the subject reverses the choice.

The choice task presents obvious advantages over the matching task in terms of providing
an incentive-compatible mechanism of real payoff enforcement. In the choice task elicitation, subjects are simply paid the chosen option from the corresponding choice pair. However, experimental research on contingent evaluation demonstrates that subjects faced with the choice task are prone to the anchoring effect. Elicited evaluation results anchored to the first values that the subject is confronted with in the experiment as Green et al., (1998) demonstrate in an experiment with hypothetical payoffs.

In the matching task the payment option is more difficult to define since it is expected that the subject is indifferent to a given payoff or its subjective evaluation provided by the subject. However, providing real payoffs without a mechanism that assures truthful preferences will lead to opportunistic behavior – nothing prevents subjects from stating the highest possible outcome as an indifference point. The matching task presents inconveniences as far as the budget is concerned. In the choice task the researcher knows possible values that can be chosen by subjects and can forecast the budget needed for the experiment. The matching task without an incentive compatible mechanism leaves the researcher without an estimate of the budget, and only the hope that subjects will choose reasonable values.

Two methods have been proposed in literature to deal with this problem. The Becker-DeGroot-Marschak (BDM) mechanism (Becker et al., 1964) can effectively be used to provide incentives to elicit truthful preferences. Under this procedure subjects are asked to provide their subjective evaluation of the immediate payoff and then its evaluation is randomly defined. If the judgment given by the subject is higher than the randomly defined evaluation the subject receives the given sooner (delayed) outcome. Otherwise, the subject receives the randomly established evaluation. Although it is demonstrated that this procedure provides correct incentives to reveal exactly the evaluation that makes subject indifferent, the implementation of this procedure in experiments is very hard. First of all, it is very hard for subjects to understand how the procedure works and why it is in their interests to report their true preferences. Secondly, implementation of this procedure requires a-priori definition of the highest possible boundary to delimit the interval from which the evaluation is randomly made. Bohm et al. (1997) demonstrate that in their willingness to pay the participant’s elicited sellers price is anchored to this upper bound defined by the experimenter. Therefore, this procedure fails to be a compatible incentive.

To deal with this problem delayed payoff is kept fix in the elicitation and subjects are asked
to provide their evaluation of the corresponding immediate payoff. In this case the upper and lower bounds are naturally defined. However, it is demonstrated that the discount rates elicited with the first method are higher than discount rates elicited with the second method, which is the famous delay-speed-up effect discussed earlier. Although this effect was discovered and studied with hypothetical payoffs (Loewenstein, 1988 and others) it was also observed in the study which implemented real payoffs (Benhabib et al., 2006). The experiments illustrated in Chapter 4 of the present dissertation provide evidence that large anchoring effects are present with the BDM procedure that lead to the overestimation of discount rates in the delay payoff scenario and underestimation of discount rates in anticipating payoff scenario.

An alternative method of providing real incentives in the matching task is through the auctions. In this procedure subjects’ evaluations constitute bids in an auction. The person that wins the auction obtains the payment of delayed outcome for which the evaluation was performed while the rest of the group receives immediate payoff. Implementation of this procedure shifts the subjects’ attention from individual decision making typical for a time preference experiment to strategic considerations needed to bid in the auction. Experimental evidence on human behavior in auctions suggests that subjects tend to drag themselves into the competition to win the auction forgetting their preferences (Bazerman and Samuelson, 1983). Experimental elicitation of value with auctions typically leads to the overestimation of value.

Manzini et al. (2008) demonstrate that while, from the theoretical point of view, the time preference elicitation with a choice task, BDM mechanism and auction should lead to the same discount rate, this result has not been confirmed experimentally. In their experiment, time preference was elicited with three alternative procedures. The discount rates elicited with choice task come out as the highest while discount rates elicited with the BDM procedure and auctions are not significantly different. Chapter 4 provides an exhaustive discussion of the difference between choice task and matching task. However, similar results obtained with the BDM procedure and the auctions suggest that these two procedures providing real incentives are prone to biases, probably different in nature, in the same way.

From the above discussion, the choice task seems to be easier to implement and causes less harm in assuring real incentives. However, the rest of dissertation will demonstrate that the choice task is not as desirable an elicitation procedure as it may appear at this point of present
2.6.4 The effect of real payoffs in time preference research

Although the importance of real payoffs is a cornerstone of the recent debates in time preference experiment methodology, experimental evidence on the effect of real incentives in this area is very limited. It is expected that providing real incentives will reduce the magnitude of the elicited discount rates (Harrison and Lau, 2005).

To the author’s knowledge there exists only 3 published studies that consider the effect of real incentives on elicited discount rates. Kirby and Marakovic (1995), compare discount rates elicited with a matching task in anticipating payoff format. Real incentives in a matching task were tested in an auction situation while in a treatment without real incentives, subjects were simply asked to provide their evaluations. Contrary to common belief discount rates elicited with real payoffs turned out to be higher than discount rates elicited with hypothetical payoffs. This result can be explained by subjects’ choices driven by the winners curse. In real payoff treatments, a subject that offers the lowest evaluation wins the auction, therefore the winners curse in this case may lead to overestimation of the discount rate. On the other hand, in a hypothetical payoff treatment, subjects’ evaluations could be driven by anchoring the initial amount resulting in an underestimation of the discount rates.

Coller and Williams (1999) is the other study that has addressed the issue of the effect of real incentives on the elicited discount rate. Discount rates in this study were elicited with a choice task in multiple price list format9. Similar to a previously considered study, a median discount rate elicited with real payoffs turns out to be higher than a discount rate elicited with hypothetical payoffs. However, the absolute difference between the two medians is rather small, the discount rate elicited with hypothetical payoffs comprised in the interval between 10 and 12,5%, while the one elicited with real payoffs belongs to the interval of between 15-17,5%. This small difference with a limited sample size does not permit us to provide a statistically significant result as the theory of minimum detectable effect predicts (Bloom, 1995). Results of regression performed on data from all 6 treatments analyzed in the experiment show a highly significant negative effect of real payoffs on the discount rate. Authors explain that such a difference in results by selection

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9The rest of the dissertation provides a detailed discussion of this method.
bias happened in treatment with hypothetical payoffs, arguing that demographic characteristics drove the result in this treatment. However, the results of regression should be taken carefully into consideration as a treated group in the treatment with hypothetical payoffs was only 1/5 of the rest of sample to which it is compared. An alternative explanation of this result can be that in a hypothetical treatment, subjects’ choice is driven by the middle table effect that will be discussed in Chapter 3 and 4.

The little evidence that exists in time preference research on the effect of real incentives does not appear to provide conclusive results neither on the direction of this effect nor on its importance. The only two experiments that have studied this effect both suffer from methodological problems of a serious and less serious nature. There is a need to perform further research in this area before implementation of real payoffs can be really considered an essential feature of experimental design in time preference.

To conclude, implementation of real payoffs in experiments on intertemporal choice presents the researcher with considerable challenges. It does not seem possible to identify optimal experimental design for elicitation of time preference with real payoffs. Each design feature considered here, i.e. length of elicitation interval, magnitude of payoff, means of payments, elicitation procedure, real payoffs themselves, should be carefully considered in the development of the experiment. The decision of design features should be made based on research objectives by finding optimal balance between the numerous tradeoffs presented here.

2.6.5 Task representation or framing

The usual framing of the payoff in an intertemporal choice experiment is to offer subjects a premium. They are then asked to decide whether they prefer to receive this premium immediately or how much they would request to be paid in addition if they accepted to receive their premium at a later date. Mental accounting theory (Benartzi and Thaler, 1995) predicts that receiving money unexpectedly once would be classified by subjects as a gift and directed to short term spending. Therefore, expression of highly impatient behavior in experiments is rather natural considering how the task was presented to subjects. Additionally, subjects faced with a task
expressed in these terms cannot be expected to behave in the same way as they would behave if
they had to decide about savings or retirement, regular and planned behavior. Some studies tend
to set up an intertemporal choice task in a way that resembles real life situation. For example,
Benzion et al. (1989) depict scenarios to their subjects that involve payment of a salary and a
traffic fine. However, these situations still regard small scale decisions that are probably classified
as less important.

Read et al. (2006) is the only study that explicitly compared discount rates elicited in
investment condition to those in no-investment condition. However, this comparison was limited
for only-money representation and found no difference between the two treatments. Chapter 3
demonstrates that, as anticipated in the next paragraph, only-money representation is treated
differently by subjects compared to other possible representations of task.

2.6.6 Representation of the alternatives

The most frequent representation of the alternatives in time preference experiments is done
in monetary terms. This means that subjects are called to choose, evaluate or compare monetary
payoffs available on different dates having no further information for the decision process. Coller
and Williams (1999) criticize this approach explaining that faced with only monetary payoffs
subjects are not able to calculate interest rates associated with every possible choice alternative
and thus are not able to compare experimental options to opportunities available to them in the
field. To help subjects in their decision process they propose to report interest rates associated
with every payoff option available in the experiment.

Possible problems with evaluation of outcomes presented in nominal terms were mentioned
already in Thaler (1981). These problems are related to the difficulty of human subjects to
estimate exponential trend known in literature as linear bias (Wagenaar and Sagaria, 1975).
However, Thaler refuses hypothesis that data in his experiment can be influence by such bias
as he expects this bias to act for very long elicitation periods (longer than 10 years – maximum
time horizon considered in his study). Later experiment by Benzion et al. (1992) demonstrated
however that subjects asked to predict future value of investment with a given interest rate and
time horizon tend to overestimate this value for periods shorter than one year and overestimate it for elicitation interval longer than one year. Corresponding interest rates recovered from subjects estimates present usual decreasing pattern and reach the required interest rate for the elicitation horizon of one year.

In the study run by Coller and Williams (1999) and Read et al. (2005) it is demonstrated that discount rates elicited with indication of associated interest rate elicited discount rate is lower than in treatments where only monetary payoffs are available for the decision.

However, argumentations based on linear bias make sense in experiments only under assumption of linear utility associated with monetary payoffs. In this case discount rate corresponds to the associated to the pair of alternatives interest rate. In the case in which the underlying utility function is not linear (see the discussion above) the situation becomes more confusing. Individual is first expected to evaluate utility derived from given monetary outcome and than discount this utility to obtain present value of this utility. At this point the only information subject would need is the monetary outcome and the date on which it will be available. Presentation of the associated with the option interest rate may distract subject’s attention. If subject with diminishing marginal utility of money takes into account this information that would be correct under assumption of linear utility resulting discount rate may be overestimate or utility function will be misestimated. Given that experimental studies show that presentation of associated interest rate decreases elicited discount rate under assumption of linear monetary utility (Harrison and Lau, 2005) one can expect that misspecification of utility function by the subject takes place.

Last two sections presented an overview of critiques of experimental research in time preference that can be found in literature. As it can be seen from exposition these critiques are very diverse in their nature. Some of them reflect variety of theoretical explanations of time preference. Others are based on methodological concerns. A common feature that generalizes this discussion is probably impossibility to satisfy all these requirements fully and at the same time. Many of the issues that were discussed here are controversial by their nature. Similar to the situation in theoretical research where there is no consensus on the model that describes time preference in the best way experimental research in time preference suffers even from more controversy. Recent developments of this research however concentrated on methodological peculiarities leaving more general problems that experimental evidence suggest without response. In
the next section after a brief overview of anomalies in experimental evidence on time preference alternative explanation of results is provided based on cognitive decision rules that subjects may be implementing in experiments.

2.7 Experimental evidence: the role of elicitation method and structure

2.7.1 Anomalies in elicitation of biases of intertemporal choice

Experimental research in time preference as it was mentioned earlier focused its efforts on discovering anomalies of the constant discounted utility model. Section 2.4 of the present chapter provides a short overview of commonly observed biases of intertemporal choice. This research has been seen to be prolific in the number of different anomalies that have been documented so far. Although anomalies of discounted model presented earlier in the chapter are considered to be a very robust phenomena, these anomalies are not always observed in experiments.

Hyperbolic discounting received the most widespread treatment in experimental literature. It has also gained a large degree of acceptance in theoretical research in time preference. Experiments provide overwhelming evidence of behavior driven by hyperbolic discounting. Recent studies that deal with this question are less categorical in their results. Thus, Harrison and Lau (2005) argue that in experiments that implement real payoffs and FED, constant discounting is observed. In fact, Harrison et al. (2002), Andersen et al. (2008) and many other studies that employ elicitation method used by the Harrison et al. (2002) data provides support for exponential discounting. At the same time Tanaka et al. (2007) and Benhabib et al. (2006) report better econometric fit of the hyperbolic discount function compared to the exponential discount function in the presence of real payoffs. Slonim et al. (2007) report a study that implements both real payoffs and FED. In addition this study reports evidence in support of hyperbolic discounting. This suggests that the results compatible with constant discounting, are driven by something else. Discount rates elicited in studies that observe constant discounting appear to be rather similar between different studies. Meanwhile, discount rates in studies that provide support for hyperbolic discounting vary a lot between studies.
A distinguishing feature of the studies that support constant discounting is the elicitation method used in these studies. Elicitation of discount rates in these studies is done with the help of choice task in the %-MPL format. From the section 2.3 it can be recalled that the choice task in %-MPL format fixes the interest rate structure of the elicitation table. I will show in chapter 5 that the use of %-MPL choice task leads to the elicitation of time consistent preferences. Studies that observe hyperbolic discounting in the literature elicit discount rates with a matching task or choice task in the $-MPL format. The results of Chapter 4 show that discount rates elicited with these elicitation tasks decrease with increase of the elicitation period.

Confusing evidence in terms of hyperbolic discounting is reported in Read (2001) and Read and Roelofsma (2003). In these studies discount rates elicited over shorter interval starting on several different FEDs are compared to discount rates elicited over a longer interval. The discount rates elicited over shorter intervals turn out as significantly higher than the discount rates elicited over a longer interval confirming hyperbolic discounting. However, discount rates elicited over a shorter interval starting on different FED’s increase with an increase in the length of FED. This behavior is directly opposed to the predictions of hyperbolic discounting.

Similar behavior was observed in the experiment by Attema et al. (2006). In this experiment subjects were asked to state the time that should elapse starting from a given FED to make sooner smaller payoffs an equally attractive given as later larger payoffs. Behavior in this experiment was heterogeneous. Only one third of subjects was behaving according to hyperbolic discounting. Another one third seemed to make their choices according to exponential discounting. The choices of the remaining one third corresponded to increasing discount rate with the increase in FED.

This evidence suggests that subjects react differently faced with a traditional "hyperbolic" elicitation task rather than the elicitation task adopted in Read and Roelofsma (2003) or Attema et al. (2006). In the traditional "hyperbolic" elicitation task, the FED is fixed and elicitation is completed over varying elicitation intervals. In Read and Roelofsma (2003) the elicitation interval is fixed while the value of FED is varying. This seemingly irrelevant feature of experimental design leads to significant differences in observed results.

Time preference reversal is considered to be a fortress of supporters of hyperbolic discounting. Results of experiments that explore preference reversal are not homogeneous. Some studies, like Kirby and Herrnstein (1995), Green et al. (1994), McClure et al. (2004) and McClure et al.
(2007), confirm the hypothesis of the preference reversal. At the same time others, like Holcomb and Nelson (1992), do not find preference reversal to be prevailing behavior. Moreover, Sopher and Sneth (2005) argue that rather than talking about preference reversal driven by hyperbolic discounting, a better account of their data would be given by a stochastic definition of choice of sooner or later reward. At the same time Sayman and Onculler (2007) observe a reverse time-inconsistency when subjects prefer a smaller-sooner reward when both options are in the future, but they decide to wait for the larger-later reward when the smaller option becomes immediate.

2.7.2 Alternative explanation of the biases of intertemporal choice

The factor that distinguishes all these different studies and leads to contradicting results is where subject’s attention is attracted during the experiment. Experimental research in psychology demonstrates that human perceptual systems enhance the accessibility of changes and differences. Accessibility is the feature of the decision task that comes to mind more easily and on which premise a decision is usually made (Kahneman, 2003). An attribute that is accessible to the individual perception is the prominent attribute of the decision task. Perception can be seen as being a reference-dependent system in which perceived attributes of the prominent stimulus reflect the contrast between this stimulus and a context of prior and concurrent stimuli.

This means that in elicitation tasks in which only one attribute changes from one decision to the other the attribute that is changing becomes a focal, prominent, attribute on which the final decision will be based. Therefore, prominence of the attribute depends on the nature of the task and on the elicitation design. As was noted earlier the response mode on one hand concentrates subjects’ attention onto the attribute that has the same scale as the required response.

In the traditional "hyperbolic" elicitation task subjects are asked to provide premiums for waiting for gradually increasing intervals of time. The amount of elicitation and FED remain stable among all the elicitation rounds. The only thing that is changed is the length of the waiting interval and that the subject should provide evaluation for this waiting period.

Experimental studies in psychophysics demonstrate that subjects required to provide a series of consecutive evaluations of phenomenon in the same experiment can use the value reported on a previous evaluation as an additional anchor for their current response (Poulton, 1989). This
bias received the name of transfer bias and refers to situations in which a quantitative value or pattern is transferred from one decision to the other.

The same effect can be hypothesized in the studies of the hyperbolic effect. As it was noted earlier these studies collect evaluations over several elicitation intervals that are presented to subjects in an increasing order of elicitation interval. It is straightforward to expect that subjects will anchor their evaluation of the elicitation interval to the response they gave for a shorter interval of elicitation.

An interesting example of this behavior can be observed in data reported by Thaler et al., 1981. In this study four different questionnaires were developed to collect time preferences for different situations in between-subjects design. This task is an example of matching a task to elicit time preference. Table 2.1 reports median amounts elicited among subjects for three of these questionnaires.

Analysis of the data in rows shows that while starting with an attribution of the same monetary value to the first interval (independently of its relative length) for an elicitation amount of $250 subjects provide lower estimates for a 1-year period if the first period is shorter. Therefore subjects fail to adjust their responses to the length of the elicitation interval and excessively anchor their response to the previously reported value. This tendency is clearer where the elicitation amount is $15 and where subjects indicating $30 for a 3-month delay evaluate a 1-year delay as worth $60, while a $20 evaluation of a 1-month delay leads to an evaluation of a 1-year delay of only $50. Anchoring to the previous amount and failure to adjust to the length of the elicitation period lead to elicitation of decreasing discount rates with an increase in the elicitation interval, just as evaluations of investments in linear bias experiments have illustrated a decreasing pattern of corresponding interest rates.

As I will discuss in Chapter 4 the elicitation task that is used in the experiment imposes limits on the subject’s choice of response. Therefore, subjects tend to use “anchoring to the previous choice” heuristic but at the same time they are limited by the elicitation task in their choice. In particular, in Chapter 5 I show that transfer bias in the %-MPL choice task leads to constant discounting while this same heuristics applied to $-MPL choice task leads to the observation of hyperbolic discounting.

Elicitation task in Read and Roelofsma (2003) fixes the elicitation interval length. In this
Table 2.1: Median responses and (continuously compounded rates in percent), Thaler (1981). Only parts of the original table relative to the discussion in the chapter are reported here.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Amount of early prize</th>
<th>Later prize paid in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 mo.</td>
<td>1 yr</td>
</tr>
<tr>
<td>(A)</td>
<td>$15</td>
<td>$ 30 (277)</td>
</tr>
<tr>
<td></td>
<td>$250</td>
<td>$ 300 (73)</td>
</tr>
<tr>
<td></td>
<td>$3000</td>
<td>$ 3500 (62)</td>
</tr>
<tr>
<td>(B)</td>
<td>$ 75</td>
<td>$ 100 (58)</td>
</tr>
<tr>
<td></td>
<td>$ 250</td>
<td>$ 300 (36)</td>
</tr>
<tr>
<td></td>
<td>$ 1200</td>
<td>$ 1500 (45)</td>
</tr>
<tr>
<td>(C)</td>
<td>$15</td>
<td>$ 20 (345)</td>
</tr>
<tr>
<td></td>
<td>$250</td>
<td>$ 300 (219)</td>
</tr>
<tr>
<td></td>
<td>$3000</td>
<td>$ 3100 (39)</td>
</tr>
</tbody>
</table>

case subjects should provide evaluation of the varying length of FED. This evaluation is more difficult to perform compared to the evaluation of a traditional “hyperbolic” elicitation task. In the latter case it is natural for the subject to imagine that the value of the investment is higher the longer the duration of the investment. Although subjects can make mistakes in the precise evaluation of this investment the direction of the change is known. In the case of varying FED and fixed intervals however it is rather difficult to identify the direction of the change and whether the change will actually occur. In the investment example there should be no difference if the investment is postponed. It should remain of the same future value independently of the FED which is interest free. Overton and MacFayden (1998) demonstrate that subjects fail to recognize this fact. In the case of preferences this evaluation may be even more difficult leading to the confounding evidence observed in literature. Also in this case it is possible that subjects use anchoring to the previous choice heuristics.

Experiments in preference reversal confront subjects with a set of choice couples of the type: do you prefer $10 today or $15 tomorrow and do you prefer $10 in 1 year or $15 in 1 year and 1 day. Studies that observe preference reversal present these choice couples one after another. In this way subjects are able to recognize that the couples of choice questions are the same except...
for greater FED on the second question. Studies that do not find support for preference reversal present the set of questions in random order. In this case subjects fail to recognize the logic of questions and need to find a different criteria for choice.

Rubinstein (2006) and Leland (2002) explain the subject’s choice in these experiments with the similarity model. According to this model subjects make their choice according to a simple procedure: both rewards and dates are compared to each other and a decision is made based on the perception of the rewards (time dates) as similar (dissimilar). Thus, if the dates of payment are perceived similar while later larger payoff is perceived as dissimilar and larger than sooner smaller payoff the later larger payoff is chosen. On the contrary, when rewards look similar while dates are dissimilar and the sooner date is preferred, the choice is made in favour of the sooner smaller payoff. In the case of indecision the choice is made randomly.

In a similar way to the results with the hyperbolic effect, other biases of intertemporal choice can be analyzed. For example, the magnitude effect is more pronounced in within subjects’ design than in between subjects’ design as demonstrated by Frederick and Read (2002). Manzini et al. (2008) found no evidence of the magnitude effect in between subjects design while comparative analysis of studies implementing the multiple price list procedure with interest rate structure demonstrates that the magnitude effect is almost absent in studies that implement the same structure of interest rates (Harrison et al., 2002, Botelho et al., 2006, Dohmen et al., 2007). The same tendency of more pronounced anomalies in within subject study Frederick and Read (2002) observe for sign effect.

Delay-speed up asymmetry is usually observed in studies that implement the matching task and in between subjects design (Loewenstein, 1988, Benzion et al., 1989, Benhabib et al., 2006, etc.). Experiments in Chapter 4 present results for which this anomaly is observed in its classical interpretation for the discount rate elicited with a matching task while changing the direction of asymmetry in choice task.

In all these experiments subject’s attention is attracted to the relevant to the experimenter variable (i.e. magnitude of the elicitation payoff for magnitude effect, sign of the payoff for sign effect) in a fashion described above. Subjects construct their evaluation for the required variable using as an additional anchor the value they reported on the previous rounds. This decision procedure explains why magnitude and sign effects are more pronounced jointly compared to
2.7.3 Differences between matching task and choice task

Read and Roelofsma (2003) report that discount rates elicited with a matching task are lower than discount rates elicited with a choice task. Manzini et al. (2008) reach the same conclusion. Meanwhile the experiment in Chapter 3 elicited higher discount rates with a matching task compared to discount rates elicited with a choice task in within subjects’ design. The experiment in Chapter 3 also demonstrates that subjects faced with a choice task after reporting a higher indifference value on a matching task keep on choosing a smaller indifference value even if the higher value chosen on the matching task is available for choice. Experiments in Chapter 4 replicating in part the design in Manzini et al. (2008) and partly based on the experiment in Chapter 3 show that discount rates elicited with some types of choice task, referred to as a nominal multiple price list, turn out to be higher compared to discount rates elicited with a matching task. Meanwhile discount rates elicited with the MPL with an interest rate structure leads to an elicitation of lower discount rates compared to matching task. This behavior can hardly be seen as a mistake given that subjects were asked, in a final questionnaire, to express whether they were satisfied with their choice in the experiment and whether they would change it if it were possible. Almost everybody was satisfied with the choice reported in the experiment.

This means that in elicitation tasks in which only one attribute changes from one decision to the other the attribute that is changing becomes a focal, prominent attribute on which the final decision will be based. Therefore, prominence of the attribute depends on the nature of the task and on the elicitation design. As was noticed earlier, the response mode on one hand focuses subjects’ attention on the attribute that has the same scale as the required response. For elicitation based on a matching task, the response mode assumes prominence according to the definition of the elicitation outcome.

On the other hand, in choice task, subjects are not asked to provide evaluations of a certain value. In elicitation with a choice task, subjects are given a list of choices where each choice pair is made up of some fixed attributes and one attribute that changes from question to question. The attribute that is being changed is the prominent attribute on which the decision will be
based. However, contrary to the matching task, subjects in the choice task will be attracted to the differences that they observe between the previous and the current question involving the attribute.

Elicitation with a matching task and a choice task that is done involving the same attribute will make this attribute a prominent factor in the decision-making in this task. However, prominence of this attribute will be expressed differently between two methods. In a matching task this attribute becomes prominent because it has the same scale as the response required on the task, but the task normally requires evaluation of the whole amount. Thus, in a matching task, subjects’ decision-making will be concentrated on reporting evaluation in terms of the whole amount. Meanwhile in the choice task, the subjects’ perception system is attracted to the difference observed between the value of the variable attribute in the current question and the one in the previous question. In the case of choice task therefore the elicitation procedure will be highly influenced by the values that subjects observed during the choice or perceive from the task structure they are faced with.

For example, when the choice task is performed in an MPL format and subjects are presented with the whole list of choices altogether they immediately notice the boundaries that are imposed on their choice. It has been demonstrated by research in psychophysics that subjects that are called to choose a value from the list tend to avoid choosing extreme positions and to choose positions that lie close to the central positions of the list, phenomenon that was named response contraction bias (Poulton, 1989). There exists evidence of anchoring in elicitation with choice tasks where subjects are faced with choice pairs in random order, Green et al. (1998). Results of this study demonstrate that the final value elicited with the choice task was correlated to the values that the subjects were confronted with on the first question in the task. This evidence suggests that, in choice task elicitation, with the help of the choice titration mechanism, the value being elicited with this task largely depends on the value chosen as the starting value for this mechanism.

The matching task that requires subjects to provide evaluation of a certain value is prone to some decision-making biases as well. Poulton (1989) in a large review of experiments concerned with quantifying judgments in psychophysics noticed that when subjects are asked to provide quantitative evaluations of a phenomenon “... very first judgments of uninitiated observers are
biased by preferences for particular numbers. When the median lies at 10 or below, it has a better chance of being 5 or 10 than of being any of the numbers 6 through 9. When the median is 20 or above, it is likely to end in a zero because most of the responses are multiples of 10. The reason is simple. Uninitiated observers do not know exactly what number to select. So they round off their response to the nearest 5 or 10" (p. 58).

A representative example of this behavior in a time preference experiment is demonstrated by Thaler (1981) and reported in table 2.1 The first feature that strikes us about this data is that all the values reported by subjects are multiples of 10 or 100 (with small exception for values elicited over $15). Attraction to focal amounts clearly arises from this data: subjects faced with a time preference elicitation over $250 report the same indifferent amount of $300 for waiting 1, 3 and 6 months and $1000 for waiting 5 and 10 years respectively. This choice of focal shows that it is relatively independent of the duration of elicitation interval that leads to hyperbolic discounting in between-subjects design.

Anchoring in a matching task is a widely studied bias in the area of contingent evaluation (Green et al., 1998) and in determining the willingness to pay (Simonson and Drolet, 2004). Anchoring and adjustment heuristics was proposed by Kahneman and Tversky (1974). In a series of experiments they demonstrate that in situations where subjects do not know the correct answer or are not sure what the right answer can be, the responses to these questions tend to be anchored to all available in experiment information, even if this information is randomly generated in front of participants number. Experimental evidence accumulated in research dedicated to this bias suggest that subjects will use all the information they can get during the experiment to generate the evaluation they are asked for.

To sum up, the matching task and the choice task, as methods of elicitation of value, are prone to different and very specific biases. These biases lead to observation of different elicitation results depending on the application of one method or the other. Subsequent chapters of this dissertation are dedicated to a detailed study of the differences in the subjects’ decision processes when confronted with these elicitation methods. It will be demonstrated experimentally that subjects adopted different decisional processes when faced with different elicitation tasks. Moreover, a detailed study of the choice task in the MPL format will be carried out that will show how the structure of the choice task and arbitrary values chosen by the experimenter for varying
attributes influence the results observed in elicitation with this task.

2.7.4 Dimension of elicitation: money or time

Loewestein (1988) demonstrates that elicitation of discount rates on time dimension leads to elicitation of higher discount rates compared to elicitation on monetary dimension. In his experiment one group of subjects was asked to provide evaluation of a future value that makes them indifferent to receiving a certain value today. This same group of subjects on a later date was asked to provide the nearest date of receiving a future payment that would make them indifferent to receiving a smaller payoff today. A different group of subjects was first faced with elicitation on a time dimension and then on a monetary dimension. Comparing median discount rates on the first-stage question between groups the discount rates elicited on time dimension came out as twice as high as discount rates elicited on a money dimension. Analysis of within-subjects responses demonstrates that this effect is also maintained within subjects.

As was explained in section 2.3 elicitation of the discount rates can be performed by elicitation of indifference values in a couple SS – LL on two main dimensions: money and time.

Benzion et al. (1992) suggest that when subjects are required to provide evaluation in monetary terms they are prone to the so-called linear bias (Wagenaar and Sagaria, 1975). The linear bias suggests that when forecasting or identifying change, humans tend to approximate using a linear function. Benzion et al. (1992) asked subjects to provide evaluations of investment made today that provides different returns on initially invested amount and have different durations. The results of this experiment show that subjects overestimate future value of investment for an investment duration of less than a year and tend to underestimate this value for an investment duration of more than a year. The tendency is more pronounced the more distant the period of elicitation is from one year. Most of subjects however managed to correctly predict the future value of investment over one year. Analysis of the responses provided by subjects suggest that subjects used the value associated with one year as a reference point and using a linear function tried to approximate the requested future value. In the study annual returns associated with reported future values of investment were calculated. These interest rates presented a familiar decreasing pattern. Consider that to perform this operation correctly subjects needed to perform
the following calculation:

\[ FV = PV \times (1 + i)^t \]  \hspace{1cm} (2.1)

where \( FV \) is the future value of investment, \( PV \) is the present value that is being invested, \( i \) is the annual return on investment and \( t \) is the duration of investment.

Evidence of linear bias coming from managerial literature (Cohen and al, 1972, Wagenaar and Timmers, 1979, etc.) suggests that subjects use simple heuristics to provide responses to questions involving prediction of exponential trends. This behavior suggests that even in experiments on elicitation of time preference subjects can implement these heuristics in providing their responses to elicitation of time preference.

On the other hand, there is evidence that subjects find it difficult to estimate loan duration (Ranyard and Craig, 1993, Lewis and van Lenrooij, 1995). In particular, subjects tend to underestimate loan duration even if they are provided with all the necessary information to perform this estimation correctly. Underestimation of loan duration suggests that the subjects underestimate the period that makes them indifferent between receiving a SS payoff and waiting for an LL outcome. Consider, that in the case of loan duration estimation (or elicitation on time dimension) subjects need to perform a calculation of the type:

\[ t = \frac{\ln(FV) - \ln(PV)}{\ln(1 + i)} \]  \hspace{1cm} (2.2)

where \( FV \) is the future value of investment, \( PV \) is the present value that is being invested, \( i \) is the annual return on investment and \( t \) is the duration of investment. This calculation is far more difficult from the cognitive point of view than the calculation required for elicitation on monetary dimension represented in 2.1.

As it is noticed in Lewis and van Venrooij (1995) subjects that used more formal methods of calculation (a calculator or mental arithmetic) were appreciably more accurate on average than subjects who guessed at an answer. However, in experiments on time preference elicitation subjects are not allowed to use any calculation tools.

Although there is no study that compares ability to estimate future value of investment and ability to estimate its duration, existing evidence suggests that subjects will be more accurate in predicting future value than in predicting duration of investment.
Difficulty of subjects to consider time dimension correctly can explain anomalous results observed in an experiment by Attema et al. (2006). In this experiment subjects are faced with elicitation of type 3 in which they are provided values associated with SS and LL outcomes and are also given the date on which a SS payoff is available (see section 2.3). The researcher is interested in eliciting the value of BED. When this value is elicited the researcher faces the next question in which FED takes the value elicited for BED and the next value of BED is elicited. This experiment observes a high percentage of responses compatible with negative time preference. In particular, a large percentage of subjects tend to report increasing lengths of time that should pass between the two payoffs to make them indifferent between SS and LL option with increase of FED. This behavior can be explained by incorrect estimation of the influence of time on the value of investment.

Difficulty of evaluation in terms of time is underlined in the study by Overton and MacFayden (1998). In addition to a classical experiment on elicitation of loan duration they conduct a treatment in which subjects are asked to evaluate the duration of a loan with a free postponement of repayment period by one year. Duration of loans with small monthly payments (larger loan duration) is underestimated while duration of loans with large monthly payments (shorter loans) is overestimated. Moreover, it is observed that underestimation of loan duration increases in the treatment with a one-year period delay of repayment without interest. This behavior is explained in the study by hyperbolic discounting. Following this logic linear bias as well can be perceived as evidence in support of hyperbolic discounting. However, both of these biases most likely explain the prevailing evidence of hyperbolic discounting in data rather than being caused by it.

To conclude, anomalies of the discounted utility model are not as frequently observed as it is believed. A whole set of results is observed in experiments on time preference in reality ranging from the generally accepted anomalies to their complete converse. I show that commonly accepted biases of intertemporal choice are nothing more than special cases of a vast quantity of experimental evidence.

An intertemporal choice model can explain the observed discrepancies in the discount rates elicited with different elicitation methods, procedures and response modes given that any of these models assume method invariance with regards to elicitation procedure.
I propose an alternative account of observed evidence. The main idea of my argument is that the results observed in experiments are driven by the elicitation procedure. The elicitation procedure focuses, willingly or without intent, the subject’s attention on a certain dimension of the elicitation task. Subjects construct their response placing too much weight on the highlighted dimension without considering other attributes of the problem. This decision process leads to elicitation of different results in seemingly equal decision problems.

2.8 Conclusions

The aim of the present chapter is to provide a general understanding of the topic that this dissertation is dealing with. Time preference is a very complex phenomenon and touches many spheres of everyday life. Not surprisingly there exist many models trying to explain time preference. A wide list of causes of time preference has been developed in more than two centuries of research. All the complexity of reasons and motives has been incorporated into one single parameter – the discount rate. The discounted utility model with constant discounting has gained popularity in theoretical applications due to its mathematical tractability. However, the descriptive ability of the model has been revealed as being far from perfect.

Experimental economics proposed a very simple method to elicit time preference. It asks subjects to state that the payoff that is to be received on a future date is as attractive as receiving a smaller payoff immediately. Application of this method led to generation of a number of anomalies of the discounted utility model which has been readily accepted in this field of research as a robust regularity. However, these regularities have been noted as not being as robust as was previously thought. Moreover, new experiments dealing with the elicitation of discount rates have continued to provide new estimates of discount rates and no progress seems to have been made from this point of view.

In the present chapter I present a list of criticisms that have been made against the experimental elicitation of time preference. I demonstrate that accounting for these issues is not an easy task. However, even adjusting experimental design to meet these critical comments does not seem to improve the situation. Divergent results keep on being produced.

Therefore, I propose to take a different look at the experimental evidence. The approach
is to abstract from the theoretical prescriptive models and try to imagine how subjects may address the problem they are faced with in experiments. This exercise led to the development of a descriptive model that explains subjects’ choice in experiments. This model provides a general explanation to the contrary experimental evidence.

In the following chapters of this dissertation I consider in more detail some aspects of this model. In particular, choice task will be confronted with a matching task and decision rules that are evoked with each elicitation task will be derived.
Chapter 3

The effect of representation mode on elicited individual discount rates

3.1 Introduction

The results of experiments on time preference vary enormously between studies (Frederick et al. 2002) although some behavioural regularities emerge. One of the most discussed regularities in the intertemporal choice literature is probably the evidence that the elicited discount rates tend to decrease with the increase in the interval over which the discount rate is elicited. This phenomenon is usually referred to as increasing patience or declining impatience (implying that subjects are very impatient when the immediate future is being considered but are less impatient if faced with a longer time horizon), hyperbolic discounting (implying a particular functional form that this impatience may take), delay or interval effect.

The phenomenon of increasing patience was first reported in Thaler (1981) and was confirmed in a number of subsequent studies (Green et al. 1997; Kirby and Marakovic 1995; among others). This evidence has led to a proliferation of theoretical models in consumer behavior research and
welfare analysis, implementing bias time preferences, usually in the form of quasi-hyperbolic
dISCOUNTING (Laibson, 1997).

Despite the numerous experimental studies performed to elicit subjective discount rates most
suffer from serious methodological problems. One the most difficult tasks in time preference
experiments is connected to the use of real incentives to provide correct incentives to the partic-
ipants in these studies. The earliest studies as well as most of the studies that elicit preferences
over significant amounts of money, adopted the hypothetical payoffs structure. This, of course,
raises doubts about the validity and robustness of the results for real incentives. Another prob-
lem connected with incentives is that most of the studies that report bias, strong preference
for outcomes in the immediate present compared to even slightly delayed future outcomes, ask
subjects to choose between immediately available money outcomes and outcomes available at
some time in the future. This choice apart from real time preference, carries uncertainty for the
subject as to whether the later amount of money will be received (whether the experimenter can
be trusted in the future) and on transaction costs (subjects need to come back to the laboratory
at a later date to receive this later payment). Thus, Harrison and Lau (2005) suggest that to
eliminate this uncertainty and make the alternatives comparable, on the same scale, the soonest
available option should also be delayed, thus stressing the need to use front-end-delay (FED).
Moreover, according to this study these two features alone, real incentives and FED, generate
evidence of hyperbolic discounting in the data. To support this idea, Harrison and Lau provide
an example of a study, a large scale field experiment conducted by Harrison et al. (2002), that
accounts for these factors and finds strong support for exponential discounting.

Another problem in time preference research that has received much less attention in literature
is that in these experiments subjects are asked to choose between or state their evaluation of a
missing amount in a given couple (matching task) over alternatives expressed in nominal terms.
From these choices the subjective discount rate is calculated. Thaler (1981) expressed some
concern about the fact that human subjects may not be able to calculate the corresponding
discount rates when faced with nominal amounts and that this can lead to what is called linear
bias, underestimation of the exponential trend that leads to observation of non-exponential
discounting. However, these concerns were dismissed by the author on the grounds that this
bias would only affect choice over very long horizons of discount rate elicitation, for example 10
years.

Coller and Williams (1999) raised concerns about the fact that subjects faced with only nominal representation of alternatives in choice, in a laboratory environment, will not be able to confront them with the opportunities they face in the field, where the more usual representation is in terms of interest rate. Their experimental design introduced treatments where subjects with nominal representation of options were given information on the associated interest rate corresponding to each alternative. They used a variation of choice task, a multiple price list (later referred to as MPL) format, where to estimate individual discount rates they confronted subjects with a list of choices between two options. The sooner smaller amount of the option was fixed at a given level and a given delay, while the later larger one varied in increasing order. Subjects were expected to choose sooner smaller option for some alternatives and then switch their preference to the later larger option. The individual discount rate is considered to lie in the interval in which the switch from sooner to the later option occurs. Coller and Williams (1999) find that discount rates elicited in this way without FED are higher than those elicited with FED, although the difference is small. Introducing information on the corresponding interest rate reduces the elicited discount rates.

Read et al. (2006) apply a similar MPL elicitation procedure and explore the influence of representation of options in only nominal, nominal with corresponding interest rate and only interest rate terms. They find that for only interest rate representation (later referred to as “only-%”) the median discount rate is close to the market interest rate and lies in the range of 7.5%, for nominal and interest rate (“$+%”) the median discount rate about 10-12.5% and for only nominal representation (“only-$”) it comprised between 25%.

This elicitation procedure, MPL with FED and real incentives, with slightly modified payoff table was used in several studies, i.e. (Harrison et al. 2002; Harrison et al. 2006; Read et al. 2006). All of these studies report that the average/median discount rate is constant for intervals from 6 to 24 months. Although Harrison et al. (2002) base their study on Coller and Williams’s (1999) design they observe a slightly different average discount rate. This discrepancy is explained by the different subject pools used in the studies: while the first was based on a representative sample of the Danish population, the second was based on a sample of college students. An interesting observation applying to all the studies using MPL is that in almost all
we observe an average discount rate that is located around the middle position of the list that subjects were presented with. Thus, in Coller and Williams (1999), the elicited average discount rates range from position 9 to 13 out of 15, for Harrison et al. (2002) it is located between positions 11 and 12 out of 20, in Read et al. (2006) the average discount rate for only nominal representation corresponds to position 10-11 out of 20.

This observation suggests that the table representation of MPL choice task may attract subjects’ choices to the middle of the list of alternatives over which the preferences are elicited fixing the preferences around this point and thus producing evidence of constant discount rate. This bias is known in experimental psychology as response contraction bias (Poulton, 1989). Many experiments demonstrate that when subjects are uncertain about the response to a given stimulus they will tend to choose close to the reference point. In the case of a list of magnitudes a focal reference point is the middle of this list. This leads to a symmetric distribution of responses with the average response positioned in the proximity of the provided magnitude scale. Andersen et al. (2004) recognize the possibility of this bias but they believe that with econometric procedures it is easy to account for it.

The present study was designed to establish whether choice task in MPL format presented as a table is subject to the response contraction bias or middle table effect which can explain the stability of discount rates over different intervals reported in studies discussed above. The next section builds the experimental design based on the literature referred to.

### 3.2 Experimental design

The experiment in the present study originated as a pilot experiment, aimed at testing whether preferences elicited in the table format of MPL choice task are affected by the response contraction bias. We are interested here in whether every representation of alternatives, if any, i.e. “only-$$”, “$$+$$%” and “only $$%” , will be affected equally by this bias. Given the exploratory nature of the study we preferred to conduct it over a single time interval, focusing on the effects of different elicitation modes.

Experimental procedures were developed based on Harrison et al. (2002), and to enable
comparison of our results with existing studies, we followed this study as closely as possible.

The subjects were given a task presented in the following way:

"One person in this room will be randomly selected to receive a considerable amount of money. If you are the person selected (Assignee) you could be paid according to two possible options of payment: option A and option B. If you choose option B you will receive a sum of money in 8 months from today. If you choose option A you will receive the sum of money in 1 month from today, but this option A will pay smaller amount of money than option B”.

The table format of this task consisted of choosing between option A and option B for every one of 20 alternatives presented at the same time (see Table 3.1). This was compared to the situation where subjects were presented with alternatives given in the MPL task presented in random order, one alternative at a time (RA format). For between and within subject comparisons half of subject group was presented first with table task followed by the RA task while the other half was faced with the opposite ordering of tasks.

To present a task with a significant stake in the game, the amount on which the choice was based was fixed at €400.00 for the first task and €390.00 for the second.

If the table format is affected by the bias then for that format the distribution of responses should be symmetric and centred around the middle of the proposed list. At the same time the RA task should not be affected by this bias since subjects cannot know the middle of the response scale at the moment when they make their decision on the single alternatives, presented in random order.

Hypothesis 1: Discount rates elicited in table format will be distributed symmetrically around the middle of the payoff table. In contrast, discount rates elicited in RA format will not present this tendency.

Andersen et al. (2004) consider the RA format representation as an alternative to the table format adapted in the study but they find it less applicable since it requires a significant cognitive

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1Experimental instructions are presented in Appendix A.1.
2For most students it is an average amount of monthly pocket cash. This amount is close to the one over which the discount rates were elicited in the study by Harrison et al. (2002) and is exactly the same as in Read et al. (2006). All other procedures are the same as in Harrison et al. (2002) except for differences in the tasks and their order.
3The intention was to make the amounts different enough to make subjects seriously consider the task without wondering if the second task was a control for the first. At the same time the amounts on the task needed to be similar enough to avoid the magnitude effect (Green et al (1997)).
<table>
<thead>
<tr>
<th>Alternative</th>
<th>First task</th>
<th>Corresponding annual interest rate</th>
<th>Second task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option A: payment in 1 month (June, 25th)</td>
<td>Option B: payment in 8 months (January, 26th)</td>
<td>Option A: payment in 1 month (June, 25th)</td>
<td>Option B: payment in 8 months (January, 26th)</td>
</tr>
<tr>
<td>1</td>
<td>€400</td>
<td>€406</td>
<td>2.5%</td>
</tr>
<tr>
<td>2</td>
<td>€400</td>
<td>€412</td>
<td>5.0%</td>
</tr>
<tr>
<td>3</td>
<td>€400</td>
<td>€418</td>
<td>7.5%</td>
</tr>
<tr>
<td>4</td>
<td>€400</td>
<td>€423</td>
<td>10.0%</td>
</tr>
<tr>
<td>5</td>
<td>€400</td>
<td>€429</td>
<td>12.5%</td>
</tr>
<tr>
<td>6</td>
<td>€400</td>
<td>€435</td>
<td>15.0%</td>
</tr>
<tr>
<td>7</td>
<td>€400</td>
<td>€441</td>
<td>17.5%</td>
</tr>
<tr>
<td>8</td>
<td>€400</td>
<td>€447</td>
<td>20.0%</td>
</tr>
<tr>
<td>9</td>
<td>€400</td>
<td>€453</td>
<td>22.5%</td>
</tr>
<tr>
<td>10</td>
<td>€400</td>
<td>€458</td>
<td>25.0%</td>
</tr>
<tr>
<td>11</td>
<td>€400</td>
<td>€464</td>
<td>27.5%</td>
</tr>
<tr>
<td>12</td>
<td>€400</td>
<td>€470</td>
<td>30.0%</td>
</tr>
<tr>
<td>13</td>
<td>€400</td>
<td>€476</td>
<td>32.5%</td>
</tr>
<tr>
<td>14</td>
<td>€400</td>
<td>€482</td>
<td>35.0%</td>
</tr>
<tr>
<td>15</td>
<td>€400</td>
<td>€488</td>
<td>37.5%</td>
</tr>
<tr>
<td>16</td>
<td>€400</td>
<td>€493</td>
<td>40.0%</td>
</tr>
<tr>
<td>17</td>
<td>€400</td>
<td>€499</td>
<td>42.5%</td>
</tr>
<tr>
<td>18</td>
<td>€400</td>
<td>€505</td>
<td>45.0%</td>
</tr>
<tr>
<td>19</td>
<td>€400</td>
<td>€511</td>
<td>47.5%</td>
</tr>
<tr>
<td>20</td>
<td>€400</td>
<td>€517</td>
<td>50.0%</td>
</tr>
</tbody>
</table>

Table 3.1: Experimental payoffs.
effort from the experimental subjects, which necessarily will lead to a high level of inconsistent responses.

**Hypothesis 1a:** The RA format will generate a significantly higher number of inconsistent responses compared to table format.

To get a good approximation of individual discount rates from the RA format task, which may be distorted by inconsistent responses, subjects were asked to perform a matching task over the same amount as the RA format task. The matching task was performed immediately following the RA format task in all treatments. The matching task requires subjects to estimate the later larger (sooner smaller) value they attach to a given sooner smaller (later larger) reward. It is used as frequently in the experimental literature on time preference as the earlier choice task discussed\(^4\) (Frederick et al. 2002).

The matching task was presented in the following way:

"You are about to receive a sum of money in 1 month from today (25th June 2006), option A. How much would you like to receive in 8 months (26th January 2007), option B, to be indifferent between these two options".

**Hypothesis 1b:** The discount rates elicited through with matching task will be a good approximation of discount rates in RA format.

Finally, to investigate whether different representations of options, i.e. “only $”, “$+\%” and “only \%”, were equally affected by the bias the tasks were presented with these different representations maintaining the same representation in the same treatment.

**Hypothesis 2:** discount rates for “only money condition” (only-$) will be higher than discount rates for “only interest rate condition” (only-%), discount rates for “money and interest rate” condition ($+\%) will be closer to “only-%”\(^5\).

To sum up, the experimental design allows for two orders of tasks, the table task followed by the RA task and matching task, and the RA task followed by matching task and table task.

\(^4\)Various problems with procedural invariance to which I appeal in this case have been reported in other areas of experimental research (Tversky et al. 1988). The massive use of both methods in time preference experiments in the literature and comparatively small differences in elicited discount rates reported in the only two studies that compared these two methods, Albrecht and Weber (1997) and Read and Roelofsma (2003), appear not to create too many problems in this area.

\(^5\)This hypothesis reflects the findings of Read et al. (2006), although in that study the task is framed as a financial investment while the task in the present study is framed as opportunity to receive a significant amount of money.

58
Table 3.2: Experimental design and number of observations per treatment.

<table>
<thead>
<tr>
<th>TABLE-RA-MT</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>Treatment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$</td>
<td>$+%</td>
<td>%</td>
</tr>
<tr>
<td>RA-MT-TABLE</td>
<td>Treatment 4</td>
<td>Treatment 5</td>
<td>Treatment 6</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

The later larger alternatives presented were “only-$”, “$+\%” and “only-%”. The overall design resulted in six experimental treatments, as presented in table 3.2.

### 3.3 Implementation

Ninety-three undergraduate students from the University of Trento participated in the experiment, 73% of them were students in the Faculty of Economics, aged 21-22 years on average, 51% were females. Subjects were randomly assigned to six experimental treatments. Sessions lasted about 45 minutes (including the reading of instructions and a trial session where sweets were used instead of money). Each person was paid €5,00 participation fee and one person in each session was randomly selected to receive the chosen outcome in a randomly selected alternative in the choice task of the experiment.

### 3.4 Results

The results are summarized in Table 3.3 and in Figure 3.1 in a box plot form.

I discuss the results related to Hypotheses 1 and 2 together since the way in which the delayed option was presented appeared to create some regularities in the observed data.

Hypothesis 1 predicted that the discount rates elicited with the table format present a tendency to centre around the middle of the payoff table while RA format representations will be neutral with respect to this bias. From hypothesis 2 it was expected that discount rates elicited with “only %” representation of delayed option would be lower compared to the “only $” representation.

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6 An hour of student work is paid at €8,00.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>TABLE-RA-MT Only-$</th>
<th>TABLE-RA-MT $+%</th>
<th>TABLE-RA-MT Only %</th>
<th>TABLE-RA-MT TABLE Only-$</th>
<th>TABLE-RA-MT TABLE $+%</th>
<th>TABLE-RA-MT Table Only-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>21.35</td>
<td>23.04</td>
<td>20.22</td>
<td>24.42</td>
<td>22.25</td>
<td>28.96</td>
</tr>
<tr>
<td>sd</td>
<td>7.78</td>
<td>9.6</td>
<td>11.38</td>
<td>12.41</td>
<td>10.6</td>
<td>12.58</td>
</tr>
<tr>
<td>median</td>
<td>21.25</td>
<td>21.25</td>
<td>18.75</td>
<td>25</td>
<td>22.5</td>
<td>28.75</td>
</tr>
<tr>
<td>Max*</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Included</td>
<td>13</td>
<td>14</td>
<td>9</td>
<td>16</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Inconsistent**</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>14</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 3.3: Summary statistics for all treatments. Means and medians are based on the middle of the interval of switch. *Number of respondents who always chose the smaller sooner option (€400), excluded from the analysis. ** Number of subjects who switched more than once.
The median discount rates for both table and RA formats are centred around 21.25\%-22.5\% (25\% corresponds to the middle of the table) for representations that include nominal amounts, and their distributions appear quite similar. Centring around the middle of the payoff table confirms Hypothesis 1 for the sessions where subjects were first presented with the table and then the RA task. First choice may fix the preferences of subjects and induce them to make the same choice in the second task. It is puzzling though that discount rates in sessions where subjects were first faced with RA format, then MT task and only afterwards with the table format task appear similar.

First, the subject pool in Read et al. (2006) consists of a representative sample of Internet users who filled in an Internet survey. These subjects needed to use the Internet to reply to this survey and experimenters did not have any control over the information subjects were consulting. Faced with an investment task and the necessity to base their decision upon interest rate it seems plausible that they might check current interest rates on the Internet to provide the answer. The university students in the experimental laboratory did not have access to any additional
information except their memories. Analysis of final questionnaires showed that subjects were not very familiar with opportunities in real life. Secondly, motivated by the framing of the task in investment terms, the subjects in Read et al. (2006) were perhaps more inclined to compare the proposed alternatives to market opportunities, while the subjects in the present experiment were faced with assigning a significant amount of money and might have been guided by other reasons in their choice.

Final questionnaires were analysed to understand the decision processes of subjects in their choices7. The majority of subjects in Treatment 1, who were first faced with the table format, stated that they defined a threshold on the most delayed sum that should be reached to convince them to accept the later option, some mentioned an amount of 欧元450. At the same time, most subjects in Treatment 4 in which they were first faced with the RA format, stated that their choices were based upon the difference between the sooner and later amounts and for many the threshold value of 欧元50 was acceptable. Only one person in each treatment reported an attempt to calculate the interest rate associated with the opportunity, but the interest rate stated on the questionnaire was far lower than the observed choice.

The final questionnaires for subjects in “$+%” treatment reveal that roughly half of the sample did consider in their decision the corresponding interest rate while the other half took account of only a nominal amount, defining the threshold either for the acceptable amount or for the difference that would make them wait for the later alternative. One person explicitly stated that he was ignoring the interest rate in the decision. All subjects that always preferred the soonest option (column “max” in table 3.3) declared that the amounts proposed at a later date were too low, probably their line of reasoning was in nominal terms as well.

Analysis of the reported interest rates used as threshold values by subjects reveals that either they did not know market interest rates and were attracted by some focal numbers such as 15%, 20% or 25% or they did not consider the alternatives as an investment opportunity comparable to the field opportunities. Only one person stated that he took into consideration the option available to him outside of the lab, in fact his discount rates ranged around the market interest rate (5% at the time of the experiment).

Analysis of Figure 3.2 reveals that in Treatment 5, where subjects were faced with alternatives

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7An example of final questionnaire is presented in Appendix A.1.
Figure 3.2: Analysis of discount rates in “$+\%” treatments by the reasoning, dr states for discount rate, mpl for table format, m for nominal reasoning and t for consideration with interest rate.

framed as “$+\%” and RA format was the first task, the reasoning in nominal terms led to discount rates situated around the middle of the table or at the limits of the table. While reasoning in interest rate terms decreases the variance when RA format is presented first.

The responses from subjects faced with “only \%” representation demonstrate that in Treatment 6 the interest rate requested as the threshold to wait for 8 months is much higher, around 40-50\%, compared to the threshold requested by subjects in Treatment 3. It is possible that not knowing which interest rate to choose in Treatment 3, where the table task was presented first, subjects chose the one close to the middle of the table. In the Treatment 6, where RA task was presented first, they had to have a decision rule to face randomly derived alternatives. Few subjects that stated that they tried to consider real life opportunities revealed overestimation of these opportunities.

To conclude, Hypothesis 1 is not confirmed by the behaviour observed in the experiment.
Indirect evidence suggests that another sort of anchoring might be happening in this task. Apparently, subjects faced with nominal representations of alternatives were attracted by some focal amount or a focal increment on the initial amount, and they used these values as a threshold for their choice. In the treatments with “$+\%” representation, only half of the subjects declared that they had considered the corresponding interest rate in their decisions while the other half considered nominal amounts. It is curious that discount rates for subjects in Treatment 3 (“only %” condition, table task is first) are lower than the corresponding discount rates in Treatment 6 (same condition, RA task presented first).

Hypothesis 1a predicted high level of inconsistent responses associated with the RA format, and this appeared to be born out, see Table 3.3. However, these inconsistent responses seem to be simple mistakes and the discount rates of the subject can be easily estimated. Most of the “mistakes” occurred in Treatment 4 where subjects were first faced with the RA format in “only $” condition. Apparently it is difficult for subjects to remember, recognize or construct the threshold value when the alternatives are presented one at a time and in random order and there is no other helpful information available (associated interest rate). At the same time, the table format following the RA format did not lead to inconsistent responses.

The matching task was performed to approximate the discount rates in the RA format. Table 3.3 and Figure 3.1 show that contrary to hypothesis 1b, discount rates elicited by matching task are much higher than those elicited by choice task. Moreover, it can be seen from Table 3.1 and Figure 3.1 that the matching amounts reported by subjects on this task were all available in the choice task for most treatments, and especially for treatments where the table task was first. It is puzzling that subjects when asked to choose from a list of alternatives choose a lower amount than the one they evaluate as indifferent to the same initial amount in the choice task. It is possible that in Treatments 1-3 where the matching task was the last task in the experiment, subjects realized that they had forgone opportunities and tried to retrieve the situation. However, this does not explain why in Treatments 4-6 where the matching task preceded the table format task, subjects after reporting larger amounts on the matching task, continued to choose lower amounts in the table task. The choices in the table task are of the same magnitude as in the first RA task even when the amounts reported in MT task were available. It is worth noting that the amounts reported on MT in Treatments 1-3 (TABLE-RA-MT) are lower than those observed.
for Treatments 4-6. Accepting anchoring and adjustment heuristics (Tversky and Kahneman 1974) as the explanation for the decision process in the matching task we might assume that for subjects faced with the MPL payoff table, it was clear that the highest amount on the list was the highest reasonable amount to ask for. Then, asked to estimate a value that subjects did not know they anchored their decision to this highest possible value. Instead, when presented with one alternative at time randomly, it was difficult to remember what was the highest amount in the list, especially as they were looking at the difference between the amounts and not the delayed amount as a whole. In this case subjects needed to arrive at a reasonable evaluation. It is somewhat surprising that the amount stated on the MT was not used as an anchor in the consequent table format task. It suggests that different heuristics were evoked by these different elicitation modes. These different heuristics lead to different observable results.

Figure 3.2 suggests that subjects who use nominal amounts as choice criteria may ask for higher sums on matching task compared to subjects that are guided in their choice by the normative principle of interest rates. Subjects who always chose the sooner option in the choice task (column max in Table 3.3) stated values on MT higher than those obtainable in both choice tasks, confirming their higher discount rates.

The next section discusses the results from the experiment and their implications for research on time preference.

### 3.5 Discussion

This section presents the results obtained in this study and discusses their implications for future research.

Although the present study was conducted with a student population which is generally believed to produce higher discount rates (Harrison et al. 2002), the discount rates on treatments with nominal representations (Treatments 1, 2, 4 and 5) observed in this study were lower than the discount rates reported for the corresponding condition in comparable studies. Thus, Harrison et al. (2002) find an average of 34% for a representative sample of the Danish population, while Read et al. (2006) report a median of 25% for a Spanish Internet users sample. While in the present study the discount rates were elicited over seven months the elicitation period in
the studies above was only six months. A legitimate question then is whether these results are
driven by hyperbolic discounting. At the same time, Coller and Williams (1999) conducted their
study of a population of students over a shorter time period, three months, and report even lower
discount rates for similar conditions: medians are in the range of 17%-20% for “$+%” condition
and 25%-30% for “only $” condition (these lower discount rates elicited over student population
were puzzling to Harrison et al. (2002).

It should be noted that while in the list of alternatives in the present study the thresholds of
€450 or €50 increments discussed in the section above correspond to the discount rate of 21.25%
for seven months of delay\(^8\) in the table in Read et al. (2006) using a six month delay this amount
corresponds to the interval between 25% and 27.5%, exactly the median of choices reported in
that study for the “only $” condition\(^9\).

If we adapt the table in Harrison et al. (2002) using the same constant increments of as-
sociated interest rate but using a different currency, this leads to the average discount rate
reported for the 6 months delay of 34% corresponding to the choice that lies between 3500DKK
and 3550DKK- another focal amount. The increments in the list of alternatives in Coller and
Williams (1999) are not constant, they range from 2% to 100% of the interest rate over 15
positions. In this study the thresholds chosen by the median subjects were of $15 or $30 corre-
sponding to 10th and 12th positions respectively. It is possible that the subjects in that study
would have chosen even larger increments, say $50, but this would make their choices very close
to the limit of the table, a situation that probably is unacceptable psychologically (Poulton,
1989).

The “threshold increment” over the initial amount strategy of decision making in the exper-
iments on time preference involving choice may be a possible explanation for the evidence of
hyperbolic discounting. A typical experiment on time preference presents subjects with sooner
smaller (larger later) amount fixed at a given delay and will elicit preferences between the fixed
amount and varied amounts over varied time intervals from the fixed one (Green et al., 1997;

\(^{8}\) This choice was forced by the vicinity of the later date to Christmas holidays that could have affected subjects choices.

\(^{9}\) Read et al. (2006) report the minimum interval where the switch occurs implying that the real discount rate lies in the interval between the reported discount rate +2.5%.
Kirby and Marakovic, 1995). Normally this elicitation is done within each time interval presenting the time intervals in increasing or decreasing order. This method of elicitation can induce a choice strategy that considers constant increments proportional to the length of the interval that varies. Thus, evidence of hyperbolic discounting is generated. Suppose a subject chooses increment $\Delta_i$, so that $x_{it} = x_0 + \Delta_i t$ is preferred over $x_0$ delayed by time $t$, then the discount factor for this choice is

$$\partial_{it} = \frac{x_0}{x_{it}} = \frac{x_0}{x_0 + \Delta_i t},$$

Put $k_i = \frac{\Delta_i}{x_0}$, then

$$\partial_{it} = \frac{1}{1 + k_i} = \frac{x_0}{x_0 + \Delta_i t},$$

where $k$ is the hyperbolic parameter.

While definition of the increment that induces the subject to wait for the later amount explains behaviour observed in choice this heuristic does not account for the differences observed in the choice and matching tasks. Although differences in the choice and matching tasks were observed in the previous literature on time discounting (Albrecht and Weber, 1997; Read and Roelofsma, 2003) the causes of these differences have not been explored. They are related to a widely studied phenomenon in choice in the risk literature on preference reversal. That is the tendency to choose the high probability low payoff bet (H bet) over a low probability high payoff bet (L bet) of the same expected value, choice task, but assign higher value to the L bet compared to H bet, matching task (Lichtenstein and Slovic, 1971). Grether and Plott (1979) observe that subjects tend to choose H bets with the same frequency even after exposure to a matching task where they have assigned a higher value to the low probability high payoff bet. This evidence is even stronger in relation to real payoffs. This observation mirrors the result of the present study. Tversky et al. (1990) report an experiment that explores preference reversal in time preference. Similar to risky choice, they find that the sooner smaller alternative is chosen over the larger later one, but the later larger option is given higher evaluation in the matching task. As to the origins of this reversal the hypothesis of overpricing of later larger option is confirmed by data. Therefore, they attribute preference reversal to the fact that payoffs are weighted more heavily.
in pricing than in choice (Tversky et al., 1988).

The present experiment was not designed to try to account for these differences. Also, the previous discussion of the strategies implemented in decision making suggests that subjects may use different heuristics in their decision processes when faced with these two tasks. The essence of the choice task is to choose between two options, thus, it attracts attention to the differences among the available options, leading to a choice based upon these differences. The matching task instead requires subjects to provide an evaluation of a missing amount given the other matching amount and delays to both. Although these tasks are equal normatively, the matching task focuses on the option for which the amount should be stated, and on the amount being stated. Thus, subjects need to “create” some amount and the easiest way to do this is to anchor it to some prominent sum.

Exposure to the table format before the matching task apparently creates a strong anchoring effect. The table format explicitly states the limits on the amounts acceptable by the experimenter, and thus viewed as reasonable by subjects. The amounts stated by subjects that were first exposed to the table format results are similar and are all included in the range of the presented table (Figure 3.1). At the same time, even if the RA format suggests possible amounts, the randomness of the presentation makes it difficult to remember the range of the amounts presented in the RA format. Also, sums such as €500 or €450 are easy to remember. Hence, some subjects in Treatments 4 and 5 probably remembered these values and opted for them. Others evidently used different procedures. At the same time, not being faced with a later larger amount in nominal terms, the subjects in Treatment 6 (only - %) assigned much higher evaluations compared to other treatments.

It seems that acceptable differences chosen in a choice task are smaller than the focal amounts for the same option in a matching task. It is not clear how the discount rates elicited with the matching task would behave compared to the discount rates elicited with the choice task when more than one time interval is considered. Matching task may be subject to sequential response contraction bias (Poulton, 1989), meaning that consequent responses are too firmly anchored to the first given response in the task. Discounting elicited in this way will present evidence of a strong present bias with very high discount rates for the immediate intervals and a consequent rapid decline in discount rates over time. Thus, discount rates elicited by a choice task compared
to those elicited by a matching task will present a smoother decline with time corresponding to the hyperbolic function. Matching task results are better described by quasi-hyperbolic discounting (Laibson, 1997) or present bias in the form of a one time premium for delay (Shelley and Omer, 1996).

3.6 Conclusions

The aim of the present study was to check whether the dynamic consistency observed in several studies implementing the elicitation procedure, MPL choice task in table format, is generated by this specific elicitation procedure. We suspected that the task expressed in table format might cause response contraction bias (or middle table effect), and by “fixing” the choice around the middle of the list of alternatives from which the choice is actually made, leads to observed constant discount rates. An experiment was developed to explore this possibility. The results of the experiment do not confirm the original hypothesis of choice being driven by the middle table effect. A particular decisional structure emerged from the analysis of final questionnaires that explains the decisions made in this particular choice task through definition of the threshold value of the increment expected on the initial value. Thus, subjects making their choices are looking at the difference between the initial and later amounts and, if this difference reaches a given value, they will choose the later amount. Applying this decisional structure to more than one temporal interval leads to the emergence of hyperbolic discounting evidence.

While this decisional structure seems to explain the choices observed in the experiment it does not enable a final conclusion on the middle table effect given the particular structure of the list of alternatives adapted in this study: the amount of increment that most subjects were attracted to was the option in the middle of the list. Further investigation is needed to distinguish between these explanations. At the same time, decisions made in the matching task differed widely from the choices observed in the choice task, with higher discount rates reported for the matching task compared to the choice task. Although some differences between the two elicitation methods have been identified in the experimental literature on time preference, this is the first study that permits the formulation of a hypothesis on the origins of these differences. It seems that in the matching task, subjects constructed the value of the later amount by anchoring on some focal
entity. Thus, in the case of treatments in which the limits on possible nominal values were clearly observed in the choice task, these values were often restated in matching task whereas in the treatments where the only information about the later amount was the corresponding interest rate the evaluations in matching task were higher and present higher variance. The decision rule based on anchoring if applied to several time intervals in the context of the matching task, is prone to sequential contraction bias (Poulton, 1989) and leads to evidence that can be described by a quasi-hyperbolic discount function. However, further research is needed into the decision rule applied in matching task and how it differs from choice task in time preference context.

The discussion above suggests that the subjects in the present experiment did not base their decision on well-defined preferences but rather constructed their decisions based on the information available to them during the experiment. These considerations pose serious doubts on the methodology used in experimental research on time preference. It is not clear what is really being measured in these experiments and how seriously the results obtained should be taken. The policy implications of these findings need to be should be seriously considered. It is important to understand whether individuals in everyday life apply decision rules based on the context of decision. If they do so, future policy advice should take into consideration the particularity of the decisional context in which the policy is applied. The present study was not designed to deal with the questions raised in the discussion although it points to some interesting avenues for future research. Further studies are needed to address the issues raised here in a complete and consistent manner. Instead of newer and fancier econometric estimates of discount rates we need to address the question of what we are measuring, and how. If the conjectures made in the present paper are confirmed by further research they will probably explain the variability in the results obtained in the research area of intertemporal choice, and the lack of methodological progress stressed by Frederick et al. (2002).
Chapter 4

The construction of time preference: The role of elicitation methods

4.1 Introduction

Experimental research in time preference, unlike any other area of the experimental literature, is characterized by high heterogeneity of results and little methodological progress (Frederick et al., 2002). Despite the numerous studies on the topic, new studies tend only to discover new anomalies and do not account for existing ones.

Recent research in intertemporal choice is seeking explanations for these problems in the theoretical assumptions that are traditionally made in elicitation of time preference (Frederick et al., 2002, Read, 2004). The assumption of a linear utility function associated with monetary payoffs is assigned a particular role in this treatment. This assumption is a necessary condition for identification of the discount rate in studies dealing with the elicitation of time preference. Joint estimation of risk and time preference leads to estimation of lower, almost at the level of market interest rate, discount rates (Andersen et al., 2008). Nevertheless, this estimation
method does not explain the variability in discount rates observed in the literature given that all studies use the same estimation technique and therefore should lead to the same results, nor does it provide information on the true form of discount function.

Another major stream of research is concerned with methodological issues related to experimental elicitation of discount rates. Coller and Williams (1999) introduced a representation of alternatives with an indication of corresponding interest rates, and conducted a study on the effect of real payments in the elicitation of time preferences in the choice task. According to Harrison and Lau (2005) these two features help to eliminate evidence of hyperbolic discounting from data.

However, Manzini et al. (2008) comparing alternative incentive mechanisms that permit implementation of real payoffs in elicitation of time preference, observe evidence of hyperbolic discounting in all three of the elicitation procedures in this study. Moreover, they demonstrate that discount rates elicited using different elicitation method differ in magnitude even when the rest of experimental procedure is kept constant. In particular, discount rates elicited with choice task appear to be higher than discount rates elicited with matching task. The same conclusion was reached by Read and Roelofsma (2003) in their study of hypothetical payoffs.

Choice task and matching task are the most widely used elicitation methods in experimental treatments of time preference (Frederick et al., 2002). Choice task requires subjects to choose between two alternative options. One provides a smaller payoff but is available at an earlier time, while the other is larger but is available for payment at a later date. One single choice task poses limits on the individual discount rate: if the sooner smaller option is chosen the subject’s discount rate is larger than discount rate associated to the two options of choice. To obtain a better estimate of the discount rate in the choice task, subjects are faced with a series of questions similar to those described above. Usually the payoff associated with the sooner smaller (or later larger) option is kept constant while the other varies. This elicitation mode is described as multiple price list (MPL) format (Coller and Williams, 1999). Subjects are expected to choose sooner smaller option for some values of the option that is changing, and switch their choice to later larger option after reaching this value. The elicited discount rate is located in the interval of values where the switch occurs.

The matching task places subjects in similar situations – two alternative payment options
available at different dates. In this task, however, one of the payoff values is missing and subjects are asked to indicate a value that would provide them with the same satisfaction as a given option. In this task, one question in the matching task mode of elicitation provides the subject with an estimate of the discount rate.

Although the choice task and matching task are different from the point of view of experimental procedures, it can be demonstrated that they provide the same incentive structure to reveal true preferences in an experimental setting (Manzini et al., 2008). Nevertheless. Their implementation leads to divergent results as mentioned earlier. The variety of elicitation methods implemented in time preference research suggests that a possible explanation of observed diversity of discount rates can be found in the elicitation methods implemented by these studies.

Comparative analysis of discount rates among studies in the experimental literature on time preference is difficult due to the large variability across studies, in experimental procedures and design features: incentive structure, amounts of elicitations, elicitation intervals, subject pools are among the factors that vary. Meanwhile, existing studies that document the differences ascribable to these elicitation methods were not designed to study these aspects; therefore, they do not provide enough evidence to reach conclusions.

The present study was designed explicitly to address discrepancies between elicitation tasks widely used in time preference research and how these differences influence conclusions on the form of the discounting function. This paper is organized as follows: the next section presents results of Experiment I developed to explore differences between alternative elicitation methods and heuristics that subjects adopt in dealing with them; the following section discusses the results of Experiment II, which investigates the implications of differences between single elicitation methods on the form of corresponding discounting function; the next section demonstrates that the results from Experiments I and II conform to the evidence in the literature on similar elicitation tasks and demonstrates that decisional rules reported by subjects in experiments lead to the construction of rather different discounting functions ranging from exponential to quasi-hyperbolic discounting. A final section concludes.
4.2 Experiment I

4.2.1 Experimental design

Experiment I was designed to address differences in the discount rates elicited using alternative elicitation tasks. Two main elicitation tasks, matching task and choice task, are analysed. Existing studies that compare the results elicited by the choice and matching tasks in the time preference literature do not reach a consensus on the direction of this relationship. Albrecht and Weber (1997), Read and Roelofsma (2003) and Manzini et al. (2008) find that implementation of a choice task leads to higher discount rates while in Chapter 3 I observe that discount rates elicited with a choice task are lower than the discount rates elicited with a matching task. Although both Manzini et al. (2008) and Chapter 3 consider choice task and matching task there are considerable differences in the structure of the tasks in these studies\(^1\). Both studies present their subjects with choice task in MPL format although construction of the alternatives in a list differed in a significant way.

The MPL choice task in Manzini et al. (2008) was constructed starting from a fixed value of the later larger option for all alternatives on the list. Values corresponding to sooner smaller options instead decreased by regular nominal amounts with each alternative departing from the fixed later larger value and reaching the value of 0. Subjects are asked to choose option A or option B in list of alternatives in which option A corresponds to $100 while option B to $100-x, the value of x increases for each successive alternative on the list. Constructed in this way, the MPL choice task maintains the same nominal values for all elicitation intervals for a given amount of elicitation. I will refer to this elicitation structure as nominal MPL format of choice task (or $-MPL) to underline the fixed nominal structure of alternatives. $-MPL choice task is widely used in elicitation of time preference (Pender, 1996; Green et al., 1997; Tanaka et al., 2007; Slonim et al. 2007, among others) Studies that implement this elicitation structure report evidence compatible with hyperbolic discounting.

The choice task implemented in Chapter 3 is based on the MPL method developed in Coller and Williams (1999). In this representation MPL confronts subjects with a list of alternatives

\(^1\)Albrecht and Weber (1997) as well as Read and Roelofsma (2003) did not consider elicitation of time preference in traditional way therefore I skip discussion of particularities associated with these two studies here.
for which the sooner smaller options are kept the same. The later larger option is calculated as
the return on the given initial value of the sooner smaller option corresponding to the interval
of elicitation. In this case the experimenter chooses the range of interest rates, annual returns,
to be considered in the study. Subjects are asked to choose between $100 and $100+x where x
corresponds to the annual return on $100 calculated over given period of elicitation. Contrary to
$-MPL this method presents subjects with alternatives in which nominal values change with the
increase in the period of elicitation. I refer to this structure of choice task as MPL choice task
with interest rate structure (or %-MPL) to emphasize that the nominal values corresponding to
alternatives of choice depend on the range of interest rates chosen by the researcher. The %-MPL
choice task has received wide acceptance in experimental treatments of time preference (Harrison
et al., 2002, Andersen et al., 2008, Dohmen et al., 2007, Bolteelho et al., 2006, etc.). Probably
not the least important factor in its popularity is that studies implementing this elicitation task
show lower and more stable discount rates (Andersen et al., 2006).

Given that studies implementing $-MPL choice task report hyperbolic evidence while studies
that use %-MPL choice task elicit stable discount rates, it is possible that differences associated
with the structure of the elicitation table lead to elicitation of qualitatively and quantitatively
different discount rates. For instance, discount rates elicited in Manzini et al. (2008) with the $-
MPL choice task are higher than the discount rates elicited in Chapter 3 with %-MPL elicitation
procedure: median discount rates in the first case vary between 124% and 514% while in the
second study they reach maximum of 30%. This discrepancy may explain the reversal in the
relation observed between matching task and choice task in these two studies. Experiment I
compares discount rates elicited with the help of %-MPL and $-MPL choice tasks.

Hypothesis 1a: Discount rates elicited with the %-MPL choice task will be lower than
discount rates elicited with the $-MPL choice task.

$-MPL is usually presented in a “speed-up” payoff frame, i.e. the later larger amount is given
and the experimenter has to find the sooner smaller amount that provides the subject with the
same satisfaction. Meanwhile the %-MPL choice task is constructed in “delay” payoff frame since
the subject is faced with a sooner smaller option and the goal of the elicitation is to find the
responding later larger value that provides the same satisfaction. Accordingly, there is a need
to balance the $-MPL choice task with a matching task in “speed-up” frame, as in Manzini et al.
Hypothesis 1b: The discount rate elicited with %-MPL format will be higher than that elicited with matching task delay receipt frame.

Hypothesis 1c: The discount rates elicited with $-MPL format will be higher than those elicited with matching task in speed-up receipt frame.

The delay–speed-up effect, lower discount rates elicited in speed-up frame compared to discount rates elicited in delay frame, is standard evidence in time preference research (Loewenstein, 1989). Although Hypothesis 1a predicts the opposite effect for the choice task it is expected that the matching task will confirm the standard evidence that the delay–speed up effect is observed with implementation of the matching task (Benzion et al., 1989; Benhabib et al., 2006; etc.).

Hypothesis 1d: Discount rates elicited with MT in the delay scenario will be higher than those elicited with the anticipating scenario.

Representation of the %-MPL choice task introduced by Coller and Williams (1999) and adopted by numerous other studies includes an indication corresponding to each alternative of the choice interest rate. There is no evidence of the effect of reporting on subjects’ corresponding interest rates in other elicitation methods. Although interest rate representation has been demonstrated to be an important design feature in elicitation of time preference (Read et al., 2005) we preferred here to present subjects only with nominal values associated with alternatives of choice to enable comparison of results among the considered elicitation methods and based on the existing evidence.

Implementation of real incentives and presentation of sooner smaller alternatives with frontend delay (FED) are considered by Harrison and Lau (2005) to be decisive features that lead to hyperbolic discounting evidence in time. Although these two design features are relatively new to experimental research in time preference, vast evidence on their implementation has been accumulated. Contrary to interest rate representation, design of Experiment I includes both real incentives and FED.

While implementation of real incentives in choice task results in a straightforward choice task – subjects are informed that they will be paid the option they choose- real incentives in the matching task are not so easy. There are two incentive mechanisms that can be applied to
Table 4.1: Experimental treatments, Experiment I.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Order of tasks</th>
<th>Number of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment I</td>
<td>$MT_{Delay} - % - MPL$</td>
<td>20</td>
</tr>
<tr>
<td>Treatment Ia</td>
<td>$% - MPL - MT_{Delay}$</td>
<td>20</td>
</tr>
<tr>
<td>Treatment II</td>
<td>$MT_{Speed-up} - $ - MPL$</td>
<td>16</td>
</tr>
</tbody>
</table>

matching tasks to make them incentive compatible: Becker-De Groot-Marshak (BDM) mechanism (Becker et al., 1964) and auctions (Kirby and Marakovic, 1995). Both mechanisms lead to similar results (Manzini et al., 2008). However, the BDM mechanism is relatively easier to implement from an experimental point of view. It was decided to implement BDM procedure to matching task.

4.2.2 Experimental procedures

Experiment I consists of the three treatments presented in Table 4.1. Each treatment includes choice task and matching task in the same frame. Treatments I and Ia address choice task in %-MPL format and matching task in delay frame and differ in terms of the order of presentation of the choice and matching tasks. Treatment II involves the $-MPL choice task and matching task in speed-up frame.

Experimental procedures were based on Harrison et al. (2002). Subjects were presented with a task in the following way:

“One person in this room will be randomly selected to receive a considerable amount of money. If you are the person selected (Assignee) you could be paid according to two possible options of payment: option A and option B. If you choose option B you will receive a sum of money in 8 months from today. If you choose option A you will receive the sum of money in 1 month from today, but this option A will pay smaller amount of money than option B”.

Experiment I was developed to examine elicitation methods rather than discounting functions, therefore it was decided to consider only one elicitation interval corresponding to six months. This interval, which is frequently used in studies on time preference, is sufficiently long for the

\footnote{BDM is based on individual choice while auction implies participation of more than one subject leading to the need for more complicated experimental software and procedures.}

\footnote{Experimental instructions are presented in Appendix A.2 and A.3.}
<table>
<thead>
<tr>
<th>Alternative</th>
<th>Option A</th>
<th>Option B</th>
<th>Associated interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Pays in 2 months)</td>
<td>(Pays in 8 months)</td>
<td>(Pays in 1 year and 2 months)</td>
</tr>
<tr>
<td>1</td>
<td>€400</td>
<td>€405</td>
<td>€410</td>
</tr>
<tr>
<td>2</td>
<td>€400</td>
<td>€410</td>
<td>€420</td>
</tr>
<tr>
<td>3</td>
<td>€400</td>
<td>€415</td>
<td>€431</td>
</tr>
<tr>
<td>4</td>
<td>€400</td>
<td>€420</td>
<td>€442</td>
</tr>
<tr>
<td>5</td>
<td>€400</td>
<td>€425</td>
<td>€452</td>
</tr>
<tr>
<td>6</td>
<td>€400</td>
<td>€431</td>
<td>€463</td>
</tr>
<tr>
<td>7</td>
<td>€400</td>
<td>€436</td>
<td>€475</td>
</tr>
<tr>
<td>8</td>
<td>€400</td>
<td>€441</td>
<td>€486</td>
</tr>
<tr>
<td>9</td>
<td>€400</td>
<td>€446</td>
<td>€498</td>
</tr>
<tr>
<td>10</td>
<td>€400</td>
<td>€452</td>
<td>€510</td>
</tr>
<tr>
<td>11</td>
<td>€400</td>
<td>€457</td>
<td>€522</td>
</tr>
<tr>
<td>12</td>
<td>€400</td>
<td>€462</td>
<td>€534</td>
</tr>
<tr>
<td>13</td>
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<td>€468</td>
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<td>€400</td>
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<td>€586</td>
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<td>17</td>
<td>€400</td>
<td>€490</td>
<td>€599</td>
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<tr>
<td>18</td>
<td>€400</td>
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<td>€613</td>
</tr>
<tr>
<td>19</td>
<td>€400</td>
<td>€501</td>
<td>€627</td>
</tr>
<tr>
<td>20</td>
<td>€400</td>
<td>€506</td>
<td>€641</td>
</tr>
</tbody>
</table>

Table 4.2: Experimental payoffs, Experiment I and II, %-MPL elicitation table.

Student subjects’ pool. FED was fixed at two months.

The amount elicited was fixed at €400. This amount is of significant magnitude for students\(^4\).

For the %-MPL choice tasks subjects were presented with the alternatives presented in Table 4.2. This table was constructed using values from Harrison et al. (2002). For the $-MPL choice task subjects were given with alternatives presented in Table 4.3. Poulton (1989) suggests that presentation of alternatives in the form of a table can lead to attraction of subjects’ choice to the middle table position. To avoid this effect in the present experiments alternatives corresponding to the choice task were presented to subjects one at a time in random order.

The matching task in the delay frame was presented in the following way:

“You are about to receive a sum of money in 2 months from today, option A. How much

\(^4\) Corresponds to the maximum monthly payment that undergraduate students can receive as a scholarship based on their income and merit while tuition fees amount to €1500 annually.

78
<table>
<thead>
<tr>
<th>Alternative</th>
<th>Option A (pays in 2 months)</th>
<th>Option B (Pays in 8 months)</th>
<th>Associated interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 months</td>
<td>1 year</td>
<td>3 years</td>
</tr>
<tr>
<td>1</td>
<td>€380</td>
<td>€400</td>
<td>10 %</td>
</tr>
<tr>
<td>2</td>
<td>€360</td>
<td>€400</td>
<td>21 %</td>
</tr>
<tr>
<td>3</td>
<td>€340</td>
<td>€400</td>
<td>33 %</td>
</tr>
<tr>
<td>4</td>
<td>€320</td>
<td>€400</td>
<td>45 %</td>
</tr>
<tr>
<td>5</td>
<td>€300</td>
<td>€400</td>
<td>59 %</td>
</tr>
<tr>
<td>6</td>
<td>€280</td>
<td>€400</td>
<td>73 %</td>
</tr>
<tr>
<td>7</td>
<td>€260</td>
<td>€400</td>
<td>89 %</td>
</tr>
<tr>
<td>8</td>
<td>€240</td>
<td>€400</td>
<td>107 %</td>
</tr>
<tr>
<td>9</td>
<td>€220</td>
<td>€400</td>
<td>126 %</td>
</tr>
<tr>
<td>10</td>
<td>€200</td>
<td>€400</td>
<td>147 %</td>
</tr>
<tr>
<td>11</td>
<td>€180</td>
<td>€400</td>
<td>171 %</td>
</tr>
<tr>
<td>12</td>
<td>€160</td>
<td>€400</td>
<td>198 %</td>
</tr>
<tr>
<td>13</td>
<td>€140</td>
<td>€400</td>
<td>229 %</td>
</tr>
<tr>
<td>14</td>
<td>€120</td>
<td>€400</td>
<td>267 %</td>
</tr>
<tr>
<td>15</td>
<td>€100</td>
<td>€400</td>
<td>312 %</td>
</tr>
<tr>
<td>16</td>
<td>€80</td>
<td>€400</td>
<td>369 %</td>
</tr>
<tr>
<td>17</td>
<td>€60</td>
<td>€400</td>
<td>446 %</td>
</tr>
<tr>
<td>18</td>
<td>€40</td>
<td>€400</td>
<td>561 %</td>
</tr>
<tr>
<td>19</td>
<td>€20</td>
<td>€400</td>
<td>777 %</td>
</tr>
<tr>
<td>20</td>
<td>€10</td>
<td>€400</td>
<td>1019 %</td>
</tr>
</tbody>
</table>

Table 4.3: Experimental payoffs, Experiment I and II, $-MPL elicitation table.
would you like to receive in 8 months, option B, to be equally satisfied receiving any of these two options “

Subjects were asked to enter the amount they preferred in the opposite bar on the screen. This bar corresponded to €400 at the beginning of the task. Subjects could increase this amount to reach the desired value by scrolling the opposite bar to increase the value by €1 at time. Alternatively, they could enter their desired value. Subjects were not told the maximum value that it was possible to report for the task, i.e. the limiting value necessary for BDM procedure was equal to €800. However, they could discover the maximum value by scrolling up or inserting a higher amount and confirming the operation. If an amount higher than was admissible was inserted, a message was provided that this amount was higher than was admissible and subject was asked to enter a lower amount.

For speed-up frame subjects could choose to insert an amount between €0 and €400. Presentation of the matching task in speed-up frame and subjects’ choices were done in the same was as for delay frame, with the obvious adjustments.

Subjects were given 21 questions consisting of 20 choice task questions and 1 matching task question. One subject in each treatment was selected for payment while all subjects received €8 fee for participation. One out of 21 questions was extracted at the end of the experiment. In the case of the question corresponding to choice task, the subject was paid according to the option chosen for this question. If the matching task was extracted for payment the option of payment was determined by the BDM mechanism.

Payment procedures were explained in detailed instructions that were read out by the experimenter. To be sure that subjects had understood a trial session was conducted using sweets. To explain how payment worked for both choice task and matching task, winners were selected and ‘paid’ in the trial session.

4.2.3 Implementation

Fifty-six undergraduate students from the University of Trento participated in experiment I. Subjects were recruited through the CEEL database and were randomly assigned to three experimental sessions. The experiment was conducted using computers and software created especially
for this experiment; the questionnaire was performed with pen and paper. Each experimental session lasted around 50 minutes including reading the instructions, the trial experiment, the actual experiment, compilation of questionnaires and selection of winners.

### 4.2.4 Results

#### General overview

Table 4.4 the median discount rates elicited in Experiment I. The median discount rate elicited with the %-MPL format for the choice task is 32.5% for Treatment I and 25% for Treatment II. The median discount rates elicited with the matching task for these treatments were 67% and 50% respectively. The Wilcoxon matched-pairs ranked test confirms Hypothesis 1b that discount rates elicited by a %-MPL choice task are lower than discount rates elicited in a matching task in delay frame. This result is in line with the evidence in Chapter 3.

The median discount rate elicited with $-MPL choice task is 89% while the discount rate elicited by the same treatment in the matching task is only 43%. Therefore, the $-MPL choice task leads to elicitation of a discount rate that is higher than the discount rate elicited in the matching task in a speed-up frame. The Wilcoxon matched-pairs ranked test confirms Hypothesis 81.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Matching task</th>
<th>Choice task (MPL)</th>
<th>Wilcoxon matched-pairs ranked test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median amount</td>
<td>Median discount rate</td>
<td>Median amount</td>
</tr>
<tr>
<td>Treatment I (MTDelay - % - MPL)</td>
<td>€555</td>
<td>67%</td>
<td>€467.5</td>
</tr>
<tr>
<td>Treatment Ia (% - MPL - MTDelay)</td>
<td>€500</td>
<td>50%</td>
<td>€452</td>
</tr>
<tr>
<td>Treatment II (MTSpeed-up - $ - MPL)</td>
<td>€325</td>
<td>43%</td>
<td>€260</td>
</tr>
</tbody>
</table>

Table 4.4: Results of experiment I.
Table 4.5: Results of Mann-Whitney tests.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>%-MPL_Ia</th>
<th>$-MPL$</th>
<th>MT_delay_Ia</th>
<th>MT_speed up</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT_delay_I</td>
<td>$z=3.58$</td>
<td>$z=-1.91$</td>
<td>$z=1.66$</td>
<td>$z=1.88$</td>
</tr>
<tr>
<td></td>
<td>$(p=0.0003)$</td>
<td>$(p=0.0561)$</td>
<td>$(p=0.0969)$</td>
<td>$(p=0.0601)$</td>
</tr>
<tr>
<td>%-$MPL_I$</td>
<td>$z=0.69$</td>
<td>$z=-4.01$</td>
<td>$z=-4.69$</td>
<td>$z=-1.05$</td>
</tr>
<tr>
<td></td>
<td>$(p=0.4902)$</td>
<td>$(p&lt;0.0001)$</td>
<td>$(p&lt;0.0001)$</td>
<td>$(p=0.2937)$</td>
</tr>
<tr>
<td>MT_delay_1a</td>
<td>$z=-1.98$</td>
<td>$z=-1.03$</td>
<td>$z=-1.05$</td>
<td>$z=1.03$</td>
</tr>
<tr>
<td></td>
<td>$(p=0.0477)$</td>
<td>$(p=0.303)$</td>
<td>$(p=0.2937)$</td>
<td>$(p=0.303)$</td>
</tr>
<tr>
<td>MT_speed up</td>
<td>$z=1.13$</td>
<td>$z=-4.39$</td>
<td>$z=1.03$</td>
<td>$z=-1.05$</td>
</tr>
<tr>
<td></td>
<td>$(p=0.2585)$</td>
<td>$(p&lt;0.0001)$</td>
<td>$(p=0.303)$</td>
<td>$(p=0.2937)$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>MT_speed up</th>
</tr>
</thead>
<tbody>
<tr>
<td>%-$MPL_Ia$</td>
<td>$z=-4.39$</td>
</tr>
<tr>
<td></td>
<td>$(p&lt;0.0001)$</td>
</tr>
</tbody>
</table>

1c at a significance level of 0.001. This result corresponds to evidence in Manzini et al. (2008) where the comparison was performed in a between subjects design.

Comparison of discount rates elicited with %-MPL and $-MPL choice task provide evidence favouring Hypothesis 1a, i.e. discount rates observed with the %-MPL choice task are lower than discount rates elicited with the $-MPL choice task. This result is significant at 0.001 level according to the Mann-Whitney test reported in 4.5.

Finally, the discount rates elicited through the matching task in the delay frame, Treatments I and Ia, are higher than the discount rates elicited in the same task in speed up frame, Treatment II, see Table 4.4. Hypothesis 1d is also confirmed by the results of the Mann-Whitney test reported in Table 4.4.

**Analysis of differences between matching task and choice task**

The difference between discount rates elicited using matching task and choice task persist regardless of the order in which the tasks are presented. In Treatments I and II the matching task was the first task in the experiment followed by the choice task, while in Treatment Ia the choice task was the first task in the experiment. Regardless of the order of presentation the difference between discount rates elicited using choice task and matching task is significant.

Method invariance requires that subjects report the same indifference values, from which discount rates are calculated later, for both elicitation methods. Instead, the majority of subjects
reported higher values in the matching task compared to the values at which the switch from choosing option A to choosing option B occurred in the choice task.

For instance, 65% of subjects in Treatment I reported a higher amount as the indifference value in the matching task, but switched their choice to a lower value: the median value chosen in the matching task was €555 while the median value at which the switch from choosing option A to choosing option B occurred was €467.5.

Two of the subjects reported an indifference value of €500 on the matching task but switched their choice to €473. Notice that the value of €500 was available also in the %-MPL Table (see tab. 4.2). However, these two subjects switched to a much lower value.

At the same time nothing precluded the remaining subjects on the matching task from expressing a preference for a value higher than the options available in the choice task, and choosing option A for all alternatives on the choice task. This behaviour would confirm their choice in the matching task. Instead they switched their choice to within the limits imposed by the %-MPL table.

Similar patterns of behaviour were observed in Treatment Ia: 90% of subjects in this treatment reported higher amounts in the matching task but switched to lower amounts in the choice task. The choice task in this treatment was the first task in the experiment followed by the matching task. The median amount at which the switch occurred in the choice task was €452 while in the matching task subjects reported a median indifference value of €500. 55% of subjects in this treatment in the matching task reported values that were available for their choice in the choice task, i.e. €500, but chose lower values. While in Treatment Ia this behaviour can be explained by their delayed regret in choosing too low a value in the choice task this explanation does not work for behaviour of subjects in Treatment I.

Although the median values of the discount rates are higher in Treatment I compared to Treatment Ia, the Mann-Whitney test confirms the alternative hypothesis that discount rates elicited in the choice task in Treatment I are similar to the discount rates elicited in the choice task in Treatment Ia (see Table 4.5). It is also hard to refute the hypothesis that discount rates elicited by the matching task in Treatments I and Ia are different, given that the probability associated with the Mann-Whitney test reported in Table 4.5 is equal to 0.1.

In Treatment I amounts reported for the matching task vary widely within the limits available
for choice (between €400 and €800). In Treatment Ia these amounts are concentrated around a focal value of €500 although some subjects report much higher amounts. While on matching task subjects could choose any value between €400 and €800 the limits on choice imposed by %-MPL table were only between €400 and €506 (see Table 4.2). These different limits on the decision space could have caused the observed differences in choices.

The subjects however did not know the limits on either task before they were called to make their choices on the corresponding tasks. On the matching task it was possible to discover the upper limit by scrolling up and reaching the upper limit or by trying to enter an amount outside the limits. Only a few subjects explored the limits before making their choice in the matching task. In the choice task, alternatives were presented to subjects one at a time in randomized order. Therefore, it was not possible for them to know the limits of the table unless they were given the last alternative first.

Discovering the limits imposed on the task they were faced with first, seems to have influenced subjects’ behaviour although this influence is not statistically significant. In Treatment I subjects probably express their preferences more freely in the matching task as the only limit of their choice is the maximum value of €800 which was not known to them at the beginning of the task. They also tend to perform their switch on choice task at higher values compared to the values in Treatment Ia. Probably the subjects in Treatment I anchor their choices in the choice task to the values they reported in the matching task. Nevertheless, they prefer to switch within the limits of the %-MPL table.

In Treatment Ia exposure to the choice task in the first place, allows subjects to discover the limiting value on the %-MPL table, which is equal to €506. This value seems to attract subjects’ attention to the amount of €500 in the consecutive matching task. 40% of subjects in Treatment Ia chose this value on the matching task compared to only 20% in Treatment I. In Treatment Ia only 35% of subjects opted for amounts higher than €500 compared to 55% of subjects in Treatment I. Clearly, if the choice task is first this imposes limits on the preference structure of subjects and even in situations where values are higher than those proposed for the choice in the first task are available they may choose not to opt for those higher values thinking that the limits on choice task are considered “fair” values by the experimenter.

Similarly, in Treatment II, subjects record higher amounts in the matching task compared
to amounts at which they switch in the choice task. However, in Treatment II this phenomenon leads to lower discount rates observed with the matching task compared to those observed with the $-MPL choice task. Contrary to Treatments I and Ia the matching task and choice task in Treatment II had the same limits on the values that subjects could choose. Notwithstanding this, 75% of subjects in Treatment II chose higher amounts on the matching task while accepting lower amounts sooner on choice task. As in the previously discussed treatments, subjects were not consistent among elicitation tasks although there was no interval between the tasks.

The different results observed for the matching and choice tasks could be explained in terms of exposure to different limits on the two tasks. Recall that while in the matching task subjects could enter any amount between €400 and €800, in the choice task this was limited to the values of option B varying from €400 to €506. This opportunity would seem to be a plausible explanation since the switching of choice within the limits of the underlying MPL table was hardly influenced by the table structure itself given that subjects were not faced with the whole table but were asked to choose between option A and option B for the individual alternatives in the MPL table. Subjects were presented with these alternatives one at a time, and there was no possibility to go back and change their choice for a previous alternative. Moreover, Treatment II presented subjects with the same limits on choice – between €400 and €0 – but subjects’ choices were no more consistent.

The observed difference between subjects’ choices on the matching and choice tasks could be explained by opportunistic motives encouraged by the matching task. While in the choice task all that subjects can do is to choose their preferred options from the two proposed, in the matching task they can express their preferences freely. To address this issue the BDM mechanism was introduced in the matching task to make it incentive compatible. Although subjects had the BDM procedure explained to them, it is possible that they stated higher values on the matching task in the hope of receiving more money if the matching task was selected for payment. In fact, three people stated the highest possible value in each treatment ignoring the fact that in this case they reduced to 0 the probability of getting delayed payment for Treatments I and Ia and being paid on a closer date in Treatment II.

While this might explain subjects’ behaviour in Treatment Ia, nothing precluded subjects reporting matching task values higher than €506 in Treatment I, the threshold value for the
choice task, from always choosing option A in consecutive choice tasks. Sticking to this strategy, to be consistent within tasks, was even easier in Treatment II where matching task and choice task had the same upper limits, known to the subjects. However, subjects switched choices within the limits of the table.

In the final questionnaires completed before the winner of the session was extracted they subjects were asked to state whether they were happy with the choices they had made in the experiment on both tasks and how they would change them if they could. Surprisingly, only two people in Treatment I who had stated the highest possible value on the matching task, €800, reported they would slightly decrease their request in the matching task, by €50-€100. Everyone else was satisfied with the choices made during the experiment. Therefore, it seems that subjects did not realize that they had been inconsistent. And even if they did realize it, they did not want to change.

The final questionnaires collected subjects’ opinions as to whether the winner of the session would be paid as promised by the experimenter. All subjects expressed a belief that the payment would be forthcoming according to the conditions of the experiment. This result confirms that the CEEL laboratory has very good reputation among the student population in terms of trustworthiness related to the payment procedures adopted in experiments. Therefore, the results of the experiment can be treated as a truthful revelation of subjects’ preferences.

The behaviour of subjects in Experiment I suggests that there is a fundamental difference between how subjects perceive the choice and matching tasks, a difference that does not depend on the order that the tasks are presented.

**Decision rules implemented in choice task and matching task**

Following the tradition of research in preference reversal in risky choice where discrepancy between choice and matching is widely observed, I searched the origin of these differences in representation structure induced by each elicitation method (Lichtenstein and Slovic, 2006). The compatibility principle is believed to explain this discrepancy (Tversky et al., 1988). According to this principle, the characteristics of the task and the response scale attract attention to the most compatible features of the stimulus. For example, in risky choice pricing of bets is likely
to emphasize payoffs more than probabilities because both the response and the payoffs are expressed in dollars. At the same time it is believed that while choosing between two gambles, subjects take account of both dimensions of the gamble – monetary and probabilistic - therefore it is possible that in pricing, gambles with higher payoff and lower probability will be assigned a higher price but that a gamble with a lower payoff associated with a higher probability of winning will be chosen.

Choice task and matching task applied to elicitation of time preference partly reflect this situation. In matching task subjects are asked to express monetary values in euros which make them indifferent to a given alternative option, while choice task requires subjects to choose between the two alternatives. However, in both matching and choice tasks the time dimension is present, whereas in the pricing task in risky choice subjects are asked to report the certainty equivalent of the bet. In situations of risky choice it is plausible to assume that subjects “forget” about risk when they assign a certainty value to bets. On the contrary, the matching task and choice task in time preference require consideration of both dimensions of the decision problem, money and time. Therefore, the compatibility principle as considered in Tversky et al. (1988) cannot be applied here.

Extended research in cognitive psychology shows that perceptual systems are designed to enhance the accessibility to changes and differences (Kahneman, 2003). The dimension that is accessible is easy to retrieve from memory and the decision is often based on it. The principle of accessibility enables a stark distinction between choice task and matching task implemented in experimental research on time preference.

The choice task considered in the present experiment presents subjects with a series of similar questions in which the only thing that changes is the value of option B in Treatments I and Ia (or option A in Treatment II), see Tables 4.2 and 4.3. In the choice task presented this way subjects’ attention is attracted to the option that is changing and to the value of this change. This change becomes accessible to subjects’ perception and the decision can be made based on the value of the changing option or the difference between the two options. Therefore, the change between the options corresponds to the requirements posed by compatibility hypothesis on the decisive dimension for choice. Thus, we can assume that in the MPL format of the choice task subjects’ attention is attracted to the changes between the two options and the decision is made based on
a reservation value imposed on the difference that should be reached between the options to be accepted.

On the other hand, the matching task consists of a single decision in the evaluation of a monetary amount. A single, one-shot evaluation of the amount requires the subject to come up with a value based on very little information other than starting amount and dates of receiving the two alternative options. This process may well be driven by anchoring and adjustment heuristics (Tversky and Kahneman, 1974). In this case a natural anchor is the given on the task amount while adjustment may depend on the interval of elicitation, other anchors encountered during the experiment, and subjects’ time preferences. Notice that the nature of the decision to be made in the matching task is rather different from the decision in the choice task. While in the choice task the subject is called upon to decide which option to choose and bases this comparison on the difference between the two options, in the matching task there is a need to form an evaluation that provides satisfaction. Although based on the principle of invariance of elicitation methods these two decisions should not be different, data from experiments on decision-making provide evidence that this is not the case (Lichtenstein and Slovic, 2006). In the final questionnaires subjects were asked to describe how they chose between the two options in the choice task and how they decided on the amount they stated in the matching task\(^5,\)\(^6\). Analysis of these responses together with analysis of the data can help to shed light on the decisional structure implemented in different elicitation procedures.

**Analysis of decisional rules in choice task**

The majority of subjects in Treatments I and Ia, corresponding to %-MPL choice task, defined a threshold value as the difference that should be reached between option A and option B to accept the delayed option. The value of this difference varied among subjects. For subjects that reported their threshold values the most frequent responses were that the difference between option A and option B should reach at least €50, some reported 1/4 of option A, others €100. Several subjects declared that they fixed the value that option B should reach to switch their choice from option A to option B. 10% of subjects reported looking at the percentage difference

\(^5\)An example of final questionary is presented in Appendix A.2.
\(^6\)Responses and values reported by subjects on final questionnaires correspond to their actual choices in the experiment.
between the two options. 20% of subjects in Treatment I reported using the amounts stated in
the matching task as a reservation value for the consequent choice task. Although the values
corresponding to option B in the alternatives were not usually multiples of 5 or 10 (see table 4.2)
subjects reported their reservation values as multiples of 50

All subjects in Treatment II (§-MPL) reported that their decisions were based on a threshold
value for option A being reached for them to be willing to accept it. In this treatment the
majority of subjects put their reservation value at €250 for option A, some stated it as €150. A
few subjects reported accepting no more than 1/4 reduction on the principal amount, option B.
In the §-MPL treatment values corresponding to option A were multiples of 10 by construction
of the task (see table 4.3), however subjects reported reservation values as multiples of 50 even
if these values were not among the alternatives.

It is possible that a decision based on the difference between the two options was reinforced
by how the choice task was explained as a series of choices between option A and option B,
where option A corresponds to €100 and option B to €100+x for §-MPL. The same kind of
representation was used in instructions for the §-MPL choice task, where option B corresponded
to €100 and option A to €100-x. However, the majority of subjects faced with the choice task
in §-MPL format reported that they took into consideration the difference between the two
options or defined a reservation value based on the difference between the two options, while
subjects faced with the §-MPL choice task made their decision by defining a reservation value
for option A. Given that both MPL formats were explained in the same way in instructions and
were presented in a similar way during the experiment, we can conclude that elicitation of time
preferences in §-MPL format is more prone to reasoning in terms of “differences” compared to
reasoning in terms of threshold value on the option. This can be explained by the fact that for
individuals it is easier to perceive the difference as an addition to something fixed rather than a
subtraction from something fixed.

A natural concern with implementation of the MPL mode of elicitation of preferences in
experiments is related to the so-called middle table effect (Andersen et al., 2006). The middle
table effect is a bias of choice whereby subjects that are called to choose one element from a

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7This representation of the task in instructions follows Coller and Williams (1999) and studies dealing with
implementation of a §-MPL choice task.
Table 4.6: Mann-Whitney test statistics (z) and associated probability of bidirectional test, null hypothesis: the row of switch is the middle of the table (row 10).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Statistics z (associated probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>%-MPL, Experiment I</td>
<td>1.34 (0.18)</td>
</tr>
<tr>
<td>%-MPL, Experiment Ia</td>
<td>0.01 (0.99)</td>
</tr>
<tr>
<td>$-MPL, Experiment I</td>
<td>-2.09 (0.04)</td>
</tr>
</tbody>
</table>

Notice that both the %-MPL and $-MPL elicitation tables consist of 20 alternatives. As the results in table 4.6 show, %-MPL in Experiments I and Ia is affected by the middle table effect since it is not possible to refuse the null hypothesis. At the same time, the subjects' choices in the $-MPL treatment do not seem to be affected by this bias.

The middle table effect is to be expected when a list is presented to a subject in tabular form (Poulton, 1989). Therefore, the random representations of alternatives implemented in Experiments I should not lead to observation of a middle table effect. The choice of switching point at position 10 in the %-MPL table corresponds to the choice of the person with the threshold switching value of €450 or + €50 for option A. As previous analyses have revealed this threshold value was a point of attraction for most of subjects. From the results of the test it is possible to conclude that for the %-MPL choice task in present experiment the choice based on the decision rule “+ €50 on option A” was focal for subjects. For the $-MPL, position 10 in the table corresponds to the value of €200. Given that the median value of acceptable option A was €260 (row 7) the value corresponding to row 10 was probably perceived by subjects as too
Analysis of the middle table effect together with subjects' self-reports of decisional rules implemented during the experiment presented so far suggest that the choice task in the MPL format induces subjects to implement decisional rules based on the difference between given options or on the reservation value defined over the option that changes.

While subjects appear to implement similar decisional rules in %-MPL and $-MPL choice tasks the results observed with the two elicitation procedures are far from being similar. Discount rates elicited with %-MPL are significantly lower than discount rates observed with $-MPL choice task (results of Mann-Whitney test are reported in table 6). This result is contradictory to speed up–delay asymmetry usually observed in time preference (Loewenstein, 1988) by which discount rates elicited in speed-up frame are lower than discount rates elicited in delay frame, the pattern observed in discount rates elicited by the matching task in the present experiment.

However, this result is not generally counterintuitive. $-MPL is presented in speed-up payoff frame while %-MPL is elicited in delay frame. As shown earlier, these two methods induce similar decisional rules. If subjects request the same difference between option A and option B to form their switching value discount rate, in this case with $-MPL it will be lower than the discount rate observed with %-MPL. For example, suppose that in both situations subjects are happy with €50 difference between option A and option B, so that they switch their choice from option A to option B for the value of €450 in %-MPL, and for the value of €350 in $-MPL. In this case, the discount rate registered with %-MPL is equal to 22.5% while that elicited using $-MPL is 59%. Instead, in the experiment subjects were willing to reduce the principal amount by much more in $-MPL to receive this reduced amount sooner than they require to add to the principal amount to receive it delayed in %-MPL. Therefore, the difference in the discount rates is even larger.

The underlying structure of the %-MPL table implies that the differences among neighbouring alternatives do not exceed €5 in nominal value, or correspond to 2.5% in interest rate terms, while in $-MPL this difference corresponds to €20 in nominal value and varies from 11% to 242% in terms of interest rates (see table 4.3). Although subjects are faced with 20 alternatives corresponding to each elicitation mode the structure in terms of interest rates corresponding to these alternatives is strikingly different. Most probably subjects enter the experiment convinced
that the “correct” value that experimenter seeks is included among the values they are presented with. Therefore, along the experiment they try to infer this “correct” value.

Moreover, the possibility of getting paid may reinforce the desire to find the “correct” value since it will assure payment. When alternatives differ very little as in %-MPL (the difference between alternatives corresponds to less than 1.3% of the principal amount) the requests of subjects stay rather limited. When the alternatives differ relatively a lot, as in $-MPL (the principal amount is reduced by 5% at a time), the requests increase accordingly. Therefore, the final results from the choice task depend on the structure of the table presented to subjects.

To conclude, choice task seems to induce application of the decision rule based on the difference between the presented options in %-MPL format or based on the definition of the reservation value in option A in the $-MPL format. The reservation value defined in this way depends on the corresponding values of alternatives with which subjects are faced during the experiment. Subjects defined their reservation values as multiples of 50 although it was not possible to express these values on the task leading to overestimation/underestimation of discount rates elicited in the choice task.

Analysis of decisional rules in matching task

Unlike the choice task, in the matching task subjects’ responses to the questionnaires imply that their decision was framed in terms of the “whole” amount as opposed to reasoning in terms of expected “differences” between the two options. This “whole” amount tends to be multiple of 50 or 100. Only around 20% of subjects in each treatment chose amounts that were not multiples of 50. In this case these amounts were multiples of 5 or 10. This choice of amounts is rather surprising given that subjects could report any amount within given limits. To state their indifference amount they could either increase (decrease) the amount starting from the principal of €400, in this case increases correspond to €1. They could also type in the amount they preferred. The amount was accepted by the computer program if it was within the limits imposed by the task. Most subjects preferred to use the first option and stopped increasing the amount of response as soon as the desired amount was reached. Few subjects explored the limits imposed on the task before making their decision. No subject reported in the final questionnaire that the limits on choice (maximum value of €800 for Treatments I and Ia) were too low and
did not correspond to their preferences.

In Treatment Ia the most frequent amount reported by subjects is €500, 45% of subjects stated this amount. In Treatment I (delay payoff scenario) 60% of subjects chose €500, €600 or €800. In Treatment II (speed-up payoff scenario) the most frequently stated amounts were €250, €300, €350 and €400 as indifference amounts for option A.

Poulton (1989) analysing representations of data from experiments on quantitative judgments in psychophysics notes that only a few researchers choose the medians to report their data. This “aversion” to the use of medians is because that median depends heavily on the underlying distribution of data, and the first quantitative evaluations expressed by inexperienced subjects are biased by preferences to certain numbers. Thus, medians that are around 10 or below will have better chance to be 10 or 5 than any other number in the range. Instead when the median is 20 or higher it is likely to be a multiple of 10. There is a simple explanation for this. Subjects that are not familiar with the task and do not know the correct response to it will round off their response to the nearest 5 or 10. Therefore, one can expect that the matching task activates mechanisms that attract subjects’ attention to certain numbers in their evaluations; these numbers are likely to be multiples of 5 or 10.

Although the definition of a reservation value as a multiple of 50 is common to both the choice and the matching task, reservation amounts themselves differ between the two tasks. In the discussion of the choice task we demonstrated that the reservation value in this task is often derived by looking at the difference among the options available. This value also depends on the values that make up choice alternatives. The matching task does not impose a structure on the subjects’ decision-making process encountered in the choice task. It requires evaluation of the option being matched where this option is likely to be the only piece of information. Therefore, this option enters the decision process as the value to which the response is anchored. In the case of Treatments I and Ia while in the choice task a satisfactory threshold value for option B can be €450 where €50 is an acceptable difference between the two options, in the matching task €500 is seen more as a “whole” thing that can be equivalent to €400. Other such examples could be - €800, doubling the principle amount, €600 – principal amount increases by half. In Treatment II values such as €350, €300 and €250 were chosen as responses in the matching task as opposed to €250, €200 or €150 declared to be reservation values in the choice task.
It is worth mentioning an interesting example of attraction to focal amounts observed in data reported by Thaler (1981) and partially reproduced in table 10. Careful analysis of the values reported in the table shows that subjects in a given study were attracted to amounts of $300 as providing the same satisfaction of $250 received immediately regardless of the length of interval of elicitation, which was equal to 1, 3 or 6 months. The same tendency is observed towards the amount of $1000 for intervals of 5 and 10 years. This pattern of choice can only be rarely traced in published data since data corresponding to means of discount rates or corresponding nominal values are usually reported.

Contrary to what was observed in the choice task, speed up-delay asymmetry registered in the matching task follows a traditional pattern: discount rates elicited in speed up frames are significantly lower than discount rates elicited in delay frames (Mann Whitney test, see table 4.5). In contrast to what was observed in the choice task in the matching task subjects were less willing to reduce the principal amount in the speed-up frame (median amount is €325) compared to how much they were willing to increase it in delay scenario (median ranges from €500 to €550). It appears that in the case of the matching task where the only structure imposed on the decision is composed of limits to the task, losses are given a higher weight than gains in the decision process.

In this light, conditioning of the decision process by the structuring of the table in the $-MPL choice task is even more evident. Matching task and choice task in this case go in opposite directions. While responses in the matching task are close to the principal amount switching points registered with $-MPL choice task distance from this amount a lot.

To conclude, the matching task appears to be governed by different decision rules compared to the choice task. Subjects faced with a matching task tend to report a focal amount that is a multiple of 50. As data from Thaler (1981) show it is possible that subjects report amounts regardless of the length of the elicitation period or of different rules from the convention prescribed by rational choice.

The results from Experiment I demonstrate that implementation of different elicitation methods effectively leads to the generation of significantly different discount rates. Given that elicitation structures compared in this experiment are the most representative of experimental research in time preference it is possible to conclude that heterogeneity of discount rates observed in the
4.3 Experiment II

Above we defined the possible heuristics that subjects may follow when faced with different elicitation procedures. In this section I explore how these heuristics affect discount functions elicited through different elicitation methods. As in previous section three elicitation procedures are compared: %-MPL choice task, $-MPL choice task and matching task in delay payoff scenario.

The interest in Experiment II is in the form of the discounting function over time depending on the elicitation method used to construct it. Although there is extended evidence on each elicitation method considered in the present experiment this evidence has been obtained under very different experimental conditions: the amount elicited, the time horizons and other experimental procedures differ dramatically from study to study. Different experimental procedures used to elicit discount rates in each study make it impossible to compare the results of different studies since it is not known whether a certain result is due to experimental procedures, elicitation methods or subject sample. The idea of the present experiment is to compare discount rates elicited using different elicitation methods under the same experimental conditions.

The structure of the %-MPL format of choice task does not permit elicited discount rates to overcome the values of the interest rates that were used for its construction. Moreover, the results from Experiment I demonstrate that subjects tend to make choices within the limits of a proposed table, avoiding choosing values that correspond to the limits of the table. Therefore, discount rates elicited with %-MPL are expected to be fairly stable and assimilate constant, exponential, discounting patterns. In Experiment II we implement the %MPL table from Harrison et al. (2002) which now is widely used in experimental research on time preference. As in Experiment I it was chosen to present alternatives without specifying corresponding to the alternative interest rate to keep this procedure similar to the other two elicitation modes frequently implemented in research: $-MPL and matching task.

The structure of the $-MPL format of choice task does not change in nominal terms between corresponding horizons of elicitation (table 4.3). The only difference between alternatives
corresponding to different time horizons is the date at which option B is available. This fixed nominal structure extended for several time horizons imposes diminishing limits on the choice in terms of possible discount rates. Given that subjects faced with this elicitation task make their choice as described in the previous section, discount rates elicited by this procedure will present a strong hyperbolic pattern for several reasons. First, it is expected that subjects’ discounting is positive, meaning that a certain payoff is worth more today than tomorrow. Positive discounting constraint applied to the $-MPL format means that if $100-x$ today were selected over $100$ in 6 months, less than $100-x$ should be selected over $100$ in 1 year. The list of $100-x$ corresponding to option A is the same for all time horizons considered in elicitation with $-MPL$. The discount rate is calculated as

\[
dr = \sqrt{\frac{100}{100 - x}}
\]

Suppose that the subject switched the choice at the value $e280$, the median value in Experiment I, corresponding to a discount rate of 89% for a 6 month horizon.

This choice restricts the choices available to the subject in consequent time intervals; it is not possible to choose a switching point corresponding to a value higher than $e280$ for intervals longer than 6 months and respect positive discounting. Suppose that we next elicit the preference over a five year horizon. The subject can only choose values that are lower than $e280$, but these values correspond to discount rates lower than 89% elicited in the first period (see table 4.3). Therefore, it is expected that discount rates elicited with $-MPL$ will tend to decrease with the increase in the considered time horizon. Discount rates elicited with $-MPL$ will start at higher values than for the %-MPL choice task and will decrease with the increase in the interval of elicitation.

In a matching task, implementation of anchoring and adjustment heuristics over several periods of elicitation may lead to sequential construction bias described in Poulton (1989). Sequential contraction bias refers to situations in which individuals judge the magnitude of events one directly after the other. In this case previous magnitude becomes an additional anchor for the current response. Although sequential contraction bias is relevant for all elicitation methods
considered so far, e.g. %-MPL and $-MPL choice tasks, it has a stronger effect on the matching task. In Experiment I it was demonstrated that in %-MPL and $-MPL the composition of the options over which elicitation is performed plays the most important role in the magnitude of observed discount rates. From the discussion of the matching task in Experiment I it becomes clear that with this elicitation method subjects are more affected by additional anchors. Therefore, nominal value elicited by the matching task over consequent time horizons is expected to be too close to previously elicited values. In terms of discount rates it is translated into a decrease in the discount rates with an increase in the time horizon: instead of exponential growth in nominal amounts linear growth is observed.

The following hypotheses were constructed for Experiment II:

*Hypothesis 1a.* Discount rates elicited by %-MPL will present a rather stable pattern that can be approximated by exponential discounting.

*Hypothesis 1b.* Discount rates elicited by $-MPL will decrease with an increase in the time horizon of elicitation in hyperbolic fashion.

*Hypothesis 1c.* Discount rates elicited by the matching task in the delay frame will present hyperbolic pattern.

To fully explore the influence of each elicitation mode we need to extend the elicitation horizon to several years as in the first experiments on time preference (Thaler, 1981; Benzion et al., 1989; Green et al., 1997; among others). However, this extension does not allow us to perform an elicitation with real payoffs as it does not seem possible to assure subjects that they will be paid in 5-10 years from today. Therefore, Experiment II was run with hypothetical payoffs.

The length of FED imposed on option A is kept the same as in Experiment I and equal to 2 months for all time intervals considered in the experiment. Elicitation periods chosen for Experiment II were 6 months, and 1, 3, 5 and 10 years, similar to those implemented in Green et al. (1997) design and common to studies in time preference with hypothetical payoffs.

Performance of three elicitation methods in a between subjects design: %-MPL and matching task in delay payoff scenario and $-MPL choice task in the usual anticipating payoff frame. The experiment was performed using pencil and paper. In the choice task subjects were presented with a table corresponding to the whole elicitation period rather than the one alternative at a

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8Experimental instructions are presented in Appendix A.4, A.5 and A.6.
time representation in Experiment I. The structure of the %-MPL and $-MPL tables was kept the same (see Tables 4.2 and 4.3) as in Experiment I except for obvious adjustments for different time horizons. In the matching task the threshold value was abolished given that there was no need to introduce it due to the implementation of a hypothetical payoff structure. Questions in the matching task and the tables in the choice task corresponding to different time horizons were presented to subjects in increasing time horizon order.

Hypothesis 2. Discount rates elicited over a 6 month period in Experiment II will not be significantly different from discount rates elicited using the corresponding elicitation method in Experiment I.

Fifty five undergraduate students from the University of Trento participated in Experiment II: 17 of them were assigned to %-MPL treatment, 20 to $-MPL treatment and 18 participated in matching task treatment. They received €5 participation fee. Completion of Experiment II took approximately 20 minutes.

4.3.1 Results

Figure 4.1 presents the mean discount rates elicited in Experiment II; table 4.7 reports the median discount rates corresponding to each elicitation method. As predicted by Hypothesis 1a the median discount rate elicited with %-MPL is rather stable with a slight decrease for the interval of 3 years. The median discount rate elicited by $-MPL decreases with time following the familiar hyperbolic pattern. The median discount rates elicited using the matching task present a strong hyperbolic pattern.

Table 4.8 reports the results of the bidirectional Wilcoxon matched-pairs signed rank test performed on discount rates elicited by the %-MPL choice task over different horizons with the null hypothesis that discount rates are the same across different time horizons. The diagonal in this table corresponds to discount rates elicited over successive time intervals. As can be seen from Table 4.8 it is not possible to refuse the null hypothesis that data points are generated from the same distribution. Not only do discount rates elicited over successive time intervals not differ from each other in a significant way (see diagonal in table 4.8) but also discount rates elicited over much shorter intervals, 6 months or 1 year, are similar to discount rates elicited
Figure 4.1: Mean discount rates elicited in Experiment II.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Length of horizon of elicitation</th>
<th>DR</th>
<th>Amount</th>
<th>M-W test</th>
<th>DR</th>
<th>Amount</th>
<th>DR</th>
<th>Amount</th>
<th>DR</th>
<th>Amount</th>
<th>DR</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 months</td>
<td>1 year</td>
<td>3 years</td>
<td>5 years</td>
<td>10 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DR</td>
<td>Amount</td>
<td>M-W test</td>
<td>DR</td>
<td>Amount</td>
<td>DR</td>
<td>Amount</td>
<td>DR</td>
<td>Amount</td>
<td>DR</td>
<td>Amount</td>
</tr>
<tr>
<td>%-MPL</td>
<td>25% (10)</td>
<td>8%</td>
<td>452</td>
<td>-0.47</td>
<td>25%</td>
<td>510</td>
<td>22%</td>
<td>718</td>
<td>25%</td>
<td>1345</td>
<td>25%</td>
<td>4046</td>
</tr>
<tr>
<td>$-MPL</td>
<td>78% (5)</td>
<td>8%</td>
<td>300</td>
<td>0.25</td>
<td>67%</td>
<td>240</td>
<td>33%</td>
<td>170</td>
<td>25%</td>
<td>130</td>
<td>21%</td>
<td>60</td>
</tr>
<tr>
<td>MT</td>
<td>206%</td>
<td>8%</td>
<td>700</td>
<td>-3.54</td>
<td>150%</td>
<td>1000</td>
<td>62%</td>
<td>1700</td>
<td>44%</td>
<td>2500</td>
<td>29%</td>
<td>5000</td>
</tr>
</tbody>
</table>

Table 4.7: Median discount rate (switching row) and corresponding amount for each treatment.
Table 4.8: Wilcoxon matched pairs signed test statistics and associated probability for %-MPL treatment.

<table>
<thead>
<tr>
<th></th>
<th>1 year</th>
<th>3 years</th>
<th>5 years</th>
<th>10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 months</td>
<td>( T^+ = 24, n=12 )</td>
<td>( T^+ = 58, n=14 )</td>
<td>( T^+ = 49.5, n=14 )</td>
<td>( T^+ = 55, n=13 )</td>
</tr>
<tr>
<td></td>
<td>( p &gt; 0.5 )</td>
<td>( p=0.76 )</td>
<td>( p &gt; 0.5 )</td>
<td>( p=0.54 )</td>
</tr>
<tr>
<td>1 year</td>
<td></td>
<td></td>
<td>( z=0.87 )</td>
<td>( z=0.43 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( p=0.38 )</td>
<td>( p=0.67 )</td>
</tr>
<tr>
<td>3 years</td>
<td></td>
<td>( T^+ = 21, n=7 )</td>
<td></td>
<td>( T^+ = 43, n=13 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( p=0.21 )</td>
<td></td>
<td>( p=0.89 )</td>
</tr>
<tr>
<td>5 years</td>
<td></td>
<td></td>
<td>( T^+ = 27, n=8 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( p=0.25 )</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.8: Wilcoxon matched pairs signed test statistics and associated probability for %-MPL treatment.

over longer periods, 5 to 10 years. Although the median discount rate elicited over 3 year and 10 year intervals appears to be smaller than the other median discount rates this difference is not significant. Therefore, we can conclude that the discount rates elicited with %-MPL choice task remain the same regardless of the length of the interval of elicitation. Hypothesis 1a is strongly confirmed.

Table 4.9 reports the results of the one-directional Wilcoxon matched-pairs signed rank test performed over discount rates elicited by the $-MPL choice task. Contrary to the previous case, implementation of the $-MPL choice task leads to elicitation of discount rates that are significantly different from the increase in the length of the time horizon for the elicitation. Discount rates elicited using this method decrease significantly with an increase in the horizon of elicitation. These results confirm Hypothesis 1b.

Table 4.10 presents the results of the one-directional Wilcoxon matched-pairs signed rank test performed over discount rates elicited using the matching task. As in the case of discount rates elicited with $-MPL choice task, discount rates elicited with the matching task decrease in a significant way with an increase in the horizon of elicitation, confirming Hypothesis 1c. Although discount rates elicited with the matching task present stronger decreasing patterns than discount rates elicited with the $-MPL choice task, the significance of the results observed for the matching task is not as high as the significance observed in the discount rates elicited by the $-MPL choice task. This can be explained by the higher variance observed in the results.
Discount rates elicited by the %-MPL and $-MPL choice tasks in Experiment I are not significantly different from the discount rates elicited by the corresponding elicitation method over the horizon of 6 months in Experiment II. This result is confirmed by the Mann-Whitney test reported in table 4.7 column III, which shows that the distributions of discount rates elicited in Experiment I are similar to the corresponding distributions elicited in Experiment II, confirming Hypothesis 2. Therefore, subjects seem to report their preferences in the MPL choice task in a truthful way regardless of real incentives. Alternatively, elicitation in the MPL tables is not influenced by real incentives. These alternative explanations will be discussed later.

Hypothesis 2 is not confirmed for discount rates elicited by the matching task. Discount rates elicited by the matching task in Experiment I, Treatment I, are different, lower, than the discount rates elicited from the matching task.
rates elicited in Experiment II (Mann-Whitney test statistics of $z=3.54$ allows us to reject the null hypothesis that data were extracted from the same distribution). It is possible that the presence of the limiting value on the amounts to be submitted in Experiment I in some way conditioned subjects’ choice. At the same time the fact that only a few subjects discovered the value of the threshold in these treatments would suggest that the reason for this difference lies in real payoffs offered in Experiment I. Subjects that participated in Experiment I were possibly driven by the incentive of actually being paid at the end of experiment. It is possible that they tried to infer the amount that would be accepted by the experimenter for payment and kept their responses low. This explanation is supported by the somewhat different amounts reported in the matching task in Treatment I and Treatment Ia in Experiment I. In Treatment Ia amounts available in the preceding choice task were more frequently observed in the matching task, leading to a lower discount rate than in Experiment I (see discussion of results from Experiment I). In Experiment I where the matching task was the first task in the experiment, the amounts reported in the task were higher and there were more choices corresponding to the limiting value. Further discussion of the possible reasons for this behaviour will be offered later.

Discount rates elicited with the matching task result in the highest discount rates elicited in Experiment II for all intervals of elicitation. The median discount rate elicited with the $-$MPL format is higher than the median discount rate elicited with the $\%$-MPL format for the first three time horizons, while it reaches in magnitude median discount rate elicited with $\%$-MPL for a 5 year horizon and becomes the smallest median discount rate for 10 year intervals of elicitation. The Mann-Whitney test confirms that the discount rates elicited with $\%$-MPL and $-$MPL for horizons of 5 and 10 years have equal distributions while the discount rates elicited with $-$MPL are higher than those elicited with the $\%$-MPL for shorter intervals (see table 4.11). Median discount rates elicited by the matching task also decrease with an increase in the length of the elicitation interval although they do not reach the discount rates elicited with the $\%$-MPL within the time horizons considered in the experiment.

These patterns of discount rates typical of each elicitation method can be explained by the decision-making strategies that subjects activate in each task.

As demonstrated in Experiment I the choice from the $\%$-MPL table elicitation is characterized by the decision rule that looks at the difference between the two options of choice. As noted
Table 4.11: Mann-Whitney test statistics and associated probability.

<table>
<thead>
<tr>
<th></th>
<th>6 months</th>
<th>1 year</th>
<th>3 years</th>
<th>5 years</th>
<th>10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle table effect</td>
<td>z=0.02</td>
<td>z=-0.57</td>
<td>z=-2.03</td>
<td>z=0.02</td>
<td>z=-0.58</td>
</tr>
<tr>
<td>%-MPL</td>
<td>p=0.984</td>
<td>p=0.5687</td>
<td>p=0.0424</td>
<td>p=0.984</td>
<td>p=0.5619</td>
</tr>
<tr>
<td>Middle table effect</td>
<td>z=4.04</td>
<td>z=-0.53</td>
<td>z=-2.42</td>
<td>z=2.69</td>
<td>z=3.77</td>
</tr>
<tr>
<td>$-MPL</td>
<td>p=0.0001</td>
<td>p=0.5961</td>
<td>p=0.0078</td>
<td>p=0.0071</td>
<td>p=0.0002</td>
</tr>
<tr>
<td>%-%-MPL vs $-MPL</td>
<td>z=4.04</td>
<td>z=2.48</td>
<td>z=1.87</td>
<td>z=-0.03</td>
<td>z=0.16</td>
</tr>
<tr>
<td></td>
<td>p=0.0001</td>
<td>p=0.0131</td>
<td>p=0.0615</td>
<td>p=0.9761</td>
<td>p=0.8729</td>
</tr>
</tbody>
</table>

above, subjects’ choices in Experiment I and Experiment II in the %-MPL choice task can be considered similar. In Experiment I, however, subjects were faced with one pair of alternatives at a time, in random order, while in Experiment II subjects were faced with the whole table of alternatives. Although it is not clear whether the same decision rule is adopted for the two presentations of the %-MPL table it can be affirmed that these two representations led to the same results regardless of incentives.

As discussed in relation to Experiment I, table representation of the %-MPL choice task may be prone to the so-called middle table effect. The median choice of subjects in Experiment II corresponds, for all horizons of elicitation except for 3 years, to the middle table position. To test the significance of this hypothesis observed switching rows for each interval of elicitation were compared to a theoretical situation in which the switch happens at the middle table position, row number 10. The results of this test are reported in table 9 and are significant for all time intervals except for the discount rates elicited over the period of 3 years. For the period of 3 years switching results at position 8 are significant (with Mann-Whitney test statistics equal to -0.62 and associated probability of 0.54).

On the other hand, switching at central positions corresponds to application of the decision rule that requires increments to the principal amount of €50 for waiting for 6 months, of €100 for waiting for 1 year, of €300 for postponing receipt for 3 years, of €1000 for 5 years and €3500-4500 for 10 years. For the first three periods considered in Experiment II this increment seems to be proportional to the lengths of the period. Note that if subjects choose to switch at row number 10 in a 3 year horizon the difference would correspond to €400. Therefore, it seems that
for the first 3 intervals of elicitation subjects used the rule of defining a difference between the two options of choice, €100 for each additional year of waiting, and increasing it proportional to the interval of elicitation. This decisional rule explains the choices of 31% of subjects over the period of 6 months, 44% for the period of 1 year, and 25% over the period of 3 years.

If subjects would follow this rule for all their choices in the experiment they would choose to switch around rows 7-8 after 5 years, and at rows 6-7 after 10 years, requesting +€500 and +€1000 for 5 and 10 years of waiting respectively. 25% of subjects followed this choice for the interval of elicitation of 5 years and 19% of subjects for an interval of 10 years. This kind of choice would lead to observation of hyperbolic discounting, and a slight decrease in discount rate would have been observed.

In any case, for a 5 year period the median subject chose +€1000 and for 10 years + €4000, much higher amounts than those predicted by the above rule. Probably the values in the table influenced the preferences of subjects and they changed the rule from one period to the other.

In general, subjects’ choices over periods of 5 and 10 years are characterized by growth in the elicitation period variability in terms of the nominal amounts at which the switch takes place, while standard deviation in terms of discount rates or switching points is rather stable. Therefore, it is difficult to individuate a stable rule that would characterize a single decision-maker faced with elicitation intervals of 5 or 10 years. This difference is explained by the fact that the %-MPL table is constructed in an exponential way that imposes precise limits on the variability of possible switching points and, consequently, on discount rates, while nominal amounts are given larger space for variation.

It is worth mentioning that for short periods, 6 months and 1 year, there were two subjects who always chose option A expressing preference for higher values of the discount rate than those that were available in the choices in the table. These subjects were choosing values within the limits of the table for longer time intervals. Also, one person always chose option B for the intervals of 5 and 10 years after choosing values within the limits of the table for other periods of elicitation, this choice corresponds to a lower discount rate than those available on the table. Both types of behavior correspond to the expression of hyperbolic behaviour that cannot be accommodated by the %-MPL table implemented in present experiments due to the limits imposed on it.
Analysis of individual patterns of discount rates elicited by the %-MPL choice task demonstrates that only 18% of subjects maintain their choice compatible with exponential discounting, choosing always to switch at the same row and that 59% of subjects act compatibly with hyperbolic discounting. Some of these subjects increased their discount rate over the 5 year elicitation period to decrease it over 10 years. Although the majority of subjects behave according to hyperbolic discounting, analysis of the aggregated result in terms of medians provides more support for exponential discounting.

Subjects’ choices in the $-MPL table differed substantially from those in the %-MPL choice task. Similar to what was observed in the %-MPL treatment, the choices in Experiment I and Experiment II for the $-MPL choice task appear to be the same (see Table 4.7 column III). Discount rates in Experiment I were elicited with alternatives being presented, one at a time, in random order while in Experiment II subjects were presented with the whole table of ordered alternatives. Differences in the presentation as well as the structure of incentives did not appear to influence subjects’ choices significantly, in terms of elicitation of discount rates in the $-MPL choice task.

Choice for the first elicitation interval, 6 months, in the $-MPL choice task is far from being centred around the middle of the table, as demonstrated by the Mann-Whitney test reported in Table 4.11. Only for the 1 year interval can subjects’ choices be described as influenced by the middle of the table. The choices of subjects faced with $-MPL choice task in Experiment II are described by the descending rows with increases in the intervals of elicitation. This choice strategy is confirmed by the results of the unilateral Wilcoxon matched pairs test reported in table 8b. Therefore, contrary to what is observed in the %-MPL choice task, subjects faced with elicitation procedure of the $-MPL type are forced to switch their choices always to the lower amount. This kind of choice respects positive discounting constraint and was followed by 70% of subjects.

Choosing to switch the choice at positions corresponding to lower values than in the preceding elicitation period prevents a sudden drop in discount rates elicited by $-MPL which is as expected given the structure of the table itself (see the limits that the table imposes on discount rates in Table 4.3). If subjects were choosing to switch their choice in $-MPL at the same row as they were switching in %-MPL, centred on the middle of the table, discount rates elicited with
$\text{-MPL}$ would exhibit a sharper decline in discount rates with time than the decline observed in the experiment. These discount rates would reach discount rates of the magnitude elicited using $\%\text{-MPL}$ at the 3 year period, while they would become much lower for horizons of 5 and 10 years. The rule of choice that follows considerations of positive discounting explains why discount rates elicited with $\text{-MPL}$ format over 5 years and 10 years are similar to the discount rates elicited with the $\%\text{-MPL}$ format even though the structure of the underlying tables would predict them to be lower.

As mentioned above, 70% of subjects followed a hyperbolic pattern in their choices when faced with the $\text{-MPL}$ choice task. 10% of subjects switched to higher positions for shorter as opposed to longer horizons, leading to observation of increasing discount rates with increased intervals of elicitation. The remaining subjects followed the usual pattern of switching at higher positions corresponding to longer time intervals. Also, some of these switches occurred at positions lying very close together; therefore for some periods of elicitation discount rate results are higher for longer periods than for the shorter preceding period. In general, patterns in terms of discount rates for these subjects result in a somewhat confusing picture, where they are decreasing for some periods and increasing over other periods, although this choice respects positive discounting in terms of nominal amounts.

Decision rules that could explain subjects’ choices in matching task seem to be more heterogeneous, demonstrated by the much higher standard deviations in discount rates observed in matching task than in other tasks in Experiment II (see Figure 4.1). Contrary to what was observed for the $\text{-MPL}$ and $\%\text{-MPL}$ choice tasks, elicitation discount rates elicited with the matching task in Experiment II are significantly different from the discount rates elicited in Experiment I using the same method. Apparently less structure, no limits on choice, and hypothetical payoffs lead to rather higher amounts being reported for this task.

As in Experiment I, responses for the matching task tend to be multiples of 100. In Experiment II the most frequent amounts reported as values providing the same satisfaction in 6 months, were €600, €700 and €800 as opposed to €500 in Experiment I. Three types of decisional rules can be distinguished in the data. One is the rule based on proportional increment: subjects define an increment over the smallest interval of elicitation, the first interval they are faced with in the experiment. The value reported in successive rounds is built based on this
increment increased proportionally with the waiting period. Reported amounts are normally rounded to the closest €500. This strategy is similar to that adopted in the %-MPL choice task although the amount of increase is rather higher in the matching task. For example, one subject chose an increase of €200 for the 6 month period and €400 for 1 year. Following this rule the subject reported €1500 for the 3 year period, corresponding to an €1100 increment, €2500 over the period of 5 years with an overall increment of €2100, and €4000 for 10 years with a €3600 increment.

Another strategy is to define the amount required as compensation for waiting one period and then proportionally increment it to obtain the compensation for the next period. This strategy is different from the strategy considered above as in the previous case the increment on the principal amount is increased proportionally while in present case the whole amount is proportionally increased. This kind of strategy is frequently observed in responses to questions relative to periods of 6 months and 1 year and between 5 and 10 years. In this case one amount is chosen as a response to the first period and is doubled to obtain a response to the next period. For example, a subject that reported an indifference amount of €1200 for the 6 month period and €2400 for a 1 year period would fall into this category. This strategy is more frequent for responses to questions considering 5 and 10 years intervals.

For 33% of subjects this strategy is behind their responses to these time periods. The amounts chosen by these subjects as the response for the corresponding time horizons vary a lot among subjects. The most frequent amounts observed for the 5 year horizon are €2500, €5000 or €12000, while for a 10 year horizon they are €5000, €10000 and €24000. The proportion of subjects that follow this decisional rule reaches 56% if some rounding up of focal amounts is implemented. Thus, a subject that chooses an amount of €9000 for the 5 year interval and €20000 for the 10 year interval would fall into this category.

The most frequently observed decisional rule for the matching task consisted of defining a rather high value required for waiting the shortest interval of elicitation. This value is increased proportional to the length of the horizon of successive evaluations. The final result is then decreased by a small portion.

30% of subjects declared in their final questionnaires to have followed the rule that with an increase in the waiting horizon they required a smaller proportional compensation for waiting
while 56% of subjects can be classified in this category. All but one of the remaining subjects followed this rule for the first three horizons of elicitation, 6 months, 1 year and 3 years, but increased the amount of the proportional compensation starting from the 5 year horizon and followed the rule again for the 10 year horizon. The decision rule on which subjects base the higher proportional value for the shorter horizon is in line with findings of Read (2001) and Read and Roelofsma (2003). In these studies the theory of subadditive discounting is presented according to which subjects attribute higher values to shorter horizons of elicitation, compared to the values attributed to longer horizons.

It is possible to trace some parallels between the decisional rules activated in the %-MPL choice task and the matching task in the present experiment, i.e. in both elicitation tasks subjects report looking at the differences between the two options. Nevertheless, while in the %-MPL choice task subjects consider a more or less constant increase in the principal value in the matching task, the required increment over the principal value decreases with an extension to the horizon of elicitation. Therefore, the pattern observed in discount rates elicited by %-MPL is at most slightly hyperbolic, while in the matching task discount rates decrease dramatically with an increase in the length of the elicitation interval. Considering discount rates at the individual level 100% of subjects faced with a matching task report discount rates that are decreasing with the increase in the elicitation horizon.

Another similarity between the %-MPL choice task and the matching task is that the passage from the 3 year to the 5 year time horizon appears to be somewhat focal for subjects. Elicitation over the interval of 5 years often leads to adjustment in behaviour in the direction of an increase in the required increment over the principal amount.

To conclude, the results of Experiment II confirm the initial hypothesis that different elicitation methods generate qualitatively different patterns of discounting. For instance, implementation of the %-MPL choice task leads to elicitation of rather stable over time discount rates that can present a slightly hyperbolic pattern. Elicitation of the time preference for $-MPL choice task and the matching task generates evidence compatible with hyperbolic discounting.

Table representations of the %-MPL and $-MPL choice tasks seem to make subjects less sensitive to the presence of real incentives while the matching task is shown to be strongly affected by the nature of incentives. The analysis of decisional rules implemented by subjects
in Experiment II confirms the results observed in Experiment I. Subjects are more prone to switching around middle of the table positions in the %-MPL choice task than in the $-MPL. Attraction to middle table positions in the %-MPL choice task seems to be a joint effect of several factors among which the nominal values associated with each option of choice play the main role.

The fixed nominal values of the $-MPL choice task seem to greatly influence the choice of subjects. Most subjects seem to be moved by considerations of positive discounting. Their choice generates evidence of hyperbolic discounting that is defined by the limits imposed by the elicitation table.

Implementation of the matching task leads to elicitation of discount rates decreasing sharply with an increase in the elicitation interval. Subjects’ self-reports in the final questionnaires provide evidence that they were not driven in their decision-making by exponential considerations. Decisional rules activated during the matching task can be characterized by the determination of monetary value as a compensation for waiting a certain period of time. Generation of this value does not follow exponential considerations. Instead it is characterized by diminishing proportional increments corresponding to larger elicitation intervals. Values generated by this rule correspond to sharply decreasing discount rates.

4.4 Discussion

The results of the experiments reported in this study are in line with evidence in the experimental literature on time preference.

Discount rates elicited with the %-MPL choice task in Experiments I and II correspond in magnitude to average discount rates elicited using the same structure of the %-MPL table as in the literature (see e.g. results in Harrison et al., 2002, Read et al., 2005, Dohmen et al., 2007, etc.). In the present study the subjects were not presented with interest rate corresponding to each alternative of %-MPL choice task table, which has been standard procedure for this elicitation method since Coller and Williams (1999). Nevertheless, I obtained results that are similar to the discount rates observed through implementation of this method.

Discount rates elicited by the $-MPL choice task provide support for hyperbolic discounting that is typically observed in studies that implement this method (see Green et al., 1997; Pender,
1996; Tanaka et al., 2007; Manzini et al., 2008). For a $-MPL elicitation structure it is not possible to compare the magnitude of elicited discount rates among studies unless the same structure of payoffs and the same elicitation periods are implemented in studies under analysis. The amount of elicitation, the difference between amounts that correspond to the alternatives in the table and the length of the interval of elicitation influence the discount rates observed in the elicitation in a given table.

There is a big variety in the structure of the $-MPL choice task adopted in literature. For example, Green et al. (1997) adopted a decision task that consisted of 20 alternatives, and time frames that ranged from 3 months to 20 years. The limits on the discount rates that could be elicited with this structure are in the range of 4370% - 4% for the 3 month period and decrease to 23%-0.05% for an elicitation period of 20 years.

Choice tasks in Tanaka et al. (2007) consisted of 5 equally spaced alternatives with time frames ranging from 3 days to 3 months. The underlying structure of these types cannot elicit discount rates different from 29825%-2287% over 3 days period and 549%-55% over 3 months period.

In Manzini et al. (2008) design subjects were faced with tables of 10 alternatives, equally spaced in terms of payoffs, that were further divided into 5 sub-positions once subjects chose the switching point. Time frames corresponded to 1, 2 and 4 months. This structure imposes limits on elicited discount rates of 10800%-133% over a 1 month elicitation interval and 934%-32% over a 4 month interval. As we can see from the limits imposed by each study on the values of discount rates, it would be difficult for different studies to lead to elicitations of discount rates of the same magnitude. At the same time this analysis shows that implementation of the $-MPL choice task leads to elicitations of decreasing pattern of discount rates.

Similar to most of the studies in the literature that elicit time preference with the matching task (Thaler, 1981; Benzion et al., 1989; Benhabib et al., 2006; Kirby and Marakovic, 1995; Kirby, 1997; Manzini et al., 2008; among others) the results of matching task in the present study provide support for hyperbolic discounting. The results can be analysed only in a qualitative way, i.e. discussing the main pattern of discount rates elicited using this method, while comparisons of magnitude are difficult between studies that implement the matching task. As has been shown, in the present study the decision-making strategies of the subjects on the matching task depend on
Table 4.12: Median responses and (continuously compounded rates in percent), Thaler (1981). Only parts of the original table relative to the discussion in the charter are reported here.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Amount of early prize</th>
<th>Later prize paid in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 mo.</td>
<td>1 yr</td>
</tr>
<tr>
<td>(A)</td>
<td>$250</td>
<td>$ 300 (73)</td>
</tr>
<tr>
<td></td>
<td>6 mo.</td>
<td>1 yr</td>
</tr>
<tr>
<td>(B)</td>
<td>$ 250</td>
<td>$ 300 (36)</td>
</tr>
<tr>
<td></td>
<td>1 mo</td>
<td>1 yr</td>
</tr>
<tr>
<td>(C)</td>
<td>$250</td>
<td>$ 300 (219)</td>
</tr>
</tbody>
</table>

the amount being elicited and the length of the elicitation interval. Subjects define compensation for waiting a certain period of time ad-hoc depending on the situation and incentives provided. This decision is influenced by consideration of focal amounts, where by “focal” amounts such as 500, 1000, 1500, etc. are understood.

Moreover, as attentive analysis of results presented in Thaler (1981) shows it is possible that the same amount can be requested as compensation for waiting different periods (see Table 4.12). In between, subjects’ design time preference for the amount of $250 and different time periods was elicited. As the results show, subjects chose the amount of $300 as required compensation for waiting 1, 3 and 6 months and of $1000 for waiting 5 and 10 years. Time preferences that are expressed in this way necessarily correspond to hyperbolic discounting.

The present study has replicated discrepancies between the choice task and the matching task. As observed in Manzini et al. (2008) it has been found that discount rates elicited with the matching task are lower than discount rates elicited with the choice task when the choice task is implemented in $-MPL format (see results of Experiment I). Meanwhile discount rates elicited with %-MPL choice task are lower than discount rates elicited with matching task, evidence that confirms the results in Chapter 3. Discount rates elicited with the matching task in Experiment II are higher than the discount rates elicited with either format of the choice task. As shown above, discount rates elicited by the choice task depend on the structure of the choice task that is adopted in the study. Therefore, it is possible that implementation of the matching task leads to elicitation of higher discount rates than those elicited with choice task, as well as the reverse.
The definition of decisional rules adopted by subjects in the present experiments enables us to analyse the discount functions generated by each elicitation method.

As shown above, the %-MPL choice task evokes a decision strategy that defines the threshold value where the choice switches from option A to option B. This threshold is constructed by subjects by considering the increment on the initially given amount that provides satisfactory compensation for waiting a certain period of time. The particularity of the decisional rules in the %-MPL choice task is that this increment seems to be defined by the subject once and then is proportionally increased depending on the duration of consequent elicitation intervals.

It is possible to represent this rule in the following way: \( x_t = x_0 + \Delta t \), where \( x_t \) is the threshold value at which the switch from choosing option A to choosing option B occurs for elicitation period \( t \), \( x_0 \) corresponds to the initial amount, \( \Delta \) is the increment required by the subject for waiting an additional period of time, \( t \) – is the duration of the interval of elicitation. The value of \( \Delta \) depends on the values that are available to be chosen from the table. This value is expected to correspond to values observed at central positions in the table and is defined by the subject on the first elicitation round.

The discount function that is generated by this decision rule is described in the following way:

\[
D(t) = \frac{x_0}{x_0 + \Delta t}
\]

Substitute \( k = \frac{\Delta t}{x_0} \) then

\[
D(t) = \frac{x_0}{x_0 + \Delta t} = \frac{1}{1 + kt}
\] (4.1)

As it is clear from equation 4.1, the decision rule of the form leads to generation of the discount function which can be represented by hyperbolic discounting with one parameter (Mazur, 1984). However, this decreasing pattern in the data is very slight compared to traditional evidence on hyperbolic discounting. Thus, following the rule in Experiment II, the subject’s choice would correspond to the discount rate of 25% for intervals of 6 months and 1 year and will decrease to 20% over an interval of 3 years. In fact, this was the choice of the median subject in the experiment for the first 3 intervals. The choices of 62% of subjects conform to this strategy. Given

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the small difference between corresponding discount rates and the relatively high variability of choices there is a need for a fairly large sample in order to detect this decreasing tendency in the data using standard parametric tests (as the literature on minimum detectable effect suggests Bloom, 1995).

Choices for the last two intervals corresponding to 5 and 10 years seem also to conform to this rule although the value of $\Delta$ is adjusted to increase.

In the $1$-MPL choice task the subjects’ choices were driven mainly by considerations of positive discounting. For instance, if on the round corresponding to an elicitation period of 6 months the switch from choosing option B to choosing option A happened at certain value, say €300, on the next round corresponding to an elicitation period of 1 year a subject will choose to switch at values equal or lower than the value chosen on the first round. To formalize this decisional rule assume that the table consists of $N$ alternatives that correspond to equally spaced diminishing values of the initial amount. That is $x_n = x_0 - n\Delta$, where $x_n$ is the value corresponding to option A at position $n$ of the table, $x_0$ is the value corresponding to initial amount, option B, and $\Delta$ is the value by which option A is decreased from position to position. In the case of experiments presented here $N = 20$, $x_0 = \€400$ and $\Delta = \€20$.

In the case of $1$-MPL elicitation format subjects can follow two possible strategies that satisfy positive discounting. One is to choose to switch always at the same position, i.e. declaring indifference between the same values of option A and option B regardless of the length of elicitation interval. This situation is described by the following discounting function:

\[ D(t) = \frac{x_0 - n\Delta}{x_0} \quad (4.2) \]

This discounting function corresponds to steeply decreasing discount rates, the decrease is sharper the higher is the position of the switch or the lower is corresponding value of option A at which the switch happens (see Table 4.2).

Another possible strategy is to choose to switch at lower amounts (higher positions in the table) as the length of elicitation period increases. The discount function of these subjects is expressed by:
\[ D(t) = \frac{x_0}{x_0 - n\Delta} \]
\[ D(t + 1) = \frac{x_0}{x_0 - (n + k)\Delta}, \quad (4.3) \]

where \( \Delta \) is the difference between positions in the $MPL$ table, \( n \) is the number of the position chosen by subject on elicitation interval \( t \), \( n \in [0; N] \); \( k \) is the jump in positions when passing to interval \( t + 1 \), \( n + k \in [n; N] \). Discount rates corresponding to this discount function decrease in a less steep fashion than those where the same position is maintained.

Notice that neither the discount function represented by equation (4.2) nor equation (4.3) depends on \( t \). It depends only on the value of \( \Delta \) and on the number of alternatives presented in the table. Therefore, the shorter is the elicitation period and the larger is \( \Delta \) the higher will be observed discount rate. Thus, among studies that considered the $MPL$ elicitation task the study by Tanaka et al. (2007) should lead to observation of the highest discount rates. Unfortunately this study does not report the results in terms of elicited discount rates but states that it finds support for quasi-hyperbolic discounting.

These results are not surprising given that the elicitation table was composed of only 5 alternatives corresponding to rather large value of \( \Delta \), around 17% of initial amount. At the same time the smallest elicitation period considered by the study corresponds to 3 days while the largest is 120 days (40 times larger than the smallest period). Given this elicitation structure it is straightforward to expect that discount rates corresponding to the shortest period will be very high while those corresponding to the largest will be relatively smaller and vary less between larger periods of elicitation compared to the sharp drop observed while passing from the shortest interval of elicitation to the next one (standard deviation of the structure in terms of interest rates of the table corresponding to 3 days is 56 larger than standard deviation of the table corresponding to 120 days, the largest interval).

The $MPL$ table considered in the present study implemented the value of \( \Delta \) that is only 5% of the initial amount with 20 positions at which the switch could happen. The largest period of elicitation is only 20 times larger than the smallest. As a consequence discount rates elicited in Experiment II decrease in a stable way without any sharp collapses and can be the best
approximated by one parameter hyperbolic discounting function of the form of equation (4.3).

Therefore, implementation of the $-MPL choice task may lead to a variety of observed results depending on the structural choices made by the experimenter. If the amount of elicitation is relatively large with large $\Delta$ compared to the initial amount, and the interval of elicitation starts at a very short length with sharp proportional increases (it may even not correspond to very long periods of time, what is important is the proportional increase) implementation of the $-MPL choice task may lead to observation of quasi-hyperbolic discounting. If instead the magnitude of the elicitation amount is not large and alternatives on the elicitation table do not differ much, leading to a large number of alternatives on the table, and if intervals of elicitation do not differ greatly, the $-MPL choice task will lead to observation of less sharply decreasing discount rates.

The matching task in delay payoff frame unlike the choice task in the %-MPL and $-MPL formats discussed above, is not characterized by a strong underlying structure. Subjects are free to express their preferences and can report what amounts they like. From the analysis of decision rules adopted in Experiment II it emerges that subjects faced with matching task tend to define certain values as compensation for waiting given periods of time. This compensation value is normally seen as an increment required to be added to the initial amount to compensate the subject for waiting. This strategy seems to be similar to that observed in the %-MPL choice task. The difference between the two methods lies in the desire to reach the threshold value on the difference between the two options in the %-MPL choice task while, in the case of matching task, the value of option B is of greatest concern to subjects. Although this difference may seem insignificant, for a rational agent it should lead to the same value attributed to option B, which is not what was observed in the experiment. Subjects tend to be attracted by “focal” values in the definition of these threshold amounts. While in the %-MPL choice task $\varepsilon50 seemed to be a reasonable compensation amount for waiting 6 months corresponding to $\varepsilon450 of option B, in the matching task this value reaches $\varepsilon500 or other multiples of 100. Therefore, subjects tend to come up with much higher values attributed to option B on the matching task. At the same time subjects report that they proportionally reduce the compensation value with an increase in the interval of elicitation.

The amount that is reported by subjects as providing the same satisfaction as option A at time $t$, option B, can be formalized as: $x_t = x_0 + \Delta(t)t$, where $x_t$ is the amount reported
by subject at elicitation interval $t$, $x_0$ is the initial amount, $\Delta(t)$ is the compensation required for waiting a period of time $t$, $\Delta(t)$ is a decreasing function of time. Then the corresponding discounting function takes the following form:

$$D(t) = \frac{x_0}{x_0 + \Delta(t) \times t}$$

Some subjects follow an even simpler rule (Frederick et al. (2002)):

$$D(t) = \frac{x_0}{nx_0}$$

Initially $\Delta$ in the matching task is quite large proportional to the initial amount and decreases dramatically within the next elicitation period remaining more or less constant for larger elicitation intervals. As can be seen from Figure 4.1 the discount rate associated with this decision rule is rather high for the first elicitation period after which it decreases more or less quite sharply. Intuition suggests that the shorter the initial elicitation interval and the proportionally larger is the next elicitation period, the sharper will be the decrease in the discount rate. For example, as previous analysis of table 10 suggests, subjects can be attracted to state the same value as required compensation for waiting different (but probably perceived by subjects as similar) intervals of time. At the same time, moving from a very short to a longer interval of elicitation produces a smaller proportional increase in the stated value of option B compared to moving from a larger starting elicitation interval. For example, in Treatments A and C subjects stated almost the same median compensation value for postponing receipt of the payoff by a year. But their starting elicitation interval was 1 month in Treatment A and 3 months in Treatment B. Therefore, discount rate elicited in Treatment C experienced a very sharp decrease compared to the decrease in Treatment A. Thus, discount rates elicited in Treatment C resemble a quasi-hyperbolic pattern while those in Treatment A present a less steep hyperbolic trend.

Although the matching task imposes less structure on subjects’ decision processes compared to the choice task it also presents some regularities. The main characteristic of the matching task is the propensity of decision makers to choose very high compensation amounts for shorter elicitation intervals and reduce the claims with an increase in the length of the elicitation period. Therefore, in the matching task the choice of the length of elicitation intervals and the distance
between successive intervals appear to be important elements of the experimental design and can lead to observation of more steep, quasi-hyperbolic, decreasing patterns or less dramatic trends in discount rates.

4.5 Conclusions

This study represents a first systematic attempt to study the influence of different elicitation methods in experimental elicitation of time preference. Although some sporadic examples of similar efforts can be found in the literature (Read and Roelofsma, 2003; Manzini et al., 2008, Chapter 3 of this thesis) existing studies were not developed to address this question and as a consequence provide only partial evidence on the phenomenon. For example, the scope of Manzini et al. (2008) was to study the effect of the structure of real incentives, therefore different incentive procedures were compared. Read and Roelofsma (2003) studied the implications of subadditive discounting and provided comparisons between matching task and choice task to show that the subadditive effect is maintained regardless of the elicitation procedure.

The analysis in the present study explains the variation in the discount rates from study to study, observed in literature review by Frederick et al. (2002). I show that the magnitude of the elicited discount rates depends on the elicitation method implemented in the study. Moreover, it is demonstrated that elicited discount rates are sensitive to different features of the experimental design: amount of elicitation, number of elicitation periods and their length, limits that are implicitly (e.g. in elicitation with matching task in speed up frame subject cannot choose an amount smaller than 0 or larger than the amount of elicitation) or explicitly (in elicitation with matching task in delay frame with BDM incentive procedure there is a need to establish the maximum amount) imposed by the experimenter, incentive structure and elicitation task.

This sensitivity of elicited discount rates to experimental design may explain the “lack of methodological progress” to which Frederick et al. (2002) refer in discussing experimental evidence on time preference. Experiments on time preference can be characterized by a high level of heterogeneity in the experimental procedures adapted by each study. Replication of and building on previous results is not a common research strategy in this area of experimental research.
In a study that compares alternative elicitation methods it is probably expected that recommendations can be provided about which elicitation method is the best and why, and when a particular method of elicitation should be implemented rather than another. Unfortunately the investigation in the present study adds more perplexities than the answers it provides.

The main concern of methodological enquiries on elicitation procedures of time preference so far has been in finding the method that provides the correct incentives to subjects (Andersen et al., 2006; Manzini et al., 2008, etc). Choice task from this point of view is the most appropriate. It is very easy to explain to subjects. The $-MPL choice task is considered to be the easiest for subjects to understand, alternatives of choice are seemingly free from researcher influence since the values decrease naturally from the initial amount to the least possible amount usually around 0 (Manzini et al., 2008). As a consequence this method is often implemented in elicitation of time preference in developing countries (Pender, 1996; Tanaka et al., 2007). At the same time, the limits that this method imposes on subjects’ choices are too strong as demonstrated by the present experiments. Its implementation leads to observation of hyperbolic discounting a priori.

The %-MPL choice task on the other hand strongly depends on the choice of values of corresponding interest rates by the experimenter. Subjects perceive the values they are faced with on this task as “correct” values from which they can choose, or values that are admissible by the researcher (Andersen et al., 2006). Most subjects try to comply with these values. Additionally, to construct reasonable alternatives of choice, while keeping a reasonable interest rate structure, there is a need for relatively high amounts of initial money (Manzini et al. (2008)). Therefore, it is not possible to provide payment to each individual, but there is a need to introduce additional structure into the payment procedure (such as random assignment of the winning amount).

Providing real incentives in matching task is difficult. The BDM procedure appears to be attractive from a theoretical point of view. But experiments with real subjects show that it is difficult to understand in practice. The results of the present study also show that the matching task is more sensitive to real incentives than either of the choice tasks considered in the study.

This study has demonstrated that the results of the experiment in time preference strongly depend on the structure of the elicitation task that subjects are faced with. Implementation of real incentives does not seem to solve this problem. It is shown that implementation of one elicitation method rather than another determines the results of the experiment a priori.
Moreover, each elicitation task generates particular patterns of discount rates.

Extended theoretical research on time preference has concentrated on finding the discounting function that best accommodates the experimental data. Thus a plethora of possible candidates has been proposed in addition to the traditional exponential discounting function (Samuelson, 1937). Different formulations of hyperbolic discounting, such as one parameter hyperbolic discounting (Mazur, 1984), quasi-hyperbolic (Laibson, 1997), generalized hyperbolic (Loewenstein and Prelec, 1992), proportional (Harvey, 1994) as well as discounting functions that account for evidence of negative time preference (Loewenstein and Prelec, 1991) have been applied.

The present study demonstrates that experiments can generate a plethora of patterns in experimental data. While it is possible to rationalize each data pattern ex-post it is not clear which pattern is the one that represents the “true” time preference if such exists. The recently reopened debate on whether discounting is hyperbolic or exponential that involved numerous studies (Benhabib et al., 2006; Tanaka et al., 2007, etc.) have not produced concrete answers as each study proposes different estimates of the same phenomenon.

Classical theoretical arguments, such as linearity of utility function associated with monetary payoffs (Frederick et al., 2002) and its recent treatment (Andersen et al., 2008), which traditionally are expected to solve the problem of variability of discount rates do not address the challenge posed by the failure of method invariance. The form of utility function over monetary payoffs is expected to be the same regardless of elicitation method. Therefore, even applying a utility function different from the linear elicited discount rates will produce different patterns.

The failure of method invariance has received extensive treatment in the risky choice experimental literature where it is called preference reversal (Lichtenstein and Slovic, 1974; Tversky et al. 1988; Kahneman et al. 1990, etc). Prevalent opinion in this stream of research is that subjects’ choice in experiments is not characterized by stable preference relations but is rather constructed based on elements of experimental design (Lichtenstein and Slovic, 2006). The discrepancy between choice task and matching task is explained by different decision rules implemented by subjects faced with these elicitation procedures. The results of the present experiments seem to confirm these ideas for time preference.

Accepting the preference construction perspective the question of the best elicitation method
is related to the ecological validity of the method, i.e. how well the method represents decisions involving time preference that individuals face in everyday life. Research efforts should concentrate on studying real life decisions of relevance to the field: decisions related to savings, investments, purchase of durables and choice of payment procedures associated with them, etc. Knowledge of the features of decision problem as well as the representation of problem at the moment of choice will help to produce more reliable results that will help to explain many behavioural anomalies registered in the field: excessive credit card use, too low levels of savings, etc.
Chapter 5

Framing effects in MPL choice task elicitation method

5.1 Introduction

The choice task elicitation procedure is widely diffused in experimental literature on time preference. The choice task (CT) requires subjects to choose between two options of payoffs available at different time delays, for example $100 today or $110 in one year. There are two major advantages in using this task: (a) for experimenters it is easy to explain to subjects; (b) for subjects it is easy to understand. Moreover, the implementation of real incentives with choice task is straightforward compared to alternative elicitation procedures from the point of view of experimental design.

A single choice task question makes it possible to establish whether discount rate is higher or lower than the interest rate corresponding to the alternatives of the choice task. For instance, if an individual prefers $100 today to $110 in one year her individual annual discount rate is higher than 10%. To elicit individual discount rate subjects are faced with a series of choice questions of the type: "do you prefer $100 today or $100+x in one year with an increasing x".

1This chapter builds on the joint work with Roberto Gabriele titled: "The elicitation of time preference with choice task in multiple price list format: is it all about structure? ", published in the Rock WP series (2008).
It is expected that the subject will choose $100 today for some values of x and will switch to
the option of $100 + x in one year to be able to benefit from higher values of x. The value of x
where this switch happens defines the value of discount rate. Henceforth, we refer to this value
as the switching point. This elicitation procedure is referred to in the literature as a multiple
price list (MPL) elicitation (Coller and Williams, 1999).

The MPL elicitation procedure has been extensively used in experimental research on time
preference due its simplicity. The simultaneous presentation of the list of alternatives in table
form is believed to ensure consistent responses within subject (Andersen et al, 2006) and it has
recently become the most popular procedure of elicitation with MPL in experimental studies on
time preference.

The discount rates elicited with MPL choice task differ both quantitatively and qualitatively
in the various studies. From a qualitative point of view two types of results can be observed.
On one hand a large number of studies find support for hyperbolic discounting, meaning that
elicited discount rates decrease with the increase of the elicitation interval (Green et al., 1997,
Pender, 1996, Manzini et al., 2008, Tanaka et al., 2007, etc). On the other hand, several other
studies present evidence of rather stable discount rates over time (Harrison et al., 2002, Read et
al., 2005, Coller et al., 2005, etc.).

From a quantitative point of view, discount rates elicited in studies that register hyper-
bolic discounting are considerably higher than interest rates observed in corresponding financial
markets (Ostaszevski et al., 1998). Meanwhile discount rates observed in studies that lead to
observation of constant discounting are typically much lower compared to studies that observe
hyperbolic discounting and are closer in magnitude to corresponding market rates of interest.

Harrison and Lau (2005) expresses the opinion that hyperbolic discounting is created by
experimental procedures implemented in corresponding studies. Normally studies that observe
stable discount rates implement real incentives and use front-end-delay (FED) presentation to
elicit time preference\(^2\). They claim that correction of experimental procedures for these two
factors will diminish observation of the hyperbolic pattern in the data. Contrary to this view
Tanaka et al. (2007) as well as Manzini et al. (2008) implement real incentives but find support

\(^2\)A detailed discussion of the significance and role of FED in experiments on time preference can be found in
Chapter 3.
for hyperbolic discounting. Slonim et al. (2007) in addition to real incentives, studies the impact of FED and still observes evidence for hyperbolic discounting. Therefore, experiments that are apparently similar, at least from the point of view of experimental procedures, produce qualitatively different results.

It should be noted that the fundamental feature that distinguishes the studies mentioned above is the way in which alternatives in the MPL table are constructed. In studies where hyperbolic discounting is observed, subjects are faced with fixed nominal values of alternatives available for choice. Subjects are asked to choose between a fixed payoff delayed by varied intervals and immediate payoff that is a proportion of the immediate payoff. For example, Green et al. (1997) confronted subjects with the choice between $100 delayed by 3, 6, 12, 36, 60, 120 and 240 months (with each option giving immediate payoffs ranging from $1 to $99. In this case subjects are faced with the same nominal values of alternatives for all elicitation intervals considered in the study. We refer to this MPL table as MPL with nominal structure ($-MPL) to emphasize that subjects are confronted with the same nominal values for all periods of evaluation.

An alternative approach is to fix the structure of the interest rate with which delayed payoffs are constructed departing from immediate payoffs. For instance, in Harrison et al. (2002) subjects are asked to choose between option A that offers 3000 DKK in 1 month and option B that corresponds to a nominal value that ranges from 2.5 to 50% increase on option A in 6, 12, 18 and 24 months. Therefore, while in $-MPL subjects are always faced with the same nominal values even if the interval of elicitation changes, in this MPL structure only the value of the immediate option remains constant while the value of delayed payoffs depends on the interval of elicitation and the corresponding interest rate. We refer to this way of constructing the MPL table as MPL with an interest rate structure (%-MPL) to underline that alternatives with which subjects are faced correspond to the same interest rate regardless of the length of the evaluation period.

Given that most of research in time preference that has implemented these two methods of elicitation, calculates discount rates assuming linear monetary utility function; we keep this assumption for the sake of present discussion. Thus, we define the discount rate as:

\[ dr = \sqrt[12]{\frac{LL}{SS}} - 1 \] (5.1)
Although the definition of the discount rate is common across the two approaches, there is a difference between $-\text{MPL}$ and $\%\text{-MPL}$ elicitation structures, namely the boundaries that the tables impose on the subject’s choices. Given that the final interest of these studies is in the elicited discount rate, we analyze these limits in terms of interest rates that correspond to the alternatives of choice.

In $\text{-MPL}$, these limits vary with the length of the interval of elicitation. The structure of the $\text{-MPL}$ table in terms of the corresponding interest rate is represented by the expression:

$$ir(t, \pi_{it_0}) = \sqrt{\frac{100}{\pi_{it_0}} - 1},$$

where $\pi_{it_0}$ represents immediate payoff corresponding to the alternative $i$. Values of the immediate as well as of the delayed payoffs associated with the same alternative $i$ on the table remain the same for all intervals of elicitation. Therefore the interest rate corresponding to the same position $i$ on the $\text{-MPL}$ table over a specific elicitation interval depends exclusively on the $t$-th root of the proportion between immediate and delayed values. In this case $t$, the length of the time interval, varies and nominal values of payoffs remain constant. From the calculus point of view, this function is hyperbolic. Thus, the choice of subjects in $\text{-MPL}$ elicitation can be seen as a choice of a point on a series of hyperbolic lines that correspond to the alternatives of choice in $\text{-MPL}$ table.

To have an idea of the differences of choices constraints imposed by the two procedures we show two paradigmatic examples. Figure 5.1 presents bounds on discount rates imposed by the payoffs available for the subjects’ choice in Green et al. (1997). Since the limits of the table reach extreme values for the shortest interval, see Table 5.2, the discount rate representation scale in Figure 5.1 is logarithmic. The menu of discount rates available for choice for the shortest period of elicitation is very large and decreases considerably when the longest period of elicitation is reached.

A distinctive feature of the alternative $\%\text{-MPL}$ table compared to the method discussed above is that in $\%\text{-MPL}$ the structure of the corresponding discount rates remains stable while nominal values corresponding to different time periods change. Figure 5.2 illustrates an example of such a presentation based on the Harrison et al. (2002) study.
Concerns about framing effects in choice task elicitation procedure are not new to experimental literature in time preference.

For instance, Frederick et al. (2002) in their discussion of elicitation procedures for time preference note that when subjects are asked to make multiple consecutive choices between immediate and delayed payoffs they may be influenced in their choice by payoffs corresponding to the alternative presented on the first round of the task.

A frequent concern with the application of the MPL elicitation procedure in time preference is that the experimenter needs to choose bounds on the MPL table (Anderson et al., 2006). While
Figure 5.2: Upper and lower limits of the MPL used by Harrison et al. (2002) and mean discount rates observed in the study.
this issue is less relevant in risky choice where these limits reflect natural limits of probability
the choice of boundaries on the MPL table in time preference is arbitrary. Subjects faced with
the MPL table may consider these boundaries as being “the right values from the point of view
of the experimenter and will adjust their choice according to this belief.

Extensive research in psychophysics demonstrates that subjects asked to express quantitative
judgment on a scale rarely choose extreme values of the scale preferring values that lie closer to
the center of the scale rather than to the boundaries (Poulton, 1989). Moreover, this choice is
highly dependent on the structure of the scale: values elicited with symmetric scale are higher
than values elicited with the scale skewed towards lower values. This tendency is called response
contraction bias. Meanwhile, subjects faced with sequential evaluation tasks tend to anchor their
current response to the previously reported value. This situation is referred to as transfer bias.

Experiment I in Chapter 2 of the present dissertation was developed to study the effect of
the middle table effect in %-MPL representation. This study was built upon the hypothesis
that if the middle table effect is caused exclusively by the table representation of alternatives,
elicitation with the table format will lead to the observation of the middle table effect in data.
Meanwhile it was expected that presentation of the same task chosen one at a time in random
order would not result in a concentration of choices around the middle positions in the table.
As it is clear from the results of the experiment reported in Chapter 2 subjects tended to make
a similar choice in both treatments. However, further analysis of data showed that the way the
table was set out made the middle positions on the %-MPL table more attractive to subjects.

Experiment II in Chapter 4 implements the same %-MPL table administered in Experiment I
of Chapter 3 in random order. Experiment II in this Chapter, however, presents subjects with the
table eliciting time preferences over more ample range of elicitation intervals. Both experiments
considered elicitation over a 6 months period and no statistical difference was found between the
two treatments leading to the conclusion that subjects were not influenced in their choices by a
middle table effect (see Table 4.7, Chapter 4). However, it is also observed that choices over all
elicitation periods for the %-MPL elicitation task are concentrated around the middle positions
on the table. Analysis of subjects’ reports from their final feedback questionnaires suggested a
joint effect of the structure of the table and nominal values, which made up the table.

Anderson et al. (2006) study the middle table effect (response contraction bias) and order
effect (transfer bias) in elicitation of time preference with %-MPL. The middle table effect in this study is dealt with in a different way to the approach taken in this dissertation. Subjects were given 3 different tables. One of them corresponded to constant increments of annual revenue, symmetric treatment. The other two treatments implemented asymmetric increments: one skewed to low values of corresponding revenue, the other one skewed to high values. Unfortunately, the number of choice rows, alternatives, of the table did not correspond between treatments, being fixed at 10 for symmetric treatment and only 6 for both of skewed treatments. Moreover, overall design of the study involved 3x3x2 treatments for time preference randomly assigned to 90 subjects that participated in the study. The very small sample size compared to the number of treatments implemented in the study makes it impossible to conduct any kind of significant test on the obtained data. The data was analyzed with the help of econometric estimation. It was found that the order of presentation of intervals in time preference tasks has a significant effect on the elicited discount rates. Meanwhile econometric estimation does not provide a significant coefficient for the dummy introduced to the test middle table effect in time preference while in tasks with risky choice this effect is significant. However, absence of significance of middle table effect in time preference treatments may be due to the joint effect of order and middle table effects since the sample size in each condition was very small.

Comparative analysis of $-MPL and %-MPL with existing experimental studies is hard to carry out/perform due to the difficulty in obtaining individual level data from each study. Moreover, the different experimental procedures used in each study, i.e. nature of payoffs, sample size and composition, etc., and differences in experimental design, i.e. magnitude of payoffs, considered time horizons, length of FED, etc., make these comparisons impossible.

Performing this analysis with experimental methods has proved to be a very difficult and costly procedure. It would require replication of a series of experiments that implemented different structures of $-MPL and %-MPL tables using subjects from the same population and maintaining the same experimental conditions across replicated studies.

Two main obstacles arise in this research. On one hand, there is a need to conduct these studies with real incentives (Harrison and Lau, 2005) that leads to significant monetary investment. On the other hand, implementation of real incentives significantly limits the time period
(horizon) that can be considered in the experiment due to the difficulty of making distant payments trustworthy for subjects. A large population of homogeneous subjects is also needed to be able to construct a reliable subject pool.

To overcome these difficulties, we conduct experiments with artificial agents using computer simulations in the style of Gode and Sunder (1993). In this study Gode and Sunder conduct market experiments in which human traders are replaced by “zero-intelligence” algorithms that submit random bids. Their study is focused on allocative efficiency of double auction with induced individual values (Smith, 1976). It was demonstrated that by imposing budget constraint (making artificial players sell below their induced prices or buy beyond induced reservation values) it is possible to reach 100% allocative efficiency in this double auction market. Behavior of artificial traders with an imposed budget constraint resembles behavior of human subjects in double auction experiments conducted with the same design. From these simulations it is concluded that the primary cause of allocative efficiency of double auctions is the market discipline imposed on traders under the notion of induced values.

Similar to the work by Gode and Sunder our goal is to distinguish between individual rationality expressed by cognitive rules adopted by single human players in experiments as well as the structure of the task with which a single player is faced.

5.2 The design of the simulation experiment

The core idea of the simulation exercise is to replicate typical experiments on time preference elicitation using different groups of artificial agents (AA) endowed with simple behavioral routines as experimental subjects. Next, we conduct an investigation of the results that can be obtained by making use of different multiple price list tables in which elicitation periods and the number of alternatives are modified.

We conduct our investigation by building a set of "artificial experiments" in which artificial agents - see below for an exact definition - are faced with the multiple price list tables usually used in the literature. In other words, we ask each of our AA to make a sequence of choices between ‘sooner smaller’ vs ‘later larger’ amounts.

Each artificial experiment is implemented referring to a sample of twenty AA, which represents
the average sample size used in experiments. AAs behaviors are based on simple stochastic algorithms, that is, their choices are based on given probability distributions chosen in order to reproduce the desired behavioral aspects of interest.

As a consequence, the same experiment with the same number of AA in general will lead to slightly different results due to the probabilistic nature of their choices. Hence, to investigate the robustness of the outcomes we conduct a Monte Carlo exploration using a sample size of 200.

We collect individual and aggregate results. In particular, we investigate the modifications induced on the median of the distribution of choices given that this measure is widely used in literature. The median provides information about the intensity of the distribution of a variable—in our case it is the discount rate—being robust respect to anomalous and extreme values\(^3\).

Computer simulations with artificial agents permit us to separate the effect of individual preferences from the effect that the decisional environment exercises on human choice\(^4\).

It seems difficult to perform experiments with human subjects with real payoffs that would extend for relatively long temporal intervals. At the same time expressed preferences in experiments with human subjects and hypothetical payoffs can be driven by other factors than those of real time preference. Therefore, to demonstrate the structural effect that elicitation mode has on population we replace human subjects by random preference artificial agents.

### 5.2.1 Artificial agents

Artificial agents in the following simulations are faced with MPL tables and are required to make their choice between immediate and delayed payoffs for each alternative presented in the table. Our interest in this exercise is to elicit discount rates. This elicitation consists of the identification of the switching point — the row at which the subject switches her choice from choosing the sooner alternative to choosing the later alternative\(^5\). The choice of artificial subjects is set as a choice of

\(^3\)This is exactly the reason why in experimental literature median is preferred to mean, which is a measure of the intensity of the distribution that is biased by extreme values, i.e. the outliers. Indeed, one of the problems in this analysis is the existence of “strange” experimental subjects, e.g. individuals that did not understand the experimental rules or individuals that would take part just to earn the participation fee and did not carry out the experiment seriously enough. If these elements are not taken properly into account they can seriously bias the results of the experiments.

\(^4\)Experimental studies that implement MPL procedure to elicit time preference only consider the results of the subjects that make consistent choices in their analysis, i.e. they only make one switch from choosing an immediate payoff to choosing a delayed payoff (Andersen et al., 2006, Manzini et al., 2008).

\(^5\)The simulations are run using R language. The source code is available upon request to the authors.
the row in which the switch takes place. Thus, given the number of alternatives and rows in the

table which correspond to the same time horizon in the MPL elicitation format, the choice of

artificial agent will correspond to the alternative in which the switch from choosing immediate
to delayed option occurs for this agent.

We first consider artificial agents whose choice is induced by a random selection from an
even distribution of alternatives available over a given time interval. Henceforth, “player with
random preferences” (RA). This choice does not impose any requirements on the artificial agent
preference structure. Analysis of these players’ behavior will permit us to draw conclusions on
the effect that the structure of the elicitation task exercises on their observed preferences.

As was seen in the analysis of the decision rules implemented by human subjects in experi-
ments in Chapter 4, considerations of positive discounting represent strong decisional factors in
individual choice. Positive discounting is a general assumption in economics research. A subject
respects positive discounting constraint if in a situation of choice between the same payoff that
can be paid today or tomorrow where invariably payoff paid today is chosen.

In the framework of the present experiment, the positive discounting constraint is translated
into the following condition: payoff available today that corresponds to $100 delayed by $t_2$ is
perceived as providing a smaller value than today’s payoff corresponding to $100 delayed by $t_1$,
where $t_2 > t_1$. Therefore, the subject who chooses $80 today over $100 in 3 months cannot
value $100 in 6 months more than $80.

The positive discounting constraint reduces the number of choice alternatives that the subject
considers on a successive elicitation task corresponding to a different time interval. The switching
point of the agent with positive discounting constraint is defined over alternatives that satisfy
positive discounting condition for the current time horizon given the choice on a previous time
horizon. For the $-MPL elicitation task, considerations of positive discounting necessarily reduce
the number of alternatives that can be taken into analysis on the current round. This is due to
the fact that nominal payoffs do not change in value from one elicitation period to the other.

In the %-MPL elicitation task, the number of alternatives or decision rows that will be cut, by
positive discounting, from the subjects’ analysis depends on the nominal values that make up the
%-MPL elicitation table on the current elicitation period. This, in turn, depends on the length
of elicitation period and interest rate, annual revenue, corresponding to decision rows.
To study the effect of positive discounting constraint on choice behavior, simulations are performed with players with random preferences and positive discounting constraint (RAPD). Each choice of RAPD player is generated as a random draw from a uniform distribution defined in a range of alternatives that satisfy positive discounting constraint on the current round.

The analysis of decisional rules governing subjects in experiments performed in Chapter 4 suggests that anchoring to the previous choice also influenced their choice to switch row in the experiment. Anchoring to a previous choice appears to be a very important decision-making strategy that subjects adopt in experiments that is confirmed by vast experimental evidence (Andersen et al., 2006, Green et al., 1998; Ladenburg, 2006). To model anchoring to the previous choice in simulations we need to find probability distribution that permits the generation of choice with a pick of probability associated to the position of previous choice. Among all possible distributions binomial distribution was selected for this role. This distribution is discrete and is defined over a flexible support, a feature that is important if one wants to compare the effect of adding more or less entries to the elicitation table. Moreover, the binomial distribution has only one parameter, namely the probability of success. Calibrating this parameter allows us to study situations in which more or less anchoring is present in the structure.

Hence, to model anchoring to the choice made on the previous time horizon (transfer effect) we introduce artificial agents whose choice is generated as a random draw from a binomial distribution – players with random preferences anchored to the previous choice (AN). The choice of an AN player in the current period depends in probability on the choice made in the previous period.

However, the analysis of decision rules in Chapter 4 reveals real behavior of human subjects is affected by both considerations of positive discounting and anchoring to the previous choice. Therefore, we introduce a fourth type of agent whose decision on a current round depends on the choice made on a previous round - players with random preferences anchored to the previous choice that respect positive discounting constraint (ANPD). However, current choice can be based only on decision rows of the table that respect positive discounting constraint. As was mentioned earlier, the $-MPL and %-MPL table structure react differently to the introduction of positive discounting. In $-MPL positive discounting cuts out all the alternatives that precede the switching row of the previous choice and current choice can be based only on decision rows.
that lie below the one chosen earlier. In %-MPL positive discounting constraint can cut out more positions or less positions depending on the nominal values associated with the table for the current elicitation period. See 5.3 for a schematization of the choice structure.

Choice in the first period of simulations is equal for all types of agents and is generated by a random draw from a uniform distribution. To add more realism to the generated patterns, simulations are repeated with the same types of agents for which the first choice corresponds to the choice made by human subjects in the experiment with human subjects.6

To sum up, in the present study we conduct simulations with four types of artificial players. Discount rates observed with players with random preferences (RA) generated by a random draw from uniform distribution are defined by the structure of a given MPL table. Simulations with RAPD and AN players make it possible to study the effect attributed to the choices based on positive discounting and choices motivated by anchoring. Finally, the behavior of ANPD players is expected to resemble human subjects’ behavior in laboratory experiments. See table 5.1 for a summary of the considered AA.

Figure 5.3: The structure of choice of a ANPD artificial agent in two consequent periods.

6This operation is not performed for agents with random preferences as their choice on each elicitation interval is independent from a previously made choice.
Table 5.1: The types of agents used in the simulation analysis.

<table>
<thead>
<tr>
<th>Agent label</th>
<th>Agent description</th>
<th>Prob. distrib. used to represent behaviors</th>
<th>Positive discounting</th>
<th>Anchoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA</td>
<td>random preference agent</td>
<td>uniform distribution</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>RAPD</td>
<td>random preference agent with positive discounting</td>
<td>uniform distribution</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>AN</td>
<td>anchored choices agent</td>
<td>binomial distrib.</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>ANPD</td>
<td>anchored choices agent with positive discounting</td>
<td>binomial distrib.</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

5.2.2 Table structures

The present study compares patterns of discount rates elicited in simulations with artificial agents faced with $-MPL and %-MPL. The results of present simulations will be compared to the results of laboratory experiments performed with real subjects.

To obtain comparable results with existing experimental evidence, elicitation tables implemented in Experiment II and presented in Chapter 4 are used for simulations in the present study (see Table 4.2 and 4.3).

The implementation of these tables offer several advantages for our goals. First of all, this is the only study that has been developed to experimentally compare $-MPL and %-MPL elicitation tasks. Tables administrated to subjects in this study are comparable from an experimental point of view given that elicitation was performed over the same amount of money, each table consisted of the same number of rows and the same length of intervals was considered for elicitation with both methods. The results produced with simulations implementing these tables are directly comparable to data collected in the experiment with human subjects both qualitatively and quantitatively.

Experiments that implement the MPL elicitation method normally elicits discount rates within the same time horizon while different temporal horizons are presented to subjects starting with shorter periods of time and then gradually increasing . We follow this presentation of time horizons in our simulations.

We propose a set of simulations not only for the tables used in Chapter 4 but also for
some tables that can be found in literature to show the ability of the algorithm in replicating experimental results obtained with different table structures and procedures.

As a representative example of elicitation with $-MPL table we use data reported in Green et al. (1997). Subjects are faced with $100 delayed by 6, 12, 36, 60, 120 and 240 months and immediate payoffs ranging from $1 to $99, forming 24 positions for each of 6 time horizons. Although there are many experiments that implement $-MPL this study is the only one that reports medians of elicited discount rates, other studies normally fit their data to some discount function and only coefficients that results from these regressions are reported in the studies (Ostaszevski et al., 1998, Slonim et al., 2007, Tanaka et al., 2006, etc.). Time preferences are also elicited over longer temporal intervals although this elicitation is done with hypothetical payoffs.

The structure adopted in Harrison et al. (2002) can be considered a typical example of elicitation with %-MPL format. This table structure was implemented in a series of later experiments becoming a sort of gold standard for experimental elicitation of time preferences. Therefore, a large set of experimental results can be found in literature obtained with this elicitation method. In the original study MPL table was constructed as a choice between payoff of 3000 DKK delayed by 1 month and payoffs delayed by 7, 13, 25 and 37 months yielding annual revenue of 2.5% to 50% of principal amount of 3000 DKK for the corresponding interval of time (see table 4.2).

To sum up, we perform simulations with 4 types of players and 2 types of structures of the MPL elicitation task, $-MPL and %-MPL. We conduct these simulations with players whose choice on the first round is generated as a random draw from the uniform distribution. Simulations are repeated with agents whose first choice is made to replicate the choice made by human subjects in the laboratory experiments. In addition, the last simulations are performed with the table structures from Green et al. (1997) and Harrison et al. (2002).

For each simulation the choices corresponding to 20 artificial agents (sample size of the Experiment II in Chapter 3) were made for each simulation. Results of simulations were positively tested for robustness using the Monte Carlo technique: each condition was repeated 500 times. The present study reports median and corresponding standard deviation obtained on each Monte Carlo experiment. For other comparisons with real subjects the design sample size was adjusted to the number of subjects participating in the original experiment.
5.2.3 Results of simulations

We first present results of simulations that explore the role of the structure of the table and analyze the effect of different decision rules. For these purposes we perform simulations with four types of players whose choice on the first round of elicitation is modeled as a random draw from the uniform distribution.

The choice of the statistics to report our results is not an easy task. Studies that implement choice task in the format considered here often only report coefficients corresponding to the fit of different discount functions to the data (Tanaka et al., 2006, Slonim et al., 2007, Harrison et al., 2002, etc.). These coefficients however do not provide information on the magnitude of the observed discount rates. It is also difficult to judge the form of the discount function relying only on this information. We consider the median to be a representative presentation of the distribution of discount rates given high variation of discount rates observed in these studies. To put it differently, we use the median given that it is a robust synthesis against anomalous values of the distribution of discount rates. Moreover, presentation of results in terms of medians makes it possible to compare results from simulations with results observed in literature: the few studies that report aggregate statistics usually report median discount rates.

Figure 5.4: Results of simulations in MPL speed up frame ($) and delay frame (%) with different artificial subjects. Dotted line reproduces human subjects’ results of experiments reported in Chapter 4.

Discount rates elicited with $-MPL structure dramatically decrease with the increase in length.
of elicitation of time horizon (5.4(a)) while discount rates corresponding to %-MPL are perfectly stable (see Figure 5.4(b)). As it was noted earlier the choice of RA players is a random draw from the uniform distribution, therefore, this agent has random preferences to proposed alternatives and the choice is completely characterized by the form of the eliciting table. The Median RA player switches her choice at the middle row of the table regardless of the length of the elicitation horizon. In the %-MPL table this alternative always corresponds to the same discount rate associated with this middle table position.

In $-MPL this discount rate decreases with time:

\[ DR(t) = \sqrt{\frac{100}{50}} - 1 \] (5.3)

Therefore, a constant discount rate is observed in elicitation with the %-MPL table while the pattern with decreasing discount rates characterizes simulations with $-MPL table.

The introduction of the positive discounting constraint imposes restrictions on the consecutive choices of random preference players. Faced with the first time interval, in the first round of elicitation, any alternative can be chosen as a switching point with equal probability. Meanwhile, the choice on the second round, corresponding to the next temporal horizon, is restricted to alternatives that satisfy positive discounting. For the $-MPL, this is presented in a speeded-up scenario, a positive discounting constraint is applied to the choice of the immediate value. These immediate values should be lower than the one at which the switch happened for the first time horizon. In this case the choice of lower nominal values corresponds to higher discount rates for the same time horizon.

In the $-MPL immediate payoffs do not change across time intervals, therefore restriction to payoffs that do not exceed previous choice gradually restricts choice alternatives to the lowest value. When choice is generated as a random draw from the uniform distribution, RAPD agents, the lowest value is reached within few horizons. The speed of this convergence depends on the number of alternatives available for choice within a single horizon. Therefore, discount rates elicited over the $-MPL register an increase in the first elicitation horizon and then a decrease when the lowest values of the table are reached (see the left panel Figure 5.4). In general the hyperbolic pattern of median discount rates is observed for RAPD agents in simulations with
In the %-MPL presented in a delay frame, positive discounting constraint restricts choice of the later option. Again in this structure positive discounting constraint restricts the number of choice alternatives considered in consequent rounds of elicitation although this restriction is less severe: the choice of a certain position on a table as a switching point on the first considered time horizon does not necessarily exclude all the positions that precede this choice on a table on consequent time horizons, as happens in the $-MPL structure.

However, the number of positions that are not considered by the subject in this structure depends on the length of the horizon between current and successive choice and exponential expansion of the values in the table with this horizon. This expansion depends on the limits imposed on discount rates by the table. Therefore, the longer the distance between the two consecutive time horizons, the fewer are the positions taken away from the consequent choice. This particular feature of the %-MPL structure leads to the observation of slightly increasing discount rates elicited with the %-MPL structure for RAPD agents in our simulation.

Anchoring that is modeled by making the choice of switching point as a random draw from the binomial distribution, does not influence the choice of artificial agents in a significant way compared to RA players when the choice in the first elicitation period is made as a random draw from a uniform distribution. Anchoring increases the probability of choice of previously chosen alternatives. Given that the first choice of RA and AN agents is the same both procedures lead to similar results. Discount rates elicited with AN agents faced with $-MPL follow hyperbolic patterns while these agents faced with the %-MPL generate rather stable discount rates (Figure 5.4). The median choice of AN agents is concentrated around positions that lie in the middle of the corresponding table like RA players. Meanwhile the variance of the choices is lower compared to discount rates elicited with RA players.

Median behavior of players with preferences anchored to previous choices that respect positive discounting constraint, ANPD, approximate in the best way the trend of median discount rates of human subjects in experiments. Median discount rates for the $-MPL follow a decreasing pattern although the decrease in discount rates is not as steep as for RA players corresponding to the choice of the middle position.

Median discount rates elicited with the %-MPL decrease slightly as well. However, this
decrease is very small and discount rates appear to be almost stable within the time domain. This relative stability of discount rates observed with ANPD players is due to the joint effect of anchoring to the previous choice preferences and positive discounting constraint. Positive discounting constraint restricts the number of positions from the table considered for the current time horizon based on choice made in previous rounds, moreover all the positions that are smaller than the ones chosen on the current round are eliminated from consideration on the successive round. Anchored preferences are defined in a way to be able to maintain the pick of the distribution on a previously-made choice while the rest of the probability is distributed in a decreasing way over the positions allowed by positive discounting. With each successive round the number of positions diminishes while the probability of choosing the position lying next to the previously chosen position increases. This particular feature helps to keep the current choice close to the one previously made preventing extreme values of the table being reached as was the case for RAPD player in $-MPL. Therefore, a smooth decreasing pattern of discount rates is observed on the $-MPL. In the %-MPL table positive discounting does not necessarily eliminate all the positions preceding the one chosen on a previous time horizon, this elimination depends on the corresponding nominal values and can include more or fewer positions for each time horizon and given nominal value chosen on the previous time horizon. Therefore, binomial distribution in the %-MPL case may be defined over positions that precede the position on which probability is concentrated. This leads to the observation of a slightly decreasing median discount rate for ANPD players.

To demonstrate that results obtained from simulations are not specific to the experiments described in Chapter 4 we conduct additional simulations implementing MPL tables encountered in the literature. As an example of the $-MPL table we consider the elicitation task from Green et al. (1997) presented in table 5.2. For simulations with the %-MPL we adopt the MPL table from Harrison et al. (2002) (see tab. 5.3). Notice that the experimental design in Green et al. (1997) and Harrison et al. (2002) differ from experiments reported in Chapter 4 by the amount of elicitation and number and length of elicitation horizons.

The choice of RA players on successive time horizons, elicitation trials, does not depend in any way on the first choice. For this reason we do not analyze behavior of RA players in this section. We compare the performance of RAPD, AN and ANPD players with the behavior of
<table>
<thead>
<tr>
<th>Amount selected as SS available today, $</th>
<th>Interval of elicitation (LL option of $100 is available in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 years</td>
</tr>
<tr>
<td>1</td>
<td>26%</td>
</tr>
<tr>
<td>2.5</td>
<td>20%</td>
</tr>
<tr>
<td>5</td>
<td>16%</td>
</tr>
<tr>
<td>7.5</td>
<td>14%</td>
</tr>
<tr>
<td>10</td>
<td>12%</td>
</tr>
<tr>
<td>15</td>
<td>10%</td>
</tr>
<tr>
<td>20</td>
<td>8%</td>
</tr>
<tr>
<td>25</td>
<td>7%</td>
</tr>
<tr>
<td>30</td>
<td>6%</td>
</tr>
<tr>
<td>35</td>
<td>5%</td>
</tr>
<tr>
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<td>5%</td>
</tr>
<tr>
<td>45</td>
<td>4%</td>
</tr>
<tr>
<td>50</td>
<td>4%</td>
</tr>
<tr>
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<td>3%</td>
</tr>
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<td>65</td>
<td>2%</td>
</tr>
<tr>
<td>70</td>
<td>2%</td>
</tr>
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<td>75</td>
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</tr>
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<td>80</td>
<td>1%</td>
</tr>
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<td>1%</td>
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<td>1%</td>
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<td>0%</td>
</tr>
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<td>95</td>
<td>0%</td>
</tr>
<tr>
<td>97.5</td>
<td>0%</td>
</tr>
<tr>
<td>99</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 5.2: Elicitation table, Green et al. (1997).
<table>
<thead>
<tr>
<th>Payoff alternative</th>
<th>Payment option A (pays amount below in 1 month)</th>
<th>Payment Option B, (pays amount below in 7 months)</th>
<th>Payment Option B, (pays amount below in 13 months)</th>
<th>Payment Option B, (pays amount below in 19 months)</th>
<th>Payment Option B, (pays amount below in 25 months)</th>
<th>Tasso d'interesse associato</th>
<th>Preferred payment option</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>kr 3.000</td>
<td>kr 3.038</td>
<td>kr 3.076</td>
<td>kr 3.153</td>
<td>kr 3.233</td>
<td>2,5</td>
<td>A B</td>
</tr>
<tr>
<td>2</td>
<td>kr 3.000</td>
<td>kr 3.075</td>
<td>kr 3.153</td>
<td>kr 3.313</td>
<td>kr 3.482</td>
<td>5</td>
<td>A B</td>
</tr>
<tr>
<td>3</td>
<td>kr 3.000</td>
<td>kr 3.114</td>
<td>kr 3.231</td>
<td>kr 3.481</td>
<td>kr 3.749</td>
<td>7,5</td>
<td>A B</td>
</tr>
<tr>
<td>4</td>
<td>kr 3.000</td>
<td>kr 3.152</td>
<td>kr 3.311</td>
<td>kr 3.655</td>
<td>kr 4.035</td>
<td>10</td>
<td>A B</td>
</tr>
<tr>
<td>5</td>
<td>kr 3.000</td>
<td>kr 3.190</td>
<td>kr 3.393</td>
<td>kr 3.837</td>
<td>kr 4.340</td>
<td>12,5</td>
<td>A B</td>
</tr>
<tr>
<td>6</td>
<td>kr 3.000</td>
<td>kr 3.229</td>
<td>kr 3.476</td>
<td>kr 4.027</td>
<td>kr 4.666</td>
<td>15</td>
<td>A B</td>
</tr>
<tr>
<td>7</td>
<td>kr 3.000</td>
<td>kr 3.268</td>
<td>kr 3.560</td>
<td>kr 4.226</td>
<td>kr 5.015</td>
<td>17,5</td>
<td>A B</td>
</tr>
<tr>
<td>8</td>
<td>kr 3.000</td>
<td>kr 3.308</td>
<td>kr 3.647</td>
<td>kr 4.432</td>
<td>kr 5.388</td>
<td>20</td>
<td>A B</td>
</tr>
<tr>
<td>9</td>
<td>kr 3.000</td>
<td>kr 3.347</td>
<td>kr 3.734</td>
<td>kr 4.648</td>
<td>kr 5.785</td>
<td>22,5</td>
<td>A B</td>
</tr>
<tr>
<td>11</td>
<td>kr 3.000</td>
<td>kr 3.427</td>
<td>kr 3.914</td>
<td>kr 5.107</td>
<td>kr 6.662</td>
<td>27,5</td>
<td>A B</td>
</tr>
<tr>
<td>12</td>
<td>kr 3.000</td>
<td>kr 3.467</td>
<td>kr 4.006</td>
<td>kr 5.350</td>
<td>kr 7.145</td>
<td>30</td>
<td>A B</td>
</tr>
<tr>
<td>13</td>
<td>kr 3.000</td>
<td>kr 3.507</td>
<td>kr 4.100</td>
<td>kr 5.604</td>
<td>kr 7.660</td>
<td>32,5</td>
<td>A B</td>
</tr>
<tr>
<td>14</td>
<td>kr 3.000</td>
<td>kr 3.548</td>
<td>kr 4.196</td>
<td>kr 5.869</td>
<td>kr 8.209</td>
<td>35</td>
<td>A B</td>
</tr>
<tr>
<td>15</td>
<td>kr 3.000</td>
<td>kr 3.589</td>
<td>kr 4.293</td>
<td>kr 6.144</td>
<td>kr 8.793</td>
<td>37,5</td>
<td>A B</td>
</tr>
<tr>
<td>18</td>
<td>kr 3.000</td>
<td>kr 3.713</td>
<td>kr 4.595</td>
<td>kr 7.039</td>
<td>kr 10.783</td>
<td>45</td>
<td>A B</td>
</tr>
<tr>
<td>19</td>
<td>kr 3.000</td>
<td>kr 3.755</td>
<td>kr 4.700</td>
<td>kr 7.362</td>
<td>kr 11.532</td>
<td>47,5</td>
<td>A B</td>
</tr>
<tr>
<td>20</td>
<td>kr 3.000</td>
<td>kr 3.797</td>
<td>kr 4.805</td>
<td>kr 7.697</td>
<td>kr 12.330</td>
<td>50</td>
<td>A B</td>
</tr>
</tbody>
</table>

Table 5.3: Elicitation table, Harrison et al. (2002).
human subjects in experiments.

Figure 5.5, 5.6, 5.7 and 5.8 show discount rates generated in simulations in which the first period choice of artificial agents is set to the median discount rates observed in experiments with human subjects\textsuperscript{7,8}. Figures refer to the following experiments:

- Figure 5.5: $-MPL frame. Simulations with different artificial players and human results (experiment in Chapter 4);

- Figure 5.6: %-MPL frame. Simulations with different artificial players and human results (experiment in Harrison et al. (2002);

- Figure 5.7: %-MPL frame. Simulations with different artificial players and human results (experiment in Chapter 4;

- Figure 5.8: $-MPL frame. Simulations with different artificial players and human results (experiment in Green et al. (1997)).

As it can be seen from Figure 5.5, 5.6, 5.7 and 5.8 neither RAPD nor AN players closely reproduce patterns of human subjects’ median discount rates. Discount rates generated by RAPD players are much higher than corresponding discount rates observed with human subjects. In the $-MPL format, introduction of positive discounting constraint with random preference players leads to a fast convergence of choice to the lowest position on the table. Discount rates corresponding to this choice register a sharp increase in the second elicitation period. This increase is observed in both the $-MPL structures under analysis. As was discussed in the previous section an increasing or decreasing pattern of discount rate in this case depends on the length of its elicitation period and on the lapse of time separating successive elicitation periods. Despite the fact that there is the same tendency in the %-MPL format, convergence on the lowest position is much slower and is not observed in our simulations.

The choice of players with anchored preferences, AN agents, is anchored to the choice made on the previous elicitation period. These players’ choice is concentrated around the position

\textsuperscript{7}Where experimental data permits, in all analyzed studies except for Green et al., 1997, the first choice is generated as a random draw from binomial distribution that is defined over 95\% confidence interval of the median observed in the experiment with a pick of probability associated with the median.

\textsuperscript{8}For Harrison et al., 2002, we report discount rates expressed as an annual interest rate while in the study itself they are reported in terms of an annual effective interest rate.
Figure 5.5: Median discount rates of human and artificial subjects, $-MPL speeded up frame experiment II Chapter 4.

Figure 5.6: Median discount rates of human and artificial subjects, $-MPL delay frame Harrison et al. (2002).
Figure 5.7: Median discount rates of human and artificial subjects, %-MPL delay frame experiment II Chapter 4.

Figure 5.8: Median discount rates of human and artificial subjects, $-MPL speed up frame Green et al. (1997).
chosen on the first round. Therefore, in the $-MPL format this choice leads to the observation of sharply decreasing discount rates while in the %-MPL format it corresponds to generation of stable discount rates.

Discount rates generated by ANPD players closely reproduce patterns of discount rates observed in experiments with human subjects. Resemblance of the pattern of discount rates generated by artificial agents and discount rates observed with human subjects is especially strong for both elicitation tables in the $-MPL format.

Discount rates elicited in simulations with the %-MPL format show a slightly decreasing pattern of discount rates than those observed with human subjects but fail to reproduce tendency to increase observed in both experiments under analysis. In the discussion of results of Experiment II in Chapter 4 we observe that this pick is caused by considerations of focal values and the lay-out of the table attracts the attention of subjects in experiments. Decision rules that define algorithms of choice proposed in the present study do not allow reflection on this feature of choice. Therefore these algorithms are not capable of reproducing human subjects’ data in all detail. However, data from simulations show the same slope as the human subjects’ data in the areas showing decreases.

Results of simulations presented in this section suggest that combinations of decision rules, anchoring to the previous choice and considerations of positive discounting make a close reproduction of the subjects’ aggregate behavior in experiments possible. These rules perform better in a $-MPL environment. However, it is possible to fine-tune the algorithm to reproduce the subjects’ behavior more closely in a %-MPL choice task format. We chose to implement the same algorithm applied to both structures of the MPL table. By doing so we consolidate our results as the same algorithm seems to explain behavior observed in different experiments that lead to different results.

5.2.4 “Speed up” vs “delay” payoff frames

Simulations with tables in speed-up and delay frames do not lead to significantly different results. This result is not surprising. Both table structures, %-MPL and $-MPL tables, maintain the same interest rate structure between the frames. In simulations the first choice was made as a
random draw from a uniform distribution that positions responses in the first elicitation period on the same position on the table corresponding to the same interest rate, independently of the frame.

We showed above that simulation results correspond more closely to the human subjects’ behavior when the first choice of artificial agents is defined as a choice made by human subjects. We expect that substituting the first choice period of artificial agents with human subjects’ choice will result in comparison of a speeding-up effect in simulations. Therefore we conclude that the speed-up - delay effect is not produced by algorithms analyzed in the present study.

Simulations in delay and speed-up frames do not lead to significantly different results. We conclude that the delay-speed-up anomaly cannot be accounted for by decision rules introduced in the present section. This bias is most probably generated by the rule that governs the first period choice.

Simulations described up till the present time have been carried out with elicitation structures used in experiments with human subjects. We showed that the underlying structure of the elicitation task defines the behavioral pattern of discount rates elicited with this task. We demonstrated that aggregate results observed in experiments can be reproduced by artificial agents that follow two simple decision rules, anchoring to previous choice and positive discounting.

5.3 Investigation of the role of table structure

In simulations reported in the previous section we used elicitation tables that can be found in the literature. There is no theoretical or empirical indications of how these tables should be constructed. Experimental literature includes a vast range of elicitation structures that have been adopted in experiments with human subjects. In the present section we study the effect of the internal composition of the $-MPL and %-MPL formats of choice task on the elicited discount rates.

The internal structure of the $-MPL depends on the choice of the initial amount of elicitation, number of choice alternatives, magnitude of the difference between choice alternatives and the number and length of elicitation intervals. All these design features influence magnitude of the discount rates that can be elicited with a given table as well as the qualitative trend that can be
observed by implementing this elicitation structure.

There is a big variety in the structure of %-MPL tables adopted in the literature. For example, Green et al. (1997) adopted a decision task that consisted of 24 alternatives and time frames that ranged from 3 months to 20 years. The limits on the discount rates that could be elicited with this elicitation structure are in the range of 4370% - 4% for a 3-month period and decrease to 23%-0.05% over an elicitation period of 20 years.

Choice tasks in Tanaka et al. (2007) consisted of 5 equally spaced alternatives with time frames ranging from 3 days to 3 months. The underlying structure of these types cannot elicit discount rates different from 29825%-2287% over a 3-day period and 549%-55% over a 3-month period.

In Manzini et al. (2008) design subjects were confronted with tables of 10 equally spaced payoffs alternatives. The time frames corresponded to 1, 2 and 4 months. This structure imposes limits on elicited discount rates of 10800%-133% over a 1- month elicitation interval and 934%-32% over a 4- month interval.

Elicitation with %-MPL elicitation tables depends on the limits of the interest rate chosen by the researcher and the variation of the corresponding interest rate between positions. Although the %-MPL offer an extensive freedom of choice of internal structure the implementation of %-MPL format in experimental literature is limited to the table developed in Harrison et al. (2002) (Read et al., 2006, Andersen et al., 2008, etc.). All these studies report rather similar discount rates regardless of the amount and length of the interval of elicitation.

Andersen et al. (2006) conduct the only study that investigates the influence of interest rate structure variation on the elicited discount rate in experiments implementing the %-MPL format. They do not find significant differences between discount rates elicited with different structures of discount rates. However, this study accounts for too many experimental treatments conducted with a limited sample size. This limited amount of observation can explain the lack of significant results reported in these studies.

The study of the role of the elicitation table structure by conducting experiments with human subjects is a very costly activity. Computer simulations are run that make it possible to disentangle the role of the internal structure of the table from the elicited discount rate. As was shown in the previous section ANPD players closely reproduce discount rate patterns elicited
with human subjects. In this section we conduct simulations only with this type of players.

As was noted earlier, the internal structure of the elicitation table in $\text{-MPL}$ format is defined by the extent of the difference between successive choice alternatives which in turn determines the number of positions on the elicitation table. Other decisive features are the number of elicitation periods and their length. We explore the effect of the number of positions on the elicitation table and of the number of elicitation intervals on discount rates elicited with the $\text{-MPL}$ structure. In simulations performed in this section we consider $\text{-MPL}$ tables that consist of 6, 15 and 25 equally spaced positions. We implement three types of temporal expansion. Each simulations is performed over 5 elicitation intervals that go from 1 to 12 months, from 6 to 36 months and from 6 to 120 months. Overall, we obtain a 3x3 experimental design.

The $\%\text{-MPL}$ elicitation table relies on the limits and internal structure of the corresponding interest rate. In our exploration of the structure of the $\%\text{-MPL}$ table we study the effect of the limits imposed on interest rates and variation of these interest rates between neighboring positions on the table. We consider three limits imposed on corresponding interest rates: 1 to 20 $\%$, 1 to 50 $\%$ and 1 to 150 $\%$; and three possible variations of interest rates in the table: symmetric, that corresponds to equal increases in interest rates, low skewed, that corresponds to smaller increases between positions associated with lower interest rates and larger increases between positions associated with higher interest rates, and high skewed, with large increases between low interest rate positions and small increases within high interest rate positions$^9$.

Results of simulations are presented in Figure 5.9 and 5.10 where we report median discount rates and its 95% confidence interval.

Figure 5.9 reports median discount rates observed in simulations with the $\text{-MPL}$ tables$^{10}$. In this figure the graphs reported in the column correspond to simulations over the same type of temporal intervals whereas graphs reported in the rows of the figure correspond to the tables with the same number of positions.

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$^9$Elicitation over different lengths of interval leads to different results with implementation of $\%\text{-MPL}$, however this difference is very small for interest rates considered in simulations. Similarly, skewness of differences between neighboring positions leads to differences in discount rates elicited with $\text{-MPL}$ tables. However, most experimental studies that elicit preferences with $\text{-MPL}$ choice task implement tables with equally spaced positions while elicitation intervals vary considerably among studies.

$^{10}$The scale of graphs in the first column of the figure corresponding to the simulations with elicitation intervals from 1 to 12 months is logarithmic.
All the graphs corresponding to the simulation design with $-MPL$ format show a hyperbolic pattern. The steepness of this pattern depends on the length of elicitation periods and differences between elicitation intervals. The steepest hyperbolic pattern is observed in discount rates illustrated in the first column of the figure corresponding to elicitation periods from 1 to 12 months. These discount rates are also the highest in terms of magnitude. This evidence is explained by the fact that the switch occurs at the same position within the row of the figure corresponding to simulations with tables with the same number of positions. As was explained in the previous section the choice of the same nominal amount as indifference value for different elicitation intervals leads to elicitation of decreasing discount rate with an increase in the length of elicitation interval. As a consequence, discount rates elicited with the same table come out higher for shorter intervals of elicitation. Elicitation over periods from 6 to 36 months and from 6 to 120 months have two elicitation periods in common and discount rates over the first two elicitation periods of the corresponding graphs are the same. However, discount rates elicited over the periods from 6 to 120 months appear to have a steeper decline compared to discount rates elicited over periods from 6 to 36 months. For the same reason we observe narrower confidence intervals with an increase of time elicitation horizons.

Discount rates are higher for elicitation tables with fewer positions. The variance of elicited discount rates is larger with fewer positions in the table when all other things are kept constant. For instance, in the first column of the Figure 5.9 discount rates elicited using the table with 6 positions range from 1417% over a 1-month interval to 254% over a 12-months period, while discount rates observed on a 25-position table correspond to 1161% in 1 month and 107% in 12 months. Fewer positions on the table produce a larger variance on the first interval of elicitation. This variance reduces dramatically with consequent choices. The elicitation table with 15 positions, however, produces higher variance than the elicitation table set up with 25 positions. Tables with fewer positions show a higher variance over the first intervals of elicitation because the distance between positions in terms of interest rates is much larger than for tables with more positions. At the same time positive discounting constraint decreases the number of positions that can be considered for choice at each consecutive round. In tables with fewer positions this behavior leads to convergence of choice on the lowest limit of the table. This convergence does not happen in elicitation with tables with more positions since most subjects
prefer not to choose limiting values. For this reason in elicitation tables with more positions the variance does not decrease to zero.

Figure 5.10 shows median discount rates and a corresponding 95% confidence interval observed in simulations with the %-MPL format. The columns of the figure contain graphs corresponding to low skewed, symmetric and high skewed structure of interest rates. The rows include graphs corresponding to tables with different limits on interest rate, from 1 to 20% in the first row and 1 to 150% in the last row.

Discount rates observed with the %-MPL present a slightly decreasing pattern. The steepness of this decrease as well as the extent of the elicited discount rate depend on the level of skewness of the table and on the limits imposed on the interest rate structure of the table. For instance, out of the three tables with the highest bounds, corresponding to the first row of the Figure 5.10, the low skewed table presents the least steep decreasing pattern of discount rates which can hardly be interpreted as significant. Meanwhile the high skewed table generates discount rates with a pronounced decreasing pattern. Discount rates elicited on a symmetric table are slightly decreasing. The same tendency, although less pronounced, is observed among discount rates elicited on tables with lower interest rates.

The variety of the discount rates expressed by the 95% confidence interval depends also on the skewness level as well as the magnitude of interest rates included in the table. Thus, for discount rates elicited on low skewed tables the confidence interval narrows down with successive rounds of elicitation. It remains constant in simulations with symmetric tables while it widens in elicitation on high skewed tables. This tendency is more pronounced for tables that include higher interest rates.

To explain this behavior it is necessary to recall the functioning of the algorithm behind ANPD players. The first choice of these players is located at the middle position on the table. The successive choice gradually climbs up the positions of the table. When this algorithm is performed on the low skewed table the differences between discount rates elicited on successive rounds decrease. They remain stable on the symmetric table and increase on high skewed tables. As a consequence, the variance of the discount rates elicited with low skewed tables decreases while it remains stable for symmetric tables and increases for high skewed tables.

In this section we have explored the effect of the internal structure of $-MPL and %-MPL
formats of choice task on elicited discount rates. We have shown that elicited discount rates largely depend not only on the format of elicitation task, $-MPL versus %-MPL, but also on the internal structure of the chosen format of elicitation task. For instance, magnitude and the behavioral pattern of the discount rates elicited on the $-MPL format depend on the choice of elicitation intervals and nominal differences between successive positions on the table. Discount rates are higher for shorter elicitation intervals and for larger differences in terms of nominal amounts between neighboring positions on the elicitation table.

Magnitude and behavioral patterns of discount rates elicited with the %-MPL depend on the magnitude of interest rates included in the table and their distribution among positions on the table. Discount rates are higher for tables with higher upper limits of interest rate and for the high skewed tables.

Results presented in this section were produced by simulations with artificial players. There is no data in experimental literature that permits us to test these results in relation to human subjects’ behavior. Although experiments with human subjects may lead to observation of slightly different magnitudes of elicited discount rates we believe that our results provide a good idea of qualitative patterns of human subjects.

5.4 Conclusions

The present study proposes an alternative approach to the analysis of experimental results in time preference. In particular, we propose the use of computational methods to enrich the experimental analysis in time preference elicitation. Our attention has been focused on MPL methodology that is widely used in the literature, even if \textit{mutatis mutandis} our approach can also be used with different elicitation procedures and in different domains (e.g. risky choice). First, we show that researchers cannot avoid considerations of table properties (i.e. time periods, skewness of the structure of interest rates corresponding to the alternatives in the table and the number of positions) which has a key role in determining results of experiments. More precisely, researchers can use the proposed method in order to ensure that the results emerging from experiments are not only the effect of a particular choice of a table.

A key result illustrated in this chapter is the ability of a simple algorithm to reproduce human
subjects’ choices over time: a random preference player with positive discounting constraints and anchored decisions. Results suggest that human subjects use simple decision rules which involve a limited amount of cognitive effort.

Finally, we have analyzed different tables structures in depth. The results of simulations reported here reveal that discount rates elicited with the MPL elicitation method are strongly affected by the structure of the underlying table. In particular, the implementation of the $-$MPL structure results in the hyperbolic discount rates. Meanwhile, discount rates observed in simulations with the %-MPL structure are rather stable within the time period and can be accepted as supporting exponential evidence. This qualitative difference between the trend of discount rates observed on two MPL tables is not due to a different framing used in experiments that implement the $-$MPL in contrast to those using the %-MPL.

A corollary of the core set of results is the variability of behavior observed in the experiments. We show that the differences in the results depends on the way that the table is set out too. Such a conclusion partly goes against a widely accepted view in experimental literature that attributes variability of elicited discount rates to experimental procedures. Indeed, we suggest that the causes of this variability should be found in the elicitation procedures.
(a) Elicitation over 1, 3, 6, 9, 12 months, 6 positions

(b) Elicitation over 6, 12, 18, 24, 36 months, 6 positions

(c) Elicitation over 6, 12, 36, 60, 120 months, 6 positions

(d) Elicitation over 1, 3, 6, 9, 12 months, 15 positions

(e) Elicitation over 6, 12, 18, 24, 36 months, 15 positions

(f) Elicitation over 6, 12, 36, 60, 120 months, 15 positions

(g) Elicitation over 1, 3, 6, 9, 12 months, 25 positions

(h) Elicitation over 6, 12, 18, 24, 36 months, 25 positions

(i) Elicitation over 6, 12, 36, 60, 120 months, 25 positions

Figure 5.9: Median discount rates and corresponding 95% confidence interval. $S$-MPL speed up frame for different structures of elicitation periods (columns) and different number of positions (rows).
(a) Elicitation over the table with bounds from 1 to 20%, low skew.
(b) Elicitation over the table with bounds from 1 to 20%, symmetric.
(c) Elicitation over the table with bounds from 1 to 20%, high skew.
(d) Elicitation over the table with bounds from 1 to 50%, low skew.
(e) Elicitation over the table with bounds from 1 to 50%, symmetric.
(f) Elicitation over the table with bounds from 1 to 50%, high skew.
(g) Elicitation over the table with bounds from 1 to 150%, low skew.
(h) Elicitation over the table with bounds from 1 to 150%, symmetric.
(i) Elicitation over the table with bounds from 1 to 150%, high skew.

Figure 5.10: Median discount rates and corresponding 95% confidence interval. %-MPL delay frame for different structures of skewness of interest rates (columns) and bounds of interest rates (rows).
Chapter 6

Summary and Conclusions

6.1 Summary

The present work provides an alternative interpretation of results observed in experimental research in time preference. In particular I focus on research related to the elicitation of individual discount rate.

Chapter 2 starts with a short introduction to the theoretical research in time preference. The discounted utility model describes a subject as complex as time preference in a simple and elegant way. These features of the model ensured its widespread acceptance and popularity in the economic world. An assumption of constant discounting proposed by Samuelson appeared to be very appealing for modeling purposes. However, this assumption does not account for behavior of real people faced with intertemporal choice.

A plethora of experimental studies surged to demonstrate the inability of a constant discounting model in explaining all the aspects of human subjects’ behavior in situations of intertemporal choice. These experimental studies aiming at providing a better explanation of time preference presented serious problems themselves. Experimental results in terms of elicited discount rates do not converge within a single parameter or a range of possible values. Instead each study reports discount rates that largely differ from previous results. Moreover, new biases of intertemporal choice are constantly found. This variability of results stirred up the development
of new intertemporal choice theories capable of explaining new experimental data. Nowadays a large variety of these models compete for recognition as the one that explains data better while additional new models are being developed. Debate about whether discounting is exponential or hyperbolic maintains its prominent place on research agendas and new contradictory evidence is frequently being created.

Divergent, often contradictory results observed in experiments in time preference make this area of research open to criticism. In Chapter 1 I provide a list of the most common objections that these experiments are faced with. I divide these critiques into those that have theoretical foundations and those that come from the area of experimental research itself.

From a theoretical point of view the most common objection is the assumption of the linear utility function associated with immediate utility made in all experimental studies dealing with elicitation of time preference. This assumption is as arbitrary as the assumption of constant discounting made by Samuelson, 1937. However, this assumption is necessary for calculation of discount rates. I show that with the elicitation method mostly used in experimental literature it is not possible to provide a joint estimation of immediate utility and discount function.

Among the objections raised about experimental research in time preference by researchers in the field of experimental economics, the most frequent is the failure to use real incentives in most experiments dealing with elicitation of discount rates. In experiments with hypothetical payoffs, it is believed that subjects express much higher discount rates than they would actually choose in real life. The use of real incentives in this area of experimental research, however, is twofold. On the one hand it is expected that real payoffs provide correct incentives to subjects to truthfully reveal their real preferences. On the other hand it is hard to implement real incentives in studies involving time. Implementation of real incentives makes it necessary to reduce the length of the elicitation intervals and creates the significant problem of reinforcement of delayed payments. I review the only 2 studies that compare subjects’ performance in real and hypothetical payoff treatments. Results of these studies indicate an opposite relationship between discount rates elicited with hypothetical and real payoffs. They find that discount rates with hypothetical payoffs are lower than discount rates elicited with real payoffs. Therefore, implementation of real payoffs in time preference research remains an open question.

Regardless of this, a wide list of critiques have been voiced against experimental elicitation
of discount rates. The few studies that correct for these objections do not seem to improve the situation. The explanation for variability of experimental results should be sought elsewhere.

I observe that results of experiments largely depend on the elicitation procedure used to elicit these results. The discounted utility model is not able to account for these results. In the light of present discussion I propose a model of subjects' behavior in experiments. This model is based on research in cognitive psychology and psychophysics while its development is inspired by the concept of a construction of preferences borrowed from the neighboring field of experimental research in risky choice (Lihtenstein and Slovic, 2006). According to this model, the elicitation procedure implemented in the experiment defines results that will be observed with this experiment. The elicitation procedure contains many different features of experimental design: the elicitation task and its presentation, response mode, the choice and the presentation order of elicitation intervals. I derive decision rules that subjects may follow if faced with a particular elicitation task and response mode.

The elicitation of discount rates involves confronting subjects with a series of elicitation tasks in which all but one dimension, the dimension in which the response is required, are kept constant. This study purports that the subjects' attention is attracted to this dimension. Subjects will attribute more weight to this dimension in their decision making and this will determine their possible response.

Chapters 3 and 4 build on the results obtained in Chapter 2. Chapter 3 explores the middle table bias in choice task in the %-MPL format. I carry out a comparative experiment in which subjects' choices on the %-MPL are presented as a table and also in random order one alternative at a time. It is expected that subjects will be driven by the middle table effect in the table representation while they will evaluate their own preference in the other representation with one alternative at a time. I find that median discount rates elicited with both treatments are located close to the middle table position and are not significantly different. Analysis of the final questionnaires suggests that the subjects’ responses to the choice task in the %-MPL format are guided by the decision rule that defines a threshold increase on the given initial value. The focal value that most subjects reported being attracted to, corresponds to the middle table position. Therefore, the middle table effect is confused with particular values that make up the table.

In addition it is unexpectedly demonstrated that the choice task presented in the %-MPL
format leads to elicitation of different discount rates compared to the discount rates elicited with matching tasks among the same subjects. The difference in discount rates is explained by different decision rules activated by these two elicitation procedures. These results confirm the model presented in Chapter 2.

Chapter 3 studies the analysis presented in Chapter 2 in more depth and compares the three most frequently used elicitation procedures in the experimental elicitation of discount rates: the choice task in the $-MPL format, the choice task in the % MPL format and the matching task. I demonstrate that discount rates elicited with these three elicitation tasks are significantly different. The reason for this difference lies in different decision rules that each elicitation task activates in subjects.

Not only do different elicitation tasks lead to elicitation of different discount rates but these discount rates correspond to different patterns of discount function. For instance, discount rates elicited with %-MPL choice task appear to be constant independently of the length of the elicitation interval. Meanwhile discount rates elicited with the $-MPL choice task and matching task display a hyperbolic pattern. Analysis of decision rules reported by subjects makes it possible to develop discount functions that can be observed with each elicitation task. This analysis suggests that it is possible to predict ex-ante the magnitude and behavioral pattern of discount rates elicited with a certain elicitation procedure.

Chapter 4 builds on the analysis in Chapter 3 and compares the performance of the decision rules discussed in the latter chapter in elicitation with choice task in the multiple price list format with nominal and interest rate structures. This study implements the computer simulation method with artificial agents first adopted in Gode and Sunder (1993). I compare the performances of artificial players faced with elicitation tasks in the form of the %-MPL and the $-MPL choice tasks. Computer simulations make it possible to split up the role of structure in the decisional environment from decisional rules. I demonstrate that the behavioral pattern of discount rates is generated by the structure of the table. For instance, the %-MPL choice task leads to elicitation of the relatively stable pattern of discount rates while discount rates elicited with the $-MPL choice task presents a hyperbolic pattern.

I introduce two simple decision rules that subjects may use in their choice during the experiments: positive discounting constraint and anchoring to the previous choice. The choice of
artificial agents is then compared to the choice of human subjects in laboratory experiments. It is demonstrated that artificial agents that follow the algorithm corresponding to the combination of the two decision rules generate evidence similar to the choice of human subjects.

To conclude I explore the role of the structure of the elicitation table. I demonstrate that changing the limits of the interest rates that are included in the table and varying the interest rate between the positions of the %-MPL table significantly influences the magnitude, behavioral pattern and variation of discount rates elicited with this table. Elicitation with the $-MPL table is sensitive to the number of positions of the elicitation table as well as to the elicitation interval length and the differences between intervals over which the discount rates are elicited.

To sum up, this dissertation contains the only systematic study of the various differences between elicitation methods used in time preference research. Starting from the fragmentary evidence existing in literature that reports differences between choice task and matching task I study the causes and direction of these differences. I demonstrate that that the origins of the divergence of results elicited with matching task and choice task lies in the decision making rules that each elicitation task evokes in subjects.

For instance, the choice task presents a lot of structures in the representation of the problem and imposes clear bounds on the decision. All possible types of behavior that can be observed with the choice task are determined by the structure of the task a priori. The researcher can define the limits on the elicited discount rates and any variation that will be observed in data.

The matching task is free of structure and leaves more freedom to the decision maker in formulation of the choice. This freedom forces subjects to look for additional cues to make the decision. These cues can be taken from both within the structure of the experiment and from external sources.

Evidence discussed in the dissertation suggests that preferences elicited in experiments in time preference are constructed during the experiment. This conclusion poses serious doubts on the external validity of experimental results in time preference as well as questioning theoretical contributions that were developed based on this evidence. Moreover, experimental results presented in the dissertation show that instead of maximizing discounted utility, subjects use rules of thumb to simplify their decision making. These results however should be taken with caution. They suggest that there is some serious problem with the elicitation method that is
used to study time preference. This problem is blocking progress in the area of intertemporal choice research.

Accepting the view of preference construction makes it possible to account for some puzzles observed in the literature. For instance, it explains the multiplicity of discount rates and lack of convergence of experimental results highlighted by Frederick et al (2002). Every study in the literature builds its own experimental structure that leads to elicitation of divergent discount rates. It also contributes to the debate on the form of discount function. I demonstrate that the elicitation method and its internal structure define the form of the observed discount function.

The preference construction theory permits a reconciliation of generally observed evidence of hyperbolic discounting with characteristic to the financial markets’ increasing yield curve. If the market was populated by investors with hyperbolic preferences no one would make short term investments. Short term investments in the market are associated with relatively low interest rates that hyperbolic discounters would not accept. Preference construction, however, suggests that individuals make decisions based on the situation. Thus, in the laboratory setting, subjects will express preference for the highest possible discount rates but faced with real life decisions will try to do their best to meet the market conditions.

6.2 Further research

This dissertation opens the door to many unresolved questions requiring further research. Despite a plethora of studies dedicated to time preference research, many critical issues that are hindering development in this field require further attention. In what follows I list what I consider these issues to be.

As was noted in Chapter 2, the elicitation method and procedures used in time preference research manifest serious flaws. Computation of discount rates is based on the assumption of linear utility function associated with monetary payoffs. Meanwhile the theory is based on applications with diminishing marginal utility. There is a need to reconcile experimental practice with theoretical developments that experiments aim to test. Research in this area can take two possible directions: One solution would be to keep the elicitation procedure that is based on the elicitation of indifferent amounts and develop econometric tools that permit the joint estimation
of the immediate utility and discount function. Related to this approach the solution adopted in Andersen et al. (2008) requires further investigation. One particular area that should be looked at in depth is the question of whether the monetary utility function estimated for risky choice is a good approximation of the monetary utility function in time preference.

Alternatively, research efforts can be invested in the development of new elicitation methods that permit elicitation of time preference without imposing any assumption on the form of utility function.

The question of the use of real incentives in experiments in time preference remains open. Additional research needs to be conducted to study the influence of real payoffs in all elicitation tasks.

Results reported in this dissertation raise doubts about the external validity of experimental evidence in time preference collected so far. If observed preferences are constructed in the course of experiments, how valuable are these results for application to real life problems? Some widely used elicitation procedures in experimental research appear artificial from the point of view of real life situations. For instance, it is hard to imagine a scenario from daily life which can be modeled as a MPL choice task. In the light of the results reported in the dissertation there is a need to study intertemporal choice decisions people are faced with in real life. Exploration of how these decisions are made in a laboratory setting will lead to more reliable evidence for the development of models.
Appendix A

Instructions

A.1 Experimental instructions, Chapter 3

Benvenuto nell’esperimento

Istruzioni

Stai partecipando a un esperimento sulle decisioni.

Per la tua partecipazione a questo esperimento riceverai un pagamento di 5 euro, inoltre parteciperai all’estrazione di un premio che consisterà in una rilevante somma di denaro. Tale premio dipenderà dalle scelte da te effettuate durante l’esperimento secondo delle modalità che ti saranno spiegate tra poco. Le scelte che farai in questo esperimento saranno trattate in modo anonimo e confidenziale e non saranno rivelate agli altri partecipanti. All’entrata ti abbiamo dato 3 carte con il codice. Dovrai utilizzare questo codice ogni volta richiesto. Ti chiediamo di mantenere il silenzio durante l’esperimento e di non discutere né far vedere le tue scelte agli altri partecipanti.

Una persona in questa stanza estratta in modo casuale riceverà considerevole somma di denaro. Se tu sarai la persona estratta (“Prescelto”), potrai essere pagato a secondo di due opzioni di pagamento: l’opzione A e l’opzione B. Se scelgi l’opzione B riceverai la somma di denaro tra 8 mesi da oggi. Se scegli l’opzione A, riceverai la somma di denaro tra 1 mese da oggi, ma questa opzione (A) pagherà una minore somma di denaro rispetto all’opzione B.
L'esperimento consiste di 2 parti. Il tuo compito è di scegliere l'opzione che preferiresti (nel caso fossi estratto come Prescelto) in ognuna delle 20 alternative presentate in ogni parte dell’esperimento. Le alternative presentate sono espresse in valuta sperimentale. Il tasso di cambio ti verrà comunicato alla fine dell’esperimento.

Ogni alternativa nella prima parte dell’esperimento ti dà possibilità di ricevere 400 euro tra un mese da oggi (opzione A) e 400+X euro tra 8 mesi da oggi (opzione B), dove l’importo di X cambia per ogni alternativa. Per ogni alternativa devi barrare l’opzione che preferiresti se fossi estratto come Prescelto. Alla fine dell’esperimento una delle 20 alternative sarà scelta a caso. Il Prescelto sarà pagato in base all’opzione da lui selezionata per questa alternativa con la conversione degli euro in euro con il tasso di cambio che sarà comunicato alla fine dell’esperimento prima dell’estrazione del Prescelto.

**Esempio 1.**

<table>
<thead>
<tr>
<th>Alternativa</th>
<th>Opzione A: pagamento tra 1 mese (25 giugno)</th>
<th>Opzione B: pagamento tra 8 mesi (26 gennaio)</th>
<th>Tasso d’interesse associato</th>
<th>L’opzione di pagamento preferita</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>€400</td>
<td>€429</td>
<td>12,5%</td>
<td>A</td>
</tr>
</tbody>
</table>

In questo esempio, se scegli l’opzione B guadagnerai 429 euro rispetto ai 400 euro che avresti potuto guadagnare scegliendo opzione A.

La parte II dell’esperimento è identica alla parte I però ti sarà chiesto di fare le scelte sull’importo di 390 euro e ci saranno 20 alternative e una domanda.

**Come sarà estratto il “Prescelto”**

Ogni persona in questa stanza ha ricevuto all’entrata 3 carte con un codice. Dovrai inserire questo codice per iniziare ogni parte dell’esperimento e nel questionario finale. Una di queste carte viene utilizzata nella prova dell’esperimento, l’altra sarà utilizzata nell’esperimento stesso, la terza resta a te per identificarli. Appena tutti hanno completato l’esperimento lo sperimentatore passerà a raccogliere una delle carte con il codice in vostro possesso mettendole nel contenitore, da cui verrà estratta la carta del Prescelto. Se il codice scritto sulla carta estratta corrisponde al codice che riporta la carta nel tuo possesso tu sei il Prescelto. Quindi tutti presenti in questa stanza hanno le stesse probabilità di essere Prescelto.

**Come viene selezionata l’alternativa**
Le alternative tra cui ti verrà chiesto di scegliere sono numerate da 1 a 20 per la prima parte e da 1 a 21 per la seconda parte dell’esperimento. Dopo che tutti hanno completato entrambe le parti dell’esperimento a uno di voi verrà chiesto di scegliere una delle carte con i numeri delle alternative dal contenitore. Prima di mettere le carte nel contenitore lo sperimentatore chiederà uno di voi controllare che le carte abbiano una corretta numerazione. L’alternativa il cui numero coincide con il numero della carta estratta sarà l’alternativa in base alla quale il Prescelto sarà pagato. Quindi, tutte le alternative hanno equa probabilità di essere estratte.

Ricorda che il Prescelto sarà pagato in base all’opzione che sceglierà per alternativa estratta. Per esempio, supponiamo che tu sia stato estratto come Prescelto e sia stata estratta l’alternativa 5 della parte 1 dell’esperimento (“Parte 1, 5”), riceverai 400 euro se per quella alternativa avevi scelto opzione A (o 429 euro, nel caso in cui abbia scelto opzione B) al tasso di cambio che sarà comunicato prima dell’estrazione.

**Esperimento di prova.**

Per dimostrare le procedure che vengono utilizzate nel corso dell’esperimento sarà condotto un esperimento di prova. Una persona in questa stanza scelta in modo casuale riceverà delle caramelle. Se tu sei la persona scelta per ricevere queste caramelle (“Prescelto”), avrai la possibilità di due opzioni; l’opzione A e l’opzione B. Se scegli l’opzione B riceverai una quantità di caramelle alla fine dell’esperimento. Se scegli l’opzione A, riceverai una quantità di caramelle immediatamente, ma questa opzione (A) ti darà una quantità di caramelle minore rispetto all’opzione B.

Ti verranno presentate 6 alternative di assegnazione diverse. Ogni alternativa ti dà 5 caramelle immediatamente (opzione A) e 5+x caramelle alla fine dell’esperimento (opzione B). Dopo che tutti hanno fatto le loro scelte lo sperimentatore raccoglierà una delle carte con il vostro codice. Una volta raccolte le carte sarà scelta l’alternativa da assegnare e il codice del “Prescelto”. Il Prescelto della sessione di prova riceverà la quantità di caramelle corrispondente alla opzione scelta per l’alternativa selezionata.
A.2 Experimental instructions, Chapter 4, Experiment I, Treatments I and Ia

Benvenuto nell’esperimento

Istruzioni

Questo è un esperimento sul modo in cui le persone prendono le decisioni. L’esperimento è stato finanziato dal gruppo di ricerca “ROCK” (Research on Organizations, Coordination and Knowledge).

La tua partecipazione in questo esperimento è volontaria. Riceverai 5 euro per la partecipazione nell’esperimento, 3 euro per la compilazione del questionario finale e inoltre potrai vincere una rilevante somma di denaro. Le scelte che farai in questo esperimento saranno tratte in modo confidenziale e non saranno rivelate agli altri partecipanti. Ti chiediamo di mantenere silenzio durante l’esperimento e di non discutere né far vedere le tue scelte agli altri partecipanti.

Le domande che ti verranno fatte durante l’esperimento non sono state disegnate per testare le tue conoscenze. Il nostro obiettivo è conoscere le tue scelte nelle situazioni proposte. Non esistono le risposte corrette alle domande che sono presentate. Le risposte rappresentano soltanto le tue scelte.

Una persona in questa stanza estratta in modo casuale riceverà una considerevole somma di denaro. Se tu sarai la persona estratta (“Prescelto”), potrai essere pagato secondo due opzioni di pagamento: l’opzione A e l’opzione B. L’opzione B garantisce pagamento di una somma di denaro tra 8 mesi da oggi (10 marzo 2009). Mentre l’opzione A propone pagamento di una somma di denaro tra 2 mesi da oggi, ma questa opzione (A) pagherà una minore somma di denaro rispetto all’opzione B.

L’esperimento consiste di 3 parti. Le alternative presentate nell’esperimento sono espresse in valuta sperimentale. Il tasso di cambio con euro sarà comunicato alla fine dell’esperimento.

Parte I.

Nella parte I dell’esperimento come se tu fossi il Prescelto devi indicare la somma di denaro da ricevere tra 8 mesi, 10 marzo 2009, che ti dà la stessa soddisfazione rispetto al ricevere una somma di denaro indicata, opzione A, tra 2 mesi, 10 settembre 2008.

Per esempio:
Stai per ricevere 200 euro tra 2 mesi (10 settembre 2008), opzione A. Quanti soldi vorresti ricevere tra 8 mesi (10 marzo 2009), opzione B, per essere altrettanto soddisfatto rispetto al ricevere 200 euro tra 2 mesi.

Fai la tua scelta:

**Parte II e parte III.**

Nelle parti II e III il tuo compito è di scegliere l’opzione di pagamento che preferiresti (nel caso fossi estratto come Prescelto) in ognuna delle 20 alternative presentati nella parte II e nella parte III.

Ogni alternativa ti dà possibilità di ricevere X euro tra 2 mesi da oggi (opzione A) e X+? euro tra 8 mesi da oggi (opzione B), dove l’importo di ? cambia per ogni alternativa. Per ogni alternativa devi barrare l’opzione A o B che preferiresti ricevere se fossi estratto come Prescelto.

**Esempio 1.**

<table>
<thead>
<tr>
<th>Alternativa</th>
<th>Opzione A: pagamento tra 2 mesi (10 settembre)</th>
<th>Opzione B: pagamento tra 8 mesi (10 marzo)</th>
<th>L’opzione di pagamento preferita</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>€200</td>
<td>€210</td>
<td>A</td>
</tr>
</tbody>
</table>

Le parti II e III dell’esperimento si differenziano per l’importo di X euro corrispondenti all’opzione A.

L’esperimento consiste di: una domanda della parte I, 20 domande della parte II e 20 domande della parte III. Alla fine dell’esperimento una delle 41 domande sarà scelta a caso. Il Prescelto sarà pagato in base alla scelta fatta per questa domanda con la conversione degli euro in euro con il tasso di cambio che sarà comunicato alla fine dell’esperimento prima dell’estrazione del Prescelto.

**Come è estratto il “Prescelto”**

Ogni persona in questa stanza ha ricevuto all’entrata 3 carte con un codice. Dovrai inserire questo codice per iniziare ogni parte dell’esperimento. Una di queste carte sarà utilizzata nella prova dell’esperimento, l’altra sarà utilizzata nell’esperimento stesso, la terza resta a te per identificarti. Appena tutti hanno completato l’esperimento lo sperimentatore passerà a raccogliere una di queste carte per metterle in un contenitore. Da questo contenitore sarà estratta una carta. Se sarà estratta la carta con il tuo codice, tu sei il Prescelto. Tutti i presenti in questa stanza
hanno la stessa probabilità di essere Prescelto e vincere la somma di denaro in questione.

**Come è selezionata la domanda in base alla quale sarà pagato il Prescelto**

Le domande dell’esperimento sono numerate: 1 per la parte I, da 1 a 20 per la parte II e da 1 a 20 per la parte III. Dopo che tutti hanno completato tutte le parti dell’esperimento, a uno di voi verrà chiesto di scegliere una delle carte con i numeri delle alternative dal contenitore. Prima di mettere le carte nel contenitore lo sperimentatore chiederà a uno di voi di controllare che le carte abbiano una corretta numerazione. La domanda il cui numero coincide con il numero della carta estratta sarà la domanda in base alla quale il Prescelto sarà pagato. Tutte le domande hanno uguale probabilità di essere estratte.

**Come è selezionata l’opzione di pagamento Parte I**

Se è estratta la domanda corrispondente alla parte I dell’esperimento per definire se il Prescelto è pagato in base all’opzione A o l’opzione B sarà estratto un numero casuale tra 0 e un numero soglia più grande di X. Se il numero estratto è minore alla somma indicata da te nella parte I riceverai la somma di X tra 2 mesi (10 settembre). Se il numero estratto è superiore alla somma che indichi nell’esperimento riceverai la somma che corrisponde al numero estratto tra 8 mesi (10 marzo).

E’ nel tuo interesse esprimere le tue preferenze in modo veritiero in questa domanda. Supponiamo, per esempio, che nella domanda ti sia stato chiesto di indicare la somma di denaro da ricevere tra 8 mesi che ti rende altrettanto soddisfatto con il ricevere 10 euro tra 2 mesi. Supponiamo che per te questa somma è uguale a 15 euro. Lo sperimentatore comunica che il valore soglia è di 20 euro, quindi sarà estratto un numero casuale tra 0 e 20.

Sarà estratto un numero tra 0 e 20. Se il numero estratto è minore di 15 riceverai 10 euro tra 2 mesi, se è maggiore di 15 riceverai il numero estratto di euro tra 8 mesi. Come dimostra il disegno la probabilità di ricevere la somma di 10 euro tra 2 mesi è proporzionale al segmento AB, mentre la probabilità di ricevere la somma corrispondente al numero estratto di euro tra 8 mesi è proporzionale al segmento BC. Più grande è la somma che scegli più aumenti il segmento AB e quindi aumenta la possibilità di ricevere 10 euro tra 2 mesi diminuendo le possibilità di prendere la somma più grande tra 8 mesi. Viceversa, più è piccola la somma che inserisci più aumenta la possibilità di ricevere la somma tra 8 mesi. Considera bene la domanda e fai la scelta che ti soddisfa di più.

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Parte II e parte III.

Se è estratta la domanda corrispondente alla parte II o parte III il Prescelto sarà pagato in base all’opzione che ha scelto in questa domanda. Per esempio, supponiamo che tu sia stato estratto come Prescelto e che sia stata estratta l’alternativa 1 dell’esempio 1. Riceverai 200 euro il 10 settembre se per quella alternativa avevi scelto opzione A (o 210 euro il 10 marzo, nel caso in cui hai scelto opzione B) al tasso di cambio che sarà comunicato prima dell’estrazione.

L’esperimento di prova

Per dimostrare le procedure utilizzate nel corso dell’esperimento sarà condotto un esperimento di prova. Una persona in questa stanza scelta in modo casuale riceverà delle caramelle. Se tu sei la persona scelta di ricevere queste caramelle (“Prescelto”), potrai riceverle secondo le due opzioni; l’opzione A e l’opzione B. Se scegli l’opzione B riceverai una quantità di caramelle alla fine dell’esperimento. Se scegli l’opzione A, riceverai una quantità di caramelle immediatamente, ma questa opzione (A) ti darà una quantità di caramelle minore rispetto all’opzione B.

Nella prima parte dell’esperimento di prova ti sarà chiesto di decidere quante caramelle ricevute alla fine dell’esperimento ti daranno la stessa soddisfazione di ricevere 6 caramelle subito. Nella seconda parte ti saranno presentate 5 alternative di assegnazione di caramelle. Ogni alternativa ti propone la scelta tra 6 caramelle subito (l’opzione A) e 6+? caramelle alla fine dell’esperimento (l’opzione B), dove ? cambia per ogni alternativa.

Dopo che tutti hanno fatto le loro scelte lo sperimentatore raccoglierà una delle carte con il vostro codice. Solo nell’esperimento di prova per spiegare le due possibili procedure di scelta dell’opzione di pagamento sarà estratto Prescelto sia per ricevere il premio per la prima parte che per la seconda parte. Il Prescelto di ogni parte della sessione di prova riceverà la quantità di caramelle in corrispondenza alla opzione scelta per l’alternativa selezionata secondo le regole spiegate prima.

Ricorda che ognuno ha uguali possibilità di essere scelto e ogni domanda ha uguali possibilità di essere estratta per il pagamento. Quindi è nel tuo interesse analizzare le domande con attenzione e fare le tue scelte come se fossi il Prescelto e come se questa domanda venisse scelta per il pagamento.
A.3 Experimental instructions, Chapter 4, Experiment I, Treatment II

Benvenuto nell’esperimento

Istruzioni

Questo è un esperimento sul modo in cui le persone prendono le decisioni. L’esperimento è stato finanziato dal gruppo di ricerca “ROCK” (Research on Organizations, Coordination and Knowledge).

La tua partecipazione in questo esperimento è volontaria. Riceverai 5 euro per la partecipazione nell’esperimento, 3 euro per la compilazione del questionario finale e inoltre potrai vincere una rilevante somma di denaro. Le scelte che farai in questo esperimento saranno trattate in modo confidenziale e non saranno rivelate agli altri partecipanti. Ti chiediamo di mantenere silenzio durante l’esperimento e di non discutere né far vedere le tue scelte agli altri partecipanti.

Le domande che ti verranno fatte durante l’esperimento non sono state disegnate per testare le tue conoscenze. Il nostro obiettivo è conoscere le tue scelte nelle situazioni proposte. Non esistono risposte corrette alle domande che sono presentate. Le risposte rappresentano soltanto le tue scelte.

Una persona in questa stanza estratta in modo casuale riceverà una considerevole somma di denaro. Se tu sarai la persona estratta (“Prescelto”), potrai essere pagato secondo due opzioni di pagamento: l’opzione A e l’opzione B. L’opzione B garantisce pagamento di una somma di denaro tra 8 mesi da oggi (10 marzo 2009). Mentre l’opzione A propone pagamento di una somma di denaro tra 2 mesi da oggi, ma questa opzione (A) pagherà una minore somma di denaro rispetto all’opzione B.

L’esperimento consiste di 3 parti. Le alternative presentate nell’esperimento sono espresse in valuta sperimentale. Il tasso di cambio con euro sarà comunicato alla fine dell’esperimento.

Parte I.

Nella parte I dell’esperimento come se tu fossi il Prescelto devi indicare la somma di denaro da ricevere tra 2 mesi (10 settembre 2009), opzione A, che ti dà la stessa soddisfazione rispetto al ricevere una somma di denaro indicata, opzione B, tra 8 mesi (10 marzo 2009).

Per esempio:
Stai per ricevere 200 euro tra 8 mesi (10 marzo 2009), opzione B. Quanti soldi vorresti ricevere tra 2 mesi (10 settembre 2008), opzione A, per essere altrettanto soddisfatto rispetto al ricevere 200 euro tra 8 mesi.

Fai la tua scelta:

**Parte II e parte III.**

Nelle parti II e III il tuo compito è di scegliere l’opzione di pagamento che preferiresti (nel caso fossi estratto come Prescelto) in ognuna delle 20 alternative presentati nella parte II e nella parte III.

Ogni alternativa ti dà possibilità di ricevere X euro tra 8 mesi da oggi (opzione B) e X-? euro tra 2 mesi da oggi (opzione A), dove l’importo di ? cambia per ogni alternativa. Per ogni alternativa devi barrare l’opzione A o B che preferiresti ricevere se fossi estratto come Prescelto.

**Esempio 1.**

<table>
<thead>
<tr>
<th>Alternativa</th>
<th>Opzione A: pagamento tra 2 mesi (10 settembre)</th>
<th>Opzione B: pagamento tra 8 mesi (10 marzo)</th>
<th>L’opzione di pagamento preferita</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>€180</td>
<td>€200</td>
<td>A</td>
</tr>
</tbody>
</table>

Le parti II e III dell’esperimento si differenziano per l’importo di X euro corrispondenti all’opzione A.

L’esperimento consiste di: una domanda della parte I, 20 domande della parte II e 20 domande della parte III. Alla fine dell’esperimento una delle 41 domande sarà scelta a caso. Il Prescelto sarà pagato in base alla scelta fatta per questa domanda con la conversione degli euro in euro con il tasso di cambio che sarà comunicato alla fine dell’esperimento prima dell’estrazione del Prescelto.

**Come è estratto il “Prescelto”**

Ogni persona in questa stanza ha ricevuto all’entrata 3 carte con un codice. Dovrai inserire questo codice per iniziare ogni parte dell’esperimento. Una di queste carte sarà utilizzata nella prova dell’esperimento, l’altra sarà utilizzata nell’esperimento stesso, la terza resta a te per identificarti. Appena tutti hanno completato l’esperimento lo sperimentatore passerà a raccogliere una di queste carte per metterle in un contenitore. Da questo contenitore sarà estratta una carta. Se sarà estratta la carta con il tuo codice, tu sei il Prescelto. Tutti i presenti in questa stanza
hanno la stessa probabilità di essere Prescelto e vincere la somma di denaro in questione.

**Come è selezionata la domanda in base alla quale sarà pagato il Prescelto**

Le domande dell'esperimento sono numerate: 0 per la parte I, da 1 a 20 per la parte II e da 1 a 20 per la parte III. Dopo che tutti hanno completato tutte le parti dell’esperimento, a uno di voi verrà chiesto di scegliere una delle carte con i numeri delle alternative dal contenitore. Prima di mettere le carte nel contenitore lo sperimentatore chiederà a uno di voi di controllare che le carte abbiano una corretta numerazione. La domanda il cui numero coincide con il numero della carta estratta sarà la domanda in base alla quale il Prescelto sarà pagato. Tutte le domande hanno equa probabilità di essere estratte.

**Come è selezionata l’opzione di pagamento Parte I**

Se è estratta la domanda corrispondente alla parte I dell’esperimento per definire se il Prescelto è pagato in base all’opzione A o l’opzione B sarà estratto un numero casuale tra 0 e X. Se il numero estratto è minore alla somma indicata da te nella parte I riceverai la somma di X tra 8 mesi (10 marzo). Se il numero estratto è superiore alla somma che indichi nell’esperimento riceverai la somma che hai indicato tra 2 mesi (10 settembre).

È nel tuo interesse esprimere le tue preferenze in modo veritiero in questa domanda. Supponiamo, per esempio, che nella domanda ti sia stato chiesto di indicare la somma di denaro da ricevere tra 2 mesi che ti rende altrettanto soddisfatto con il ricevere 20 euro tra 8 mesi. Supponiamo che per te questa somma è uguale a 10 euro. Sarà estratto un numero casuale tra 0 e 20.

Se il numero estratto è minore di 10 (il numero che hai indicato) riceverai 20 euro tra 8 mesi, se il numero estratto è maggiore di 10 riceverai 10 euro tra 2 mesi. Come dimostra il disegno la probabilità di ricevere la somma di 20 euro tra 8 mesi è proporzionale al segmento AB, mentre la probabilità di ricevere la somma di 10 euro tra 2 mesi è proporzionale al segmento BC. Più
grande è la somma che scegli più è grande il segmento AB e quindi aumenta la possibilità di ricevere 20 euro tra 8 mesi. Se vuoi aumentare le possibilità di ricevere la somma tra 2 mesi devi scegliere la somma più piccola aumentando il segmento BC (diminuendo il segmento AB), però la somma che andrai a ricevere tra 2 mesi sarà più piccola.

Considera bene la domanda e fai la scelta che ti soddisfa di più.

**Parte II e parte III.** Se è estratta la domanda corrispondente alla parte II o parte III il Prescelto sarà pagato in base all’opzione che ha scelto in questa domanda. Per esempio, supponiamo che tu sia stato estratto come Prescelto e che sia stata estratta l’alternativa 1 dell’esempio 1. Riceverai 200 euro il 10 settembre se per quella alternativa avevi scelto opzione A (o 210 euro il 10 marzo, nel caso in cui hai scelto opzione B) al tasso di cambio che sarà comunicato prima dell’estrazione.

**L’esperimento di prova**

Per dimostrare le procedure utilizzate nel corso dell’esperimento sarà condotto un esperimento di prova. Una persona in questa stanza scelta in modo casuale riceverà delle caramelle. Se tu sei la persona scelta di ricevere queste caramelle (“Prescelto”), potrai riceverle secondo le due opzioni; l’opzione A e l’opzione B. Se scegli l’opzione B riceverai una quantità di caramelle alla fine dell’esperimento. Se scegli l’opzione A, riceverai una quantità di caramelle immediatamente, ma questa opzione (A) ti darà una quantità di caramelle minore rispetto all’opzione B.

Nella prima parte dell’esperimento di prova ti sarà chiesto di decidere quante caramelle ricevute subito ti daranno la stessa soddisfazione di ricevere 6 caramelle alla fine dell’esperimento. Nella seconda parte ti saranno presentate 5 alternative di assegnazione di caramelle. Ogni alternativa ti propone la scelta tra 6 caramelle alla fine dell’esperimento (l’opzione B) e 6-? caramelle subito (l’opzione A), dove ? cambia per ogni alternativa.

Dopo che tutti hanno fatto le loro scelte lo sperimentatore raccoglierà una delle carte con il vostro codice. Solo nell’esperimento di prova per spiegare le due possibili procedure di scelta dell’opzione di pagamento sarà estratto Prescelto sia per ricevere il premio per la prima parte che per la seconda parte. Il Prescelto della parte I e della parte II della sessione di prova riceverà la quantità di caramelle in corrispondenza alla opzione scelta per l’alternativa selezionata secondo le regole spiegate prima.

**Ricorda che ognuno ha uguali possibilità di essere scelto e ogni domanda ha uguali
possibilità di essere estratta per il pagamento. Quindi è nel tuo interesse analizzare le domande con attenzione e fare le tue scelte come se fossi il Prescelto e come se questa domanda venisse scelta per il pagamento.
A.4 Experimental instructions, Chapter 4, Experiment II, Treatment ”% - MPL”

Benvenuto nell’esperimento

Istruzioni

Questo è un esperimento sul modo in cui le persone prendono le decisioni. L’esperimento è stato finanziato dal gruppo di ricerca “ROCK” (Research on Organizations, Coordination and Knowledge).

La tua partecipazione in questo esperimento è volontaria. Riceverai 5 euro per la partecipazione nella parte I dell’esperimento e fino a 10 euro in base alle tue scelte nella parte II dell’esperimento. Le scelte che farai in questo esperimento saranno trattate in modo confidenziale e non saranno rivelate agli altri partecipanti. Ti chiediamo di mantenere silenzio durante l’esperimento e di non discutere né far vedere le tue scelte agli altri partecipanti. L’esperimento consiste di 2 parti.

Parte I

Le domande che ti verranno fatte durante questa parte dell’esperimento non sono state disegnate per testare le tue conoscenze. Il nostro obiettivo è conoscere le tue scelte nelle situazioni proposte. Non esistono risposte corrette alle domande che sono presentate. Le risposte rappresentano soltanto le tue scelte.

Immagina di poter ricevere una considerevole somma di denaro. Questa somma di denaro può essere pagata secondo due opzioni di pagamento: l’opzione A e l’opzione B. L’opzione B garantisce pagamento di una somma di denaro tra 8 mesi da oggi. Mentre l’opzione A propone pagamento di una somma di denaro tra 2 mesi da oggi, ma questa opzione (A) pagherà una minore somma di denaro rispetto all’opzione B.

L’opzione B sarà disponibile in 5 date diverse, mentre l’opzione A sarà sempre disponibile tra 2 mesi. Per ogni data di pagamento dell’opzione B dovrai fare 20 scelte tra l’opzione A e l’opzione B, queste scelte saranno presentate in forma di una tabella. Ogni riga di questa tabella, ogni alternativa, ti dà possibilità di ricevere €100 tra 2 mesi (opzione A) o €100+x tra 8 mesi (opzione B) dove l’importo di x cambia per ogni riga della tabella. Per ogni riga della tabella devi scegliere l’opzione di pagamento, opzione A o opzione B, che avresti preferito nel caso in
cui avresti potuto ricevere questa somma di denaro veramente. Metti la croce sull’opzione di pagamento preferita.

**Esempio 1.**

<table>
<thead>
<tr>
<th>Alternativa</th>
<th>Opzione A: pagamento tra 2 mesi (10 settembre)</th>
<th>Opzione B: pagamento tra 8 mesi (10 marzo)</th>
<th>L’opzione di pagamento preferita</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>€100</td>
<td>€129</td>
<td>A</td>
</tr>
</tbody>
</table>

Nella parte I ti sarà chiesto di fare le tue scelte in 5 tabelle come quelle descritte sopra. Queste tabelle saranno identiche a parte la data di pagamento dell’opzione B. Analizza bene le domande e fai le tue scelte.
A.5 Experimental instructions, Chapter 4, Experiment II, Treatment ”$ - MPL”

Benvenuto nell’esperimento

Istruzioni

Questo è un esperimento sul modo in cui le persone prendono le decisioni. L’esperimento è stato finanziato dal gruppo di ricerca “ROCK” (Research on Organizations, Coordination and Knowledge).

La tua partecipazione in questo esperimento è volontaria. Riceverai 5 euro per la partecipazione nella parte I dell’esperimento e fino a 10 euro in base alle tue scelte nella parte II dell’esperimento. Le scelte che farai in questo esperimento saranno trattate in modo confidenziale e non saranno rivelate agli altri partecipanti. Ti chiediamo di mantenere silenzio durante l’esperimento e di non discutere né far vedere le tue scelte agli altri partecipanti. L’esperimento consiste di 2 parti.

Parte I

Le domande che ti verranno fatte durante questa parte dell’esperimento non sono state disegnate per testare le tue conoscenze. Il nostro obiettivo è conoscere le tue scelte nelle situazioni proposte. Non esistono risposte corrette alle domande che sono presentate. Le risposte rappresentano soltanto le tue scelte.

Immagina di poter ricevere una considerevole somma di denaro. Questa somma di denaro può essere pagata secondo due opzioni di pagamento: l’opzione A e l’opzione B. L’opzione B garantisce pagamento di una somma di denaro tra 8 mesi da oggi. Mentre l’opzione A propone pagamento di una somma di denaro tra 2 mesi da oggi, ma questa opzione (A) pagherà una minore somma di denaro rispetto all’opzione B.

L’opzione B sarà disponibile in 5 date diverse, mentre l’opzione A sarà sempre disponibile tra 2 mesi. Per ogni data di pagamento dell’opzione B dovrai fare 20 scelte tra l’opzione A e l’opzione B, queste scelte saranno presentate in forma di una tabella. Ogni riga di questa tabella, ogni alternativa, ti dà possibilità di ricevere €100 tra 8 mesi (opzione B) o €100-x tra 2 mesi (opzione A) dove l’importo di x cambia per ogni riga della tabella. Per ogni riga della tabella devi scegliere l’opzione di pagamento, opzione A o opzione B, che avresti preferito nel caso in
cui avresti potuto ricevere questa somma di denaro veramente. Metti la croce sull’opzione di pagamento preferita.

Esempio 1.

<table>
<thead>
<tr>
<th>Alternativa</th>
<th>Opzione A: pagamento tra 2 mesi</th>
<th>Opzione B: pagamento tra 8 mesi</th>
<th>L’opzione di pagamento preferita</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>€85</td>
<td>€100</td>
<td>A</td>
</tr>
</tbody>
</table>

Nella parte I ti sarà chiesto di fare le tue scelte in 5 tabelle come quelle descritte sopra. Queste tabelle saranno identiche a parte la data di pagamento dell’opzione B. Analizza bene le domande e fai le tue scelte.
A.6 Experimental instructions, Chapter 4, Experiment II, Treatment ”MT”

Benvenuto nell’esperimento

Istruzioni

Questo è un esperimento sul modo in cui le persone prendono le decisioni. L’esperimento è stato finanziato dal gruppo di ricerca “ROCK” (Research on Organizations, Coordination and Knowledge).

La tua partecipazione in questo esperimento è volontaria. Riceverai 5 euro per la partecipazione nella parte I dell’esperimento e fino a 10 euro in base alle tue scelte nella parte II dell’esperimento. Le scelte che farai in questo esperimento saranno trattate in modo confidenziale e non saranno rivelate agli altri partecipanti. Ti chiediamo di mantenere silenzio durante l’esperimento e di non discutere né far vedere le tue scelte agli altri partecipanti. L’esperimento consiste di 2 parti.

Parte I

Le domande che ti verranno fatte durante questa parte dell’esperimento non sono state disegnate per testare le tue conoscenze. Il nostro obiettivo è conoscere le tue scelte nelle situazioni proposte. Non esistono risposte corrette alle domande che sono presentate. Le risposte rappresentano soltanto le tue scelte.

Immagina di poter ricevere una considerevole somma di denaro. Questa somma di denaro può essere pagata secondo due opzioni di pagamento: l’opzione A e l’opzione B. L’opzione B garantisce pagamento di una somma di denaro tra 8 mesi da oggi. Mentre l’opzione A propone pagamento di una somma di denaro tra 2 mesi da oggi, ma questa opzione (A) pagherà una minore somma di denaro rispetto all’opzione B.

Nella parte I dell’esperimento ti è chiesto di indicare la somma di denaro da ricevere tra 8 mesi (opzione B), che ti dà la stessa soddisfazione rispetto al ricevere una somma di denaro indicata, opzione A, tra 2 mesi.

Per esempio:

Immagina di poter ricevere 200 euro sperimentali tra 2 mesi, opzione A. Quanti soldi vorresti ricevere tra 8 mesi, opzione B, per essere altrettanto soddisfatto rispetto al ricevere 200 euro
sperimentali tra 2 mesi.

Fai la tua scelta:

Nella parte I ti sarà chiesto di fare 5 scelte come quelle descritte sopra. Le domande corrispondenti a queste scelte saranno identiche a parte la data di pagamento dell’opzione B. Analizza bene le domande e fai le tue scelte.
Questionario

Grazie per aver partecipato all'esperimento. Per favore compila questo questionario in ogni sua parte, alla sua riconsegna ti verrà consegnato il modulo per il pagamento dei 5 euro per la tua partecipazione all'esperimento.

Codice personale assegnato nell’esperimento___________________

Sesso
☐ M  ☐ F

Età ___________ anni

Facoltà:
☐ Economia  ☐ Sociologia  ☐ Scienze
☐ Giurisprudenza  ☐ Lettere  ☐ Scienze cognitive
☐ altra facoltà

Anno:
☐ 1°  ☐ 2°  ☐ 3°  ☐ fuori corso
☐ triennale  ☐ quadriennale  ☐ specialistica

Che ragionamento hai seguito nella tua scelta (descrivi brevemente il criterio che hai usato per confrontare le alternative nella tua scelta)

_______________________________________________________________________________

_______________________________________________________________________________

Possiedi un contro corrente?
☐ Sì  ☐ No

Se sì, qual è il tasso d’interesse che la tua banca ti paga sui tuoi depositi? __________ %

qual è il tasso d’interesse che devi pagare vai in passivo sul conto? __________ %

Hai fatto acquisti a rate durante ultimo anno?
☐ Sì  ☐ No

Se sì, qual è il tasso d’interesse applicato a questo prestito? __________%

Tu o la tua famiglia avete un prestito o mutuo presso la banca?
☐ Sì  ☐ No

Se sì, qual è il tasso d’interesse applicato a questo prestito __________%

qual è il tasso d’interesse applicato a questo Mutuo __________%

Grazie per la tua collaborazione!
Questionario

Grazie per aver partecipato all’esperimento. Compilando questo questionario in ogni sua parte aggiungi altri 3 euro ai 5 euro guadagnati nell’esperimento.

Per favore, compila questo questionario in ogni sua parte, alla sua riconsegna ti verrà consegnato il modulo per il pagamento dei 8 euro per la tua partecipazione all’esperimento.

Codice personale assegnato nell’esperimento___________________

Domande generali

1. Sesso  □ M  □ F
   (barra la tua scelta)

2. Età ____________ anni

3. Facoltà:  □ Economia  □ Sociologia  □ Scienze
            □ Giurisprudenza  □ Lettere  □ Scienze cognitive
            □ altra facoltà
   (barra la tua scelta)

4. Anno di iscrizione:  □ 1°  □ 2°  □ 3°  □ fuori corso
   □ triennale  □ quadriennale  □ specialistica  □ magistrale
   (barra la tua scelta)

5. Qual è la tua media dei voti (approssimativamente): ____________  □ Non ho ancora sostenuto alcun esame

6. Qual è la tua media dei voti nelle materie matematiche (approssimativamente): ____________  □ Il mio piano di studi non prevede esami nelle materie matematiche

Domande sull’esperimento

7. Come valuti la probabilità che la persona che è stata estratta come Prescelto riceverà il pagamento promesso?
   □ Sicuramente  □ 2  □ 3  □ 4  □ 5  □ Pìù sì che no  □ Credo di sì  □ Pìù no che sì  □ Sicuramente no

8. Nella parte I perché hai scelto proprio quell’importo che hai riportato nella tua risposta nell’esperimento come la somma di denaro da ricevere tra 2 mesi?
   __________________________________________________________
   __________________________________________________________

9. L’importo che hai specificato nella parte I corrisponde alle tue vere preferenze o avresti preferito cambiare la tua scelta se potessi tornare indietro? Se la cambieresti, cosa avresti risposto?
   __________________________________________________________
   __________________________________________________________

Figure A.2: Questionnaire of Experiment exposed in Chapter 4, Experiment I, Treatment $-MPL.
Questionario

Grazie per aver partecipato all’esperimento.
Per favore, compila questo questionario in ogni sua parte, alla sua riconsegna ti verrà consegnato il modulo per il pagamento per la tua partecipazione all’esperimento.

Codice personale assegnato nell’esperimento

Domande generali

1. Sesso
   □ M □ F
   (basta la tua scelta)

2. Età __________ anni

3. Facoltà:
   □ Economia □ Sociologia □ Scienze
   □ Giurisprudenza □ Lettere □ Scienze cognitive
   □ altra facoltà
   (basta la tua scelta)

4. Anno di iscrizione:
   □ 1° □ 2° □ 3° □ fuori corso
   □ triennale □ quadriennale □ specialistica □ magistrale
   (basta la tua scelta)

5. Qual è la tua media dei voti (approssimativamente): _________________ □ Non ho ancora sostenuto alcun esame

6. Qual è la tua media dei voti nelle materie matematiche (approssimativamente): _________________ □ Il mio piano di studi non prevede esami nelle materie matematiche

Domande sull’esperimento

7. Immagina di poter ricevere 400 euro tra 2 mesi, opzione A. Quanti soldi vorresti ricevere tra 8 mesi, opzione B, per essere altrettanto soddisfatto rispetto al ricevere 400 euro tra 2 mesi.
Fai la tua scelta: __________________

8. Che ragionamento hai seguito nella tua scelta nella risposta alle domande di parte I (vedi domanda 7) (descrivi brevemente il criterio che hai usato nella tua scelta)
_______________________________________________________________________________
_______________________________________________________________________________

9. Come cambiava la tua scelta dell’importo da inserire nella parte I con aumentare dell’intervallo di tempo da trascorrere tra l’opzione A e l’opzione B:
_______________________________________________________________________________
_______________________________________________________________________________

Figure A.3: Questionnaire of Experiment exposed in Chapter 4, Experiment II, Treatment MT
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