



**Facoltà di Economia di Forlì**

Laurea Magistrale in Economia e Management  
delle Imprese Cooperative e delle Organizzazioni Non profit



# Working Papers

# 80

## **Impatience, Anticipatory Feelings and Uncertainty: A Dynamic Experiment on Time Preferences**

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Gennaio 2011

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Impatience, Anticipatory Feelings and Uncertainty:  
A Dynamic Experiment on Time Preferences <sup>(\*)</sup>

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3 December 2010

Abstract

We study time preferences in a real-effort experiment with a one-month horizon. We report that two thirds of choices suggest negative time preferences. Moreover, choice reversal over time is common even if temptation plays no role. We propose and measure three distinct concepts of choice reversal over time to study time consistency. This evidence calls for an important role for anticipatory feelings and uncertainty in intertemporal behavior.

JEL codes: C91, D01, D80, D90

Keywords: negative time preferences, choice reversal, risk, time inconsistency, real-effort experiment

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Intertemporal choices are ubiquitous in economics, and understanding their motivations is crucial to predict patterns of retirement savings, purchase of durable goods, addictions, and health choices, just to name a few. The empirical literature has shown that impatience and temptation are major motivations of intertemporal choices (e.g., Schelling, 1978, Warner and Pleeter, 2001, Benartzi and Thaler, 2004, Brown et al., 2009). There may be other important drives such as risk, uncertainty, and anticipatory feelings. These drives have some bearing on the topic and may be an essential part of many intertemporal problems (Loewenstein and Prelec, 1991, Sozou, 1998, Fernandez-Villaverde and Mukherji, 2002, Caplin and Leahy, 2004, Dasgupta and Maskin, 2005, Halevy, 2008, Manzini and Mariotti, 2010). This study aims at uncovering their impact. The empirical issue is how to disentangle the impact of anticipatory feelings and uncertainty from the role played by impatience and temptation. To this end, we design and run an experiment where impatient agents are predicted to behave in the same way, irrespective of whether they are exponential or quasi-hyperbolic discounters. Hence observed deviations from these predictions ought to originate from motivations other than impatience or temptation.

Interestingly, the vast majority of the experimental studies on time preferences have a static setting: subjects choose only at a single point in time. This study presents an experiment of intertemporal choices in a dynamic setting where subjects choose at multiple points in time, which allows a deeper understanding of time preferences. In particular, it helps understanding choice reversals over time. This issue is relevant because, in economic models, it is customary to assume that time preferences are exponential. This implies that an individual chooses an optimal plan of consumption and, given the same information, will then carry out the plan (Strotz, 1955). To empirically investigate this prediction, one should follow the individual choices over time or, at least, elicit the current plan and then track its future implementation. However, many experiments adopt a different technique to study time consistency: they compare a series of intertemporal choices made in a given moment. We refer to this as the *static* experimental approach. Such experiments often report a lower discount factor for short-run rather than long-run horizons and then conclude that time preferences are not exponential (e.g., Ainslie and Haendel, 1983, Kirby, 1995, Read, 2001).<sup>1</sup> To account for this evidence, many scholars argue in favor of a quasi-hyperbolic model of time preferences as a better descriptor of intertemporal

choices and suggest that individuals are tempted by, and some of them fall for, instantaneous gratification (e.g., Laibson, 1997).

By eliciting individual decisions at multiple points in time, we adopt a *dynamic* experimental approach toward time preferences and time consistency. The dynamic experimental approach allows tracking the consistency between a plan and its implementation better than the static approach. More generally, it sheds light on the methodological and empirical debate about time inconsistency, which has generated misunderstandings between theorists and experimentalists. To this end, we propose an array of complementary definitions of choice reversal over time. One of the definitions reflects the notion of choice reversal used by theorists, and another refers to the notion used by experimentalists. Given the dynamic design of our experiment, we are able to identify the occurrence of each type of choice reversal and measure their frequency.

An important feature of the experimental design is that it includes a nonmonetary stimulus to be consumed in the lab. This allows solving two relevant methodological issues present in the standard experimental practice of using money as a reward; sometimes they are also present using consumption goods such as rice or chocolate (e.g., Pender, 1996, Coller and Williams, 1999, Cubitt and Read, 2007). One issue is storability, which does not allow controlling for the timing of consumption. When the chosen reward is to be consumed in the lab and cannot be stored instead, one can be sure about the timing of consumption and obtain more reliable information on time preferences. Another issue is tradability outside the lab, which allows for intertemporal arbitrage due to the existence of an external market for money and for certain consumption goods. Both storability and tradability of the reward medium may bias the measurement of intertemporal preferences in the laboratory. To avoid these biases, our stimulus is annoying noise to be administered in the lab using headphones. As this is non-storable and non-tradable, it allows perfect control over the timing of consumption. The noise is administered as an indivisible package to help disentangle the role of time preferences from the preferences for consumption, in particular from the degree of concavity of the individual utility function.

In our experiment less than 5% of subjects made choices compatible with models of exponential or quasi-hyperbolic discounting. About two thirds of them preferred to anticipate noise listening, which, for convenience, is labeled “negative time preferences.” Choice reversal was common even if temptation played no role. This empirical evidence is not a falsification of

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<sup>1</sup> Similar results from survey data are found, e.g., in Thaler, 1981, Lowenstein, 1987, Chapman, 1996.

the exponential or the quasi-hyperbolic models but rather strongly suggests the presence of other major motivations for intertemporal choices beyond impatience and temptation. In particular, the data points toward an important role for uncertainty and anticipatory feelings.

The paper is structured as follows. Section 1 describes the experimental design. Section 2 introduces three definitions of choice reversal over time. Section 3 puts forward theoretical predictions for models driven by discounting, uncertainty, and anticipatory feelings. Section 4 presents the experimental results. Section 5 reviews the literature. Discussions and concluding remarks are presented in Sections 6 and 7.

## 1. EXPERIMENTAL DESIGN

We recruited subjects for a supersession that included three sessions covering a one-month period. These experimental sessions were run at two-week intervals at dates 0, 1, and 2. The main decision was about when to listen to a 20-minute indivisible package of annoying noise,<sup>2</sup> i.e., at date 0, 1, or 2. Following participation in all three sessions, each subject received €30. Exactly 100 subjects started off the experiment: 40 under treatment 1 and 60 under treatment 2, which presents some differences in the procedure.<sup>3</sup> Unless otherwise noted, the description refers to treatment 2. We begin by describing the procedure for session 0.

**Session 0** included various color-coded parts: a ranking of the dates for noise listening (blue), an auction for flexibility (red), an auction for a dummy task (white), an auction for listening to additional noise at 0 (yellow), and a choice of exit penalty (green). In treatment 1, the actual order was white, yellow, blue, red, and green, while in treatment 2 it was white, blue, red, and green.

In the blue part, subjects expressed their preferences on when to listen to 20 minutes of noise. Before choosing, everyone listened to a 3-minute sample noise. The available dates were 0 (today), 1 (two weeks later) and 2 (four weeks later), which generated six possible rankings (Table 1). At the end of the session, a 10-face die was rolled for every participant to determine the date of noise listening, and depending on the die roll, subjects listened to noise. If session 0

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<sup>2</sup> The noise had to be listened to once, and the 20 minutes could not be spread over two or more sessions. Therefore, the concavity of the utility function cannot have any impact on the optimal timing of consumption. Instead, intertemporal choices are usually elicited using larger rewards for later dates, which implies that, for a given discount factor, the optimal timing of consumption also depends on the concavity of the instantaneous utility function.

<sup>3</sup> Treatment 2 was longer and also included intertemporal decisions about monetary rewards. We have not yet

was ranked as most preferred, then the probability of listening to noise at 0 (today) was 0.60; if least preferred, then the probability was 0.10; and 0.30 otherwise. The timing of noise listening had no impact on the monetary payments. In treatment 1, the random draw and noise listening took place right after the blue part. Note that there is a positive probability that the subject would listen to noise at any date. Each subject has the incentive to truthfully reveal the ranking of noise listening for all sessions, and not simply to reveal her most preferred date: she will select the highest probability for her most preferred date and the smallest probability for the least preferred one.

Ranking Code	Most preferred date for noise listening	Intermediate preference for noise listening	Least preferred date for noise listening	Frequency of choices (no. of subjects)
210	Four weeks later	Two weeks later	Today	5 (5.7%)
102	Two weeks later	Today	Four weeks later	8 (9.2%)
012	Today	Two weeks later	Four weeks later	57 (65.5%)
201	Four weeks later	Today	Two weeks later	2 (2.3%)
120	Two weeks later	Four weeks later	Today	10 (11.5%)
021	Today	Four weeks later	Two weeks later	5 (5.7%)
Total				87 (100%)

Table 1. Ranking of preferred dates for noise listening, elicited in session 0

*Note: The table lists profiles as they appeared in the instructions of treatment 2. The order of treatment 1 was 012, 102, 210, 021, 120, and 201. We did not detect a bias in favor of the first profile listed in the table.*

In the red part, participants were partitioned into groups of two and placed a bid to buy flexibility in a second-price auction. This flexibility option allows for updating the blue ranking two weeks later (date 1). The red coupons with subjects' bids were publicly collected, randomly partitioned into pairs, and stapled. Subjects with the highest bid in their pair won the auction and paid the other bid amount in session 2. Auction results were revealed in session 1. This auction yields a measure of the willingness to pay for flexibility due to unforeseeable contingencies. Positive bids

analyzed choices over money.

reveal a perceived uncertainty. Subjects from treatment 1 who had already listened to noise in session 0 skipped the red part.

To familiarize subjects with the auction format, an auction for a dummy task (white) preceded the red part. In the white part, participants stated their minimum compensation for going to a room located one floor below the lab and bring back a book. An experimenter publicly collected the bids, randomly partitioned and publicly stapled them in pairs. Subjects with the lowest bid in their pair won the auction and received the other bid amount at the end of the session. The results were shown on a screen, and the winners were publicly announced and immediately requested to fetch the book. The instructions explicitly mentioned the optimal strategy of revealing the true minimum compensation for the task. In treatment 1, there were groups of four subjects.

Only treatment 1 had a yellow part with a second-price auction. Subjects bid for their willingness to listen to a 20-minute package of noise in a random group of four. The lowest bidder won the auction and listened to noise in session 0. Hence it was possible that in session 0 a subject listened twice to 20 minutes of noise, i.e., in the yellow and the blue parts. The rationale of the yellow part was to check whether noise was annoying, which it was, and whether the disutility of noise was convex. With convex disutility a subject preferred spreading two packages of noise in two distinct sessions rather than listening to both in the same session.<sup>4</sup>

If a subject dropped out during a session, she received a show-up fee (€3, 1 subject did drop out). In addition, a subject could refuse to listen to noise when asked to do so by the experimenters, i.e., opt out. A subject that participated in all three sessions and opted out received €30 minus an exit penalty. In the green part, each subject chose her exit penalty from among €15, €20, €25, and €30. The instructions explained that raising the exit penalty could discourage opting out behavior and hence help in earning the full €30 participation fee. The exit penalty is a form of soft precommitment to listen to noise because it does not remove the option of refusing to listen when asked to do so (Rachlin, 2000). Instead, it lowers the temptation of not implementing a plan of action by making it less attractive not to listen to noise.

At the end, the winners of the white and yellow auctions were paid. In treatment 1, a non-anonymous questionnaire had to be completed before payment.

**Session 1** included a ranking of the dates for noise listening (blue) and a choice over opting out

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<sup>4</sup> Auction winners still had to listen to a 3-minute sample noise in the blue part. Non-winners could do any reading activity at their desk.

(green). All subjects listened to a 1-minute sample noise and then expressed their preferences on when to listen to a 20-minute noise between date 1 (today) and 2 (two weeks later). The blue part was not completed by subjects who had listened to noise in session 0. Subjects learned the results of the auction for flexibility (red) after completing the blue part. For auction winners, the relevant preferences on the date of noise listening were those revealed in session 1; for everyone else the relevant preferences were those revealed in session 0. A subject listened to noise in session 1 with a probability 0.66 if session 1 was ranked as most preferred, 0.33 if least preferred. In the green part, subjects had the option to refuse to listen to noise if asked to do so. Finally, a 6-face die was rolled for every participant to determine the date of noise listening, and depending on the die roll, subjects listened to noise.

**Session 2** included a choice over opting out (green) and a questionnaire. Subjects who were not asked to listen to 20 minutes of noise in session 0 or 1 completed the green part and, when appropriate, listened to noise. All subjects then completed a questionnaire and received the participation fee net of the price paid by the winners of the auction for flexibility (red) and of the exit penalty paid by those who refused to listen to noise.<sup>5</sup>

Subjects were recruited from the undergraduate population of the University of (omissis).<sup>6</sup> All sessions were run on Wednesdays. In the invitation message, we asked subjects to bring reading material of their choice. In order to minimize attrition, the invitation message also specified that participation was required in all three sessions. This may have generated an oversampling of more patient subjects, but our aim is not a quantitative measure of the discount factor.

Subjects were seated at computer terminals separated by partitions. No communication among subjects was allowed. Instructions were distributed and read aloud. All decisions were taken with pen and paper. The decisions concerning the different color-coded parts were written on coupons of the same color. To listen to noise, subjects wore high-fidelity headphones connected to the computer terminals.<sup>7</sup> Including instruction reading, average session durations were 120, 120, and 75 minutes, respectively. For treatment 1 average session durations were about 75, 40, and 40 minutes, respectively. Overall, the average payment per subject was 30€.

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<sup>5</sup> In treatment 1, the questionnaire answers given in session 2 could not be associated to a specific subject ID.

<sup>6</sup> In fall 2008, we ran two supersessions at the School of Economics (treatment 1) and in Spring 2009, three supersessions at the Laboratory (omissis).

<sup>7</sup> The noise employed in the experiment was characterized by rapid and acyclical peaks as, e.g., the blare of a 54 kb modem or the blast of a guitar-jack extracted from the amplifier at a moderate volume. A sample of the noise, prepared by the composer (omissis), is available upon request to the authors.

## 2. THREE DEFINITIONS OF CHOICE REVERSAL

The experimental literature defines choice reversal over time differently from the theoretical literature. Experimentalists generally infer choice reversal through comparisons *across* decision problems that are faced *at one point in time*. In the typical choice task, subjects are presented with two decision problems: one over a short-run horizon and another over a long run-horizon. For instance, they choose between receiving \$100 now and receiving \$110 tomorrow, and between receiving \$100 in 30 days and receiving \$110 in 31 days. If a subject chooses \$100 now in the former decision and \$110 in 31 days in the latter one, then a choice reversal is detected (Rachlin and Green, 1972, Thaler, 1981, among others).<sup>8</sup>

Theorists instead define choice reversal through comparisons within the *same* decision problem that is faced *at different points in time* (Mas-Colell et al., 1995, p. 734, Koopmans, 1960, Strotz, 1955). Consider, for instance, a person deliberating whether to start dieting in March rather than April. If in January she prefers to start dieting in March and then in March she prefers to start in April, then theorists detect a choice reversal.

The aim of this section is to show that these two notions of choice reversal over time are related but distinct, as each reversal may occur without implying the other. This is helpful to characterize intertemporal choices and clarify the misunderstandings between the experimental and the theoretical literature. To this end, we propose three formal definitions: static, calendar, and dynamic choice reversal. These definitions are not confined to our setting and can be extended to a general intertemporal decision problem. Given our dynamic experimental design, we will be able to quantify choice reversals according to all three definitions in the results section.

Consider three equally distant dates, 0, 1 and 2, and the following three decision problems (Fig. 1):

- Decision A: at date 0, choose between consuming x at date 0 or y at date 1
- Decision B: at date 0, choose between consuming x at date 1 or y at date 2
- Decision C: at date 1, choose between consuming x at date 1 or y at date 2

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<sup>8</sup> Sometimes the literature refers to this pattern as “preference reversal” or “time inconsistency.” As we remain agnostic about the origin of this behavior, we use the label “choice reversal.”

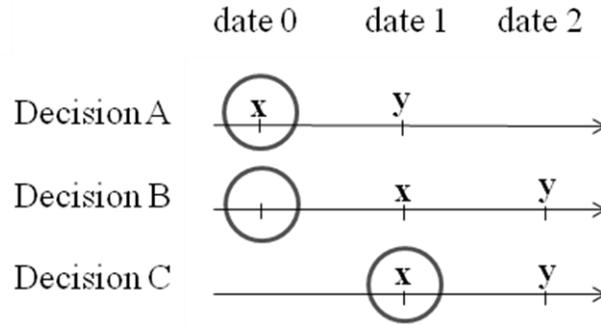


Figure 1. Decisions A, B, and C. The circle indicates when the choice between  $x$  and  $y$  is elicited. *Notes: Comparison between A and B informs on static choice reversal, comparison between B and C on dynamic choice reversal, comparison between A and C on calendar choice reversal.*

Pairwise comparisons between the choices made in Decisions A, B, and C allow to measure three different notions of choice reversal.

**Definition 1:** *Static choice reversal* is detected if either

- $x$  is chosen in A and  $y$  in B, or
- $y$  is chosen in A and  $x$  in B.

**Definition 2:** *Dynamic choice reversal* is detected if either

- $x$  is chosen in B and  $y$  in C, or
- $y$  is chosen in B and  $x$  in C.

**Definition 3:** *Calendar choice reversal* is detected if either

- $x$  is chosen in A and  $y$  in C, or
- $y$  is chosen in A and  $x$  in C.

Only a dynamic experimental design that includes Decision C enables us to measure all three notions of choice reversal. Each notion sheds light on different properties of intertemporal preferences. Experimentalists typically employ the notion of *static choice reversal* as evidence for a nonconstant discount rate. When  $x < y$ , there is a sooner smaller reward and a later larger reward, and static choice reversal suggests a higher impatience over a short-run horizon than over a long-run horizon, or vice versa. An exponential discounter has constant discount rates and does not incur static choice reversal; instead, a present-bias subject may do so (Strotz, 1955, Phelps and Pollak, 1968, Laibson, 1997). In our design, the interpretation needs adjustment because the consumption items are of the same amount ( $x = y$ ). Hence static choice reversal

occurs only if a subject reveals positive time preferences for one decision and negative time preferences for the other. This implies that in our setting, a subject with positive time preferences at all dates, either exponential or present-bias, should never exhibit static choice reversal.<sup>9</sup>

For studying self-control problems, *dynamic choice reversal* is a more useful notion than static choice reversal. When self-control is at stake, one is interested in assessing whether the choice made under the temptation of immediate gratification (Decision C) is consistent with the plan made in advance (Decision B), when the temptation was still distant in time. Given the same alternatives and information, the stationarity axiom of Koopmans (1960) implies the absence of dynamic choice reversal. In game theory and optimal control theory, dynamic choice reversal is also known as dynamic inconsistency. Dynamic choice reversal is relevant for choices concerning saving for retirement, quitting smoking, and procrastinating chores, among others. Strotz (1955) proved that in a certainty scenario, if  $x < y$ , exponential discounting never generates dynamic choice reversal, while for all other discounting functions dynamic choice reversal may occur. When  $x = y$ , no subject discounting the future (including present-biased subjects) will exhibit dynamic choice reversal. In an uncertainty scenario, dynamic choice reversal may originate also from *unexpected* events such as a mood change, the arrival of new information, or shocks, e.g., regarding wealth, health, or the weather (Fernandez-Villaverde and Mukherji, 2000, Amador et al., 2006).

Consider a situation where the decision date and the consumption dates equally shift in time. When a subject switches from preferring later consumption (Decision A) to earlier consumption (Decision C), or vice versa, we detect a *calendar choice reversal*. Calendar choice reversal may originate from *predicted* future events, such as birthdays, exams, doctor's appointments, vacations, as well as from *unpredicted* future shocks. A calendar choice reversal may also be due to a change in the time preferences that occurred between the two decision dates, for instance when children grow into adults, or as a consequence of addiction.<sup>10</sup>

The three notions of choice reversal capture important features of time preferences, and they are interconnected, as stated below.

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<sup>9</sup> In our design, a subject never exhibits static choice reversal even if she has *negative* time preferences for consumption at any horizon.

<sup>10</sup> A change in the time preferences that occurred between the two decision dates could also generate dynamic choice reversal.

**Proposition 1.** *A subject exhibits either two types of choice reversal or none.*

The proof is in the Appendix. Proposition 1 implies that one type of choice reversal is necessarily connected to one other type. For instance, static choice reversal either comes with dynamic or calendar choice reversal but not with both. Consider a smoker that at date 0 reveals a preference profile 102: she prefers quitting smoking tomorrow to quitting smoking today, which she prefers to quitting the day after tomorrow. She exhibits static choice reversal. If tomorrow she does not quit smoking and will only do so the following day, then she exhibits dynamic choice reversal. If, instead, tomorrow she implements her plan and quits smoking, then she exhibits calendar choice reversal but no dynamic choice reversal. As is apparent from this example, an experimentalist may detect static choice reversal in subjects that might not exhibit dynamic choice reversal.

Moreover, dynamic choice reversal may occur even if there is no static choice reversal. Consider a person planning a family picnic and choosing between Friday, Saturday, or Sunday. Suppose on Friday she prefers Sunday to Saturday and Saturday to Friday (her ranking is 210), which reveals no static choice reversal. On Saturday morning, the weather forecasts unexpectedly predict rain for Sunday, which makes her change her schedule and organize the picnic on Saturday (her ranking is 12). In such a case, both a calendar and a dynamic choice reversal occur due to an unexpected event.<sup>11</sup>

### 3. THEORETICAL CONSIDERATIONS

This section presents predictions on the preferred profiles for noise consumption, possible occurrence of choice reversal, demand for flexibility and for the exit penalty for each of the following models:

- 1) the agent discounts the future in a certainty scenario,
- 2) the agent has state-dependent preferences in an uncertainty scenario,
- 3) the agent has anticipatory feelings in a certainty scenario.

In the above models, behavior is driven by a single motivation – discounting, uncertainty, and anticipatory feelings, respectively – though these motivations are not mutually exclusive, and they plausibly coexist when a person makes intertemporal choices. In model 1, we pool the pre-

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<sup>11</sup> There are two possible situations without any type of choice reversal: when the subject chooses either 012 and then 12; or 210 and then 21.

dictions for an exponential discounter and a quasi-hyperbolic discounter. In the other models we focus on the polar situation where the agent does not discount the future, so that we can isolate the impact of uncertainty (2), and of anticipatory feelings (3). Studying these models is a step toward establishing theoretical benchmarks and guidelines to empirically classify subjects.<sup>12</sup>

All statements rely on the following standard assumptions on individual preferences. First, the instantaneous utility function depends on the amount and timing of noise consumption,  $x$  and  $t$ , and on the amount and timing of monetary payments,  $m$  and  $T$ . Second, the instantaneous utility function increases with the amount of money, and decreases with the amount of noise. Third, utility is weakly concave, which implies that our predictions do not rely on the instantaneous utility being linear. Fourth, the instantaneous utility over money and noise is additively separable. Proofs of the following Predictions are presented in the Appendix. We begin with the predictions for the exponential and quasi-hyperbolic models.

### 3.1 Exponential and quasi-hyperbolic discounting, certainty scenario

The net present utility of a subject that discounts the future is

$$U(m, T, x, t) = D(T)v(m) - D(t)c(x), \quad (1)$$

where  $D(T)v(m)$  is the discounted utility of money cashed after a delay  $T$  and  $D(t)c(x)$  is the discounted disutility of listening to noise after a delay  $t$ . For an exponential discounter,  $D(s) = \delta^s$  for all  $s$ , where  $0 < \delta < 1$  is a constant discount factor (Samuelson, 1937, Koopmans, 1960). For a quasi-hyperbolic discounter,  $D(s) = 1$  if  $s = 0$ , and  $D(s) = \beta\delta^s$  if  $s > 0$  (Phelps and Pollak, 1968, Laibson, 1997), where  $0 < \beta < 1$  measures the present bias.

The following Prediction focuses on *solid fulfillers*: subjects who are always willing to attend all three sessions of the experiment and to listen to noise whenever asked to do so.

**Prediction 1.** *Consider a certainty scenario and subjects who are solid fulfillers. An exponential or quasi-hyperbolic discounter:*

- a) chooses 210 as her best profile;*
- b) never exhibits dynamic, static and calendar choice reversal;*
- c) does not demand flexibility;*

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<sup>12</sup> There may be other drives behind intertemporal choices; hence the above list above should not be treated as exhaustive.

*d) is indifferent over increasing the exit penalty.*

A key feature of our design is that the available options differ only in the timing, but not in the amount of consumption. Hence in a certainty scenario, a subject that discounts the future always prefers anticipating a given reward, such as money, and postponing a given pain, such as annoying noise. Hence impatience generates a preference for profile 210 for all agents discounting the future, including exponential and quasi-hyperbolic discounters, and the predictions for both models are aligned.

In many experimental designs of intertemporal choice, the typical question to detect static choice reversal is as follows: would you prefer 100 dollars today or 110 dollars tomorrow; and would you prefer \$100 in 30 days or \$110 in 31 days? As shown in the previous section, a static choice reversal may occur for quasi-hyperbolic discounters but not for exponential discounters.

In our setting, however, the choice is similar to the following dollar questions: would you prefer \$100 today or \$100 tomorrow, and would you prefer \$100 in 30 days or \$100 in 31 days? Clearly, no static choice will be observed even for quasi-hyperbolic subjects because anticipating the timing of consumption is always preferred. Moreover, no dynamic choice reversal can occur for either exponential or quasi-hyperbolic discounters. The absence of calendar choice reversal is a consequence of the absence of static and dynamic choice reversal (Proposition 1).

In our design, no conflict exists between present and future self because the consumption items are equal, i.e.,  $x=y$ . In such a situation, the present self would like the self of session 2 to listen to noise, and the self of session 1 agrees to postpone listening to noise. As a consequence, no dynamic choice reversal can occur for either exponential or quasi-hyperbolic discounters. With reference to the noise stimuli, both session-0 and session-1 selves want to postpone listening to session 2. Importantly, in our setting the observation of choice reversals cannot be rationalized through a model where there is certainty and the only driver is discounting, even if it is quasi-hyperbolic discounting.

Given the certainty scenario, flexibility has no economic value and is not demanded when it is offered at a cost, as in our design. By definition, a solid fulfiller never incurs the exit penalty; hence its amount is irrelevant.

Before presenting the predictions for the other models, we make a digression on the role of attendance costs, which may be particularly relevant in a design with multiple sessions. Prediction 2 explicitly considers such costs and shows their impact on attrition and on the elicited pref-

erences. Attrition may take the form of subjects not returning to the lab after the initial session (dropping out) or paying the exit penalty for not listening to noise. This digression is included for completeness as attendance costs will turn out to have a minor empirical role in the experiment. The uninterested reader may skip to Section 4.2.

In the lab, subjects who attended all three sessions and listened to noise when asked to do so are classified as fulfillers. They can either be solid fulfillers – who are always willing to listen to noise – or *casual fulfillers*. Casual fulfillers are never willing to listen to noise in session 0. When asked to do so, they would either leave the lab or pay the exit penalty and attend all three sessions. Some casual fulfillers are observationally equivalent to solid fulfillers while others are not.

**Prediction 2.** *Consider a certainty scenario and subjects who are casual fulfillers. An exponential and a sophisticated quasi-hyperbolic discounter:*

*a) may choose either profile 210 or 201;*

*b) never exhibits dynamic choice reversal; may exhibit static and calendar choice reversal;*

*c) does not demand flexibility;*

*d) may increase the exit penalty.*

As an example, consider those casual fulfillers who would refuse to listen to noise in both sessions 0 and 1 but are willing to attend all three sessions. They are therefore indifferent between the rankings 210 or 201. Subjects who choose 201 generate static and, possibly, calendar choice reversal. Furthermore, they may want to increase the exit penalty to induce the self of session 1 to attend the session or to listen to noise if asked to do so. To sum up, Prediction 2 allows for a wider set of choices than Prediction 1.<sup>13</sup> One final note on Prediction 2: it is never optimal for a sophisticated quasi-hyperbolic discounter to anticipate noise listening in session 0 as a commitment strategy to facilitate attendance of future sessions.

### **3.2 Uncertainty on the future disutility of noise, no discounting**

We did not deliberately introduce uncertainty into the experiment, yet it is often an intrinsic feature of intertemporal decisions. To explicitly consider how uncertainty may affect individual

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<sup>13</sup> Prediction 2 refers to sophisticated agents that correctly predict the preferences they will have in the future. Naïve hyperbolic discounters reveal the same preferences at date 0 but may drop out or opt out at later dates. If they show

choices within the experimental design, we propose a model of state-dependent preferences characterized by individual-specific shocks on the disutility of noise listening.

For simplicity, we illustrate the predictions for a perfectly patient agent whose behavior is exclusively driven by state-dependent preferences. In any given period, an agent may be either in bad or good mood. Let the disutility of noise be  $c(x)$  if the agent is in good mood, and  $c(x) + \lambda$ , with  $\lambda > 0$ , if she is in bad mood. At date 0, the agent knows her current mood and the probability distribution of her future moods. Suppose moods result from exogenous events that follow an i.i.d. Bernoulli distribution. Bad mood occurs with probability  $0 \leq f \leq 1$ . The agent knows her current mood and the probability distribution of her future moods. The expected disutility of noise at a future date is  $(c(x) + \lambda)f + c(x)(1-f) = c(x) + f\lambda$ .

**Prediction 3.** *Consider an uncertainty scenario. A perfectly patient agent with state-dependent preferences:*

- a) *chooses profile 012 or 021 when currently in good mood, chooses 210 and 120 when currently in bad mood;*
- b) *may exhibit calendar choice reversal with probability  $2f(1-f)$ , static and dynamic choice reversal with probability  $f + k - 2fk$ ;*
- c) *demands flexibility;*
- d) *does not increase the exit penalty.*

The parameter  $k$  is a tie-breaking probability when the subject is indifferent between two profiles (012 and 021, or 210 and 120).<sup>14</sup> For perfectly patient agents the decision problem of the ranking of dates depends on their current mood. If currently in good mood, listening at date 0 is the best option (012, 021); if currently in bad mood, listening at date 0 is the worst option (210, 120). Profiles 102 and 201 are not compatible with a perfectly patient subject with mood uncertainty. If not asked to listen to noise at date 0, the subject's ranking at date 1 will also depend on her current mood (at date 1), and calendar and dynamic choice reversal may occur, as illustrated in Figure 2.

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up at session 1, they may incur dynamic and calendar choice reversal.

<sup>14</sup> A value  $k = 1/2$  suggests a purely random choice when the subject is indifferent between 021 and 012, or between 210 and 120. If  $k > 1/2$ , the agent prefers listening in session 2 to listening in session 1 at date 0, which is compatible with the coexistence of state-dependent preferences and discounting. If  $k$  is less than  $1/2$ , she prefers listening in session 1 rather than in session 2, which is compatible with the coexistence of state-dependent preferences and anticipatory feelings.

Both risk averse and risk neutral subjects demand flexibility. A risk-neutral agent is willing to pay at most  $f(1-f)\lambda/3$  for flexibility. Agents in bad mood do not want to increase the exit penalty while agents in good mood are indifferent.

Introducing discounting will change Prediction 3. In such a case, a subject would not reveal static choice reversal because she strictly prefers 012 over 021 if in good mood and 210 over 120 if in bad mood. All other predictions hold.

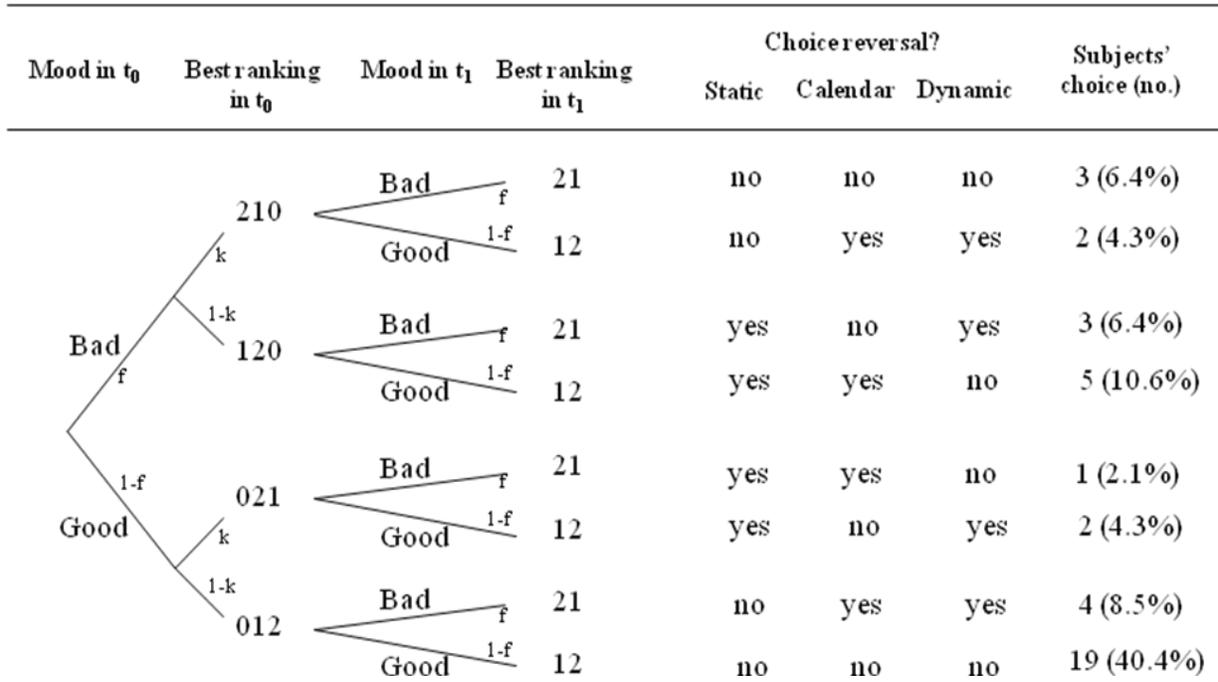


Figure 2. Predictions of a model with state-dependent preferences (N=39)

### 3.3 Anticipatory utility, certainty scenario

Finally, consider the model of a decision maker with anticipatory feelings as proposed in Loewenstein (1987). To isolate the role of anticipatory feelings, we consider a perfectly patient agent. In such a case, the present value of noise consumption is as follows:

$$U(x,t) = c(x) \left[ L + \frac{\alpha}{\omega^2} (1 - e^{-\omega t}) (1 - e^{-\omega L}) \right]. \quad (3)$$

The utility function (3) has two components: utility from consumption  $c(x)L$ , where  $L$  is the duration of noise, and utility from anticipation, with  $\alpha > 0$ . For any degree of anticipatory feelings

$\omega > 0$ , it is optimal to anticipate noise consumption ( $\partial U(x_t)/\partial x_t > c$ ). This generates choices that are observationally equivalent to negative time preferences, as stated in the following prediction.

**Prediction 4.** *Consider a perfectly patient agent with anticipatory feelings à la Loewenstein (1987). The agent:*

- a) chooses 012 as her best profile;*
- b) never exhibits dynamic, static and calendar choice reversal;*
- c) does not demand flexibility;*
- d) does not increase the exit penalty.*

Except for the statement on the best profile, Prediction 4 is identical to Prediction 1. The difference can be explained as follows. By discounting, a subject wants to defer a given pain to a later point in time; with anticipatory feelings she wants to bring it forward to an earlier point in time. This holds no matter when the preference is elicited. Thus no form of choice reversal should be observed for a patient subject that experiences anticipatory feelings.

#### 4. RESULTS

Exactly 100 *participants* initiated the experiment. From these, 12 subjects dropped out: 1 during session 0, 8 between session 0 and session 1, and 3 between session 1 and session 2.<sup>15</sup> Moreover, 1 subject paid the exit penalty and attended all three sessions. Our full sample is therefore made up of 87 *fulfillers*: subjects who attended all three sessions and listened to noise when asked to do so. Of this set of fulfillers, 40 listened to noise at date 0. The *restricted sample* is made up of the remaining 47 subjects who did not listen to noise at date 0 and therefore revealed their preferences both at dates 0 and 1 under proper incentives.

This section presents three main results, namely on profiles for noise listening (Result 1), on choice reversals (Result 2), and on the demand for flexibility and for exit penalty (Result 3). Unless otherwise noticed, the results refer to the full sample of fulfillers (N=87).

**Result 1.** *In session 0, only 8% of subjects preferred the latest date for noise listening; about 71% preferred to listen immediately.*

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<sup>15</sup> The evidence suggests that the causes of attrition were likely to be random shocks. Consider that of the 12 dropouts, 5 preferred to listen to noise immediately, 3 in session 1, and 4 in session 2. Moreover, of the 11 subjects who dropped out after session 0, 6 had already listened to noise. None of these subjects received the show-up fee.

Table 1 provides support for Result 1. The evidence from choices in session 0 does not support Predictions 1 and 2 for exponential and a quasi-hyperbolic discounter. According to Prediction 1, the best choice is profile 210, which was chosen by only 5.7% of subjects. According to Prediction 2, the best choices are profiles 210 or 201, which were chosen by only 8% of subjects. We conclude that exponential and quasi-hyperbolic discounting models explain at most 8% of the preferences of subjects on when to listen to noise. On the contrary, 88.5% of the rankings revealed in session 0 are compatible with a model of perfectly patient subjects with state-dependent preferences (77/87 obs., Prediction 3). A similar percentage is reported for the restricted sample (39/47 obs., 89%). In addition, we can test whether the estimated frequency of subjects in bad mood is invariant over time. Consider the restricted subsample of  $N=39$  subjects who jointly (i) supplied rankings both at date 0 and 1, and (ii) are compatible with the model of mood uncertainty. In session 0, the profiles compatible with being in bad mood are 13/39 (33.3%); in session 1, they are 11/39 (28.2%). We cannot reject the hypothesis that the estimated frequency is equal for the two dates ( $N=39$ , McNemar's  $\chi(2)=.33$ ,  $p\text{-value} = 0.56$ ). Assuming that the estimated frequency of bad mood is close to the expected probability of bad mood, we assume that  $f = 0.3$ , and we use this value to discuss Result 2 on choice reversal.

A model of anticipatory feelings predicts the choice of profile 012, which was the most common one (65.5% of choices, Prediction 4). In sum, the observed choices over profiles suggest that both uncertainty and anticipatory feelings are possible motivations behind intertemporal choices (Predictions 3 and 4). Table 2 illustrates the results of a probit regression to explain choices of profile 012 (negative time preferences). One regression is run on the full sample and the other on the restricted sample. Regressors coded individual characteristics as reported in the questionnaire and included a dummy on whether the subject had just listened to additional noise. Recall that in treatment 1, subjects participated in an auction to listen to additional noise (yellow) before revealing their preferences. Consistent with convex disutility of noise listening, auction winners were more likely to postpone listening to additional noise. Those subjects who stated, "I wanted to get rid of the noise as soon as possible" were significantly more likely to choose profile 012.<sup>16</sup>

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<sup>16</sup> In the questionnaire, we asked "select which criteria have influenced your choice (you can mark one or more options)."

Dependent variable: 1=ranking about listening to noise is 012; 0=otherwise	Full sample		Restricted sample	
Male	0.030	(0.24)	0.058	(0.324)
Economics Major	-0.393	(1.90)	-0.249	(0.486)
Humanities Major	-0.808	(3.00)**	-0.753	(0.295)*
High score on cognitive abilities	-0.072	(0.63)	-0.296	(0.238)
Not impulsive	0.140	(1.15)	0.625	(0.207)**
Former smoker	-0.089	(0.50)		
Smoker, tried to quit unsuccessfully	0.293	(2.06)*	0.354	(0.307)
Never smoked	0.142	(0.83)	0.314	(0.340)
Never had unsafe sex	-0.013	(0.11)	0.054	(0.265)
Better-than-average driver	-0.273	(2.06)*	-0.607	(0.210)**
Eats the most preferred bite at the end of the meal	-0.055	(0.50)	-0.222	(0.235)
Just listened to additional noise (yellow part)	-0.451	(2.07)*	-0.528	(0.233)*
I wanted to get rid of the noise as soon as possible	0.518	(4.03)**	0.835	(0.094)**
Pseudo R-squared	0.36		0.54	

Table 2. Determinants of negative time preferences

*Notes: Probit regressions on ranking revealed in session 0. The table reports the marginal effects, the standard errors are in parentheses. \* significant at 5%; \*\* significant at 1%. The default for smoking habits is "smoker who never tried to quit."*

Self-reported above-average drivers were less likely to anticipate noise listening. Students who were majoring in humanities were also less likely to anticipate noise listening. Interestingly, subjects who were not impulsive were more likely to anticipate noise listening (restricted sample only). Subjects who were not impulsive scored two or three out of the three questions in the Cognitive Reflection Test suggested by Frederick (2005). There was also a weak correlation with smoking habits. Gender, cognitive abilities, or eating habits did not correlate with wanting to anticipate noise listening. Subjects coded with high cognitive abilities correctly answered three out of three IQ-type questions. The next result concerns choice reversal.

Ranking	Subjects' choice in	Choice reversal (no.)	No choice reversal (no.)
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code	the restricted sample (no.)				
		Static	Calendar	Dynamic	
210	5 (10.6%)	0	2	2	3
012	23 (48.9%)	0	4	4	19
Others	19 (40.4%)	19	13	6	0
Total	47 (100.0%)	19 (40.4%)	19 (40.4%)	12 (25.5%)	22 (46.8%)

Table 3. Results on static, dynamic, and calendar choice reversal

Notes: The restricted sample includes fulfillers who never listened to noise in session 0 ( $N=47$ ). Of the larger sample of fulfillers ( $N=87$ ), 25 subjects exhibited static choice reversal. In the subsample of subjects compatible with state-dependent preferences ( $N=39$ ), the number of static, calendar and dynamic choice reversals is 11, 12, and 11, respectively.

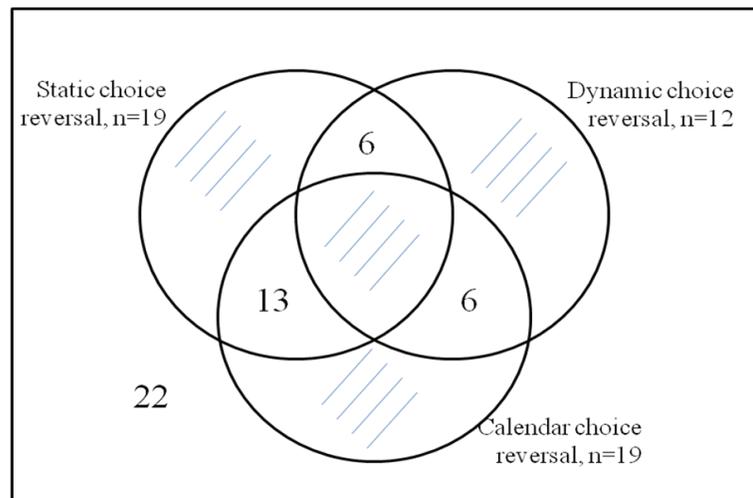


Figure 3. Subjects classification based on choice reversals

Notes:  $N=47$ . The dashed zones are empty.

**Result 2.** Of the restricted sample, about 40% exhibited static choice reversal, 40% exhibited calendar choice reversal, and 25% exhibited dynamic choice reversal. About 47% of subjects did not exhibit any form of choice reversal.

Table 3 provides support for Result 2. The evidence does not fit well Predictions 1, 2, or 4. Exponential and quasi-hyperbolic discounters should never reverse their choices (Prediction 1),

with the possible exception of casual fulfillers (Prediction 2). Similarly, subjects with anticipatory feelings should never reverse their choices (Prediction 4). Hence the majority of the choices (53%) contradicts both Predictions 1 and 4; consider that at most 8% of subjects may be casual fulfillers (Table 1). Hence Prediction 2 cannot account for the observed pattern either.

By contrast, a model of perfectly patient subjects with state-dependent preferences is compatible with the observed preference profiles and patterns of choice reversals (Prediction 3). Let us consider the subsample of  $N=39$  subjects with profiles compatible with a model of state-dependent preferences. According to Prediction 3, the expected probability of static and dynamic choice reversals is the same and equal to  $f + k - 2fk$ . Consistent with Prediction 3, static and dynamic choice reversals are found empirically to occur with the same frequencies ( $11/39 = 28.2\%$ ). We cannot reject the hypothesis that the two frequencies are the same (paired t-test,  $N=39$ , p-value = 0.14). Given the empirical frequency of bad mood, which was estimated after Result 1,  $f = 0.3$ , the expected probability  $f + k - 2fk$  is compatible with the observed evidence for a value of  $k$  close to 0. Furthermore, the evidence on calendar choice reversal is also consistent with Prediction 3. Calendar choice reversal occurs with a 30.8% frequency ( $12/39$ ). Given an expected probability of  $2f(1-f)$  (Proposition 3) and  $f = 0.3$ , we obtain a numerical prediction of 42%. Although higher than the empirically recorded frequency, this numerical prediction is not statistically different from the recorded frequency (one-sample t-test,  $N=39$ , p-value = 0.14).<sup>17</sup> To sum up, the evidence on choice reversals supports the hypothesis that state-dependent preferences are possible drives behind intertemporal choices.

Table 4 reports probit regressions that shed light on the possible determinants of static, dynamic, and calendar choice reversals. Regressions were run on a restricted sample except for static choice reversal, where also data from the full sample are available. The regressors in Table 4 are identical to those in Table 3. We report that subjects are less likely to exhibit static choice reversal when wanting to get rid of the noise as soon as possible and when not impulsive (restricted sample).<sup>18</sup> On the contrary, subjects are more likely to exhibit static choice reversal when they have won the yellow auction (both regressions) and when they major in humanities (full sample).

	Static	Dynamic choice	Calendar choice
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<sup>17</sup> Moreover, we cannot reject the hypothesis that the frequencies of the three types of choice reversals are the same (paired t-test,  $N=39$ , p-value = 0.14).

<sup>18</sup> Interestingly, subjects who were not impulsive and wanted to get rid of the noise as soon as possible were both more likely to anticipate noise listening (Table 3) and less likely to exhibit static choice reversal (Table 4).

Dep.var.: 1=choice reversal, 0=otherwise	choice reversal		reversal		reversal	
	Full sample	Restricted sample	Restricted sample	Restricted sample	Restricted sample	Restricted sample
Male	-0.060 (0.114)	-0.240 (0.263)	0.004 (0.015)	0.104 (0.228)		
Economics Major	0.244 (0.175)	-0.112 (0.685)	0.027 (0.070)	-0.509 (0.316)		
Humanities Major	0.681 (0.220)**	0.388 (0.739)		-0.457 (0.276)		
High score on cognitive abilities	0.076 (0.103)	0.370 (0.203)	-0.091 (0.252)	0.228 (0.172)		
Not impulsive	-0.128 (0.099)	-0.544 (0.180)**	-0.131 (0.255)	-0.111 (0.256)		
Former smoker	0.026 (0.156)	0.447 (0.463)	-0.002 (0.011)	0.131 (0.408)		
Smoker, tried to quit unsuccessfully	-0.140 (0.126)	0.479 (0.420)	0.000 (0.008)	-0.310 (0.206)		
Never smoked	0.030 (0.151)	0.283 (0.253)	-0.827 (0.313)**	-0.247 (0.261)		
Never had unsafe sex	0.062 (0.101)	0.143 (0.199)	-0.629 (0.278)*	0.198 (0.179)		
Better-than-average driver	0.194 (0.119)	0.439 (0.233)	0.331 (0.275)	0.128 (0.184)		
Eats the most preferred bite at the end of the meal	0.097 (0.096)	0.559 (0.199)**	-0.017 (0.077)	0.276 (0.180)		
Just listened to noise (yellow auction)	0.484 (0.210)*	0.785 (0.170)**	-0.001 (0.005)	0.140 (0.272)		
I wanted to get rid of the noise as soon as possible	-0.390 (0.088)**	-0.579 (0.150)**	-0.034 (0.098)	-0.240 (0.197)		
Pseudo R-squared	0.30	0.51	0.64	0.17		

Table 4 Determinants of choice reversal

*Notes: Probit regressions. Number of observations: 87 in the full sample and 47 in the restricted sample. The table reports the marginal effects, standard errors are in parentheses. \* significant at 5%; \*\* significant at 1%*

Regarding dynamic choice reversal, subjects who never smoked and subjects who never had unsafe sex are significantly less likely to reverse their choices. We find no significant effect on cal-

endar choice reversal. Below we present the results on the demand for flexibility and for the exit penalty. The results are based on the choices of 71 subjects.<sup>19</sup>

**Result 3.** *About 38% of subjects were willing to pay for flexibility, and 22.5% increased the exit penalty.*

In a certainty scenario, neither exponential, nor quasi-hyperbolic discounters, nor subjects with anticipatory feelings should demand flexibility. In our sample, 62% of subjects did not demand flexibility, while 38% did.<sup>20</sup> Both types of behavior are compatible with state-dependent preferences. All subjects jointly exhibiting static and dynamic choice reversal demanded flexibility with a remarkably high frequency ( $8/13=61.5\%$ ). On the contrary, flexibility was demanded by no more than one third of the subjects exhibiting static and calendar, static and dynamic choice reversal, or no choice reversal.

Only 22.5% (16/71) increased the exit penalty. This evidence does not contradict Predictions 1 and 2, although no quantitative prediction could be made. Half of the 71 subjects demanded neither flexibility nor an increase in the exit penalty.

		Demand for exit penalty (no.)		
		Yes	No	Total
Demand for flexibility (no.)	Yes	7	20	27 (38.3%)
	No	9	35	44 (62%)
Total		16 (22.5%)	55 (77.5%)	71 (100%)

Table 5. Demand for flexibility and exit penalty

Table 6 reports probit regressions on the demand for flexibility. Subjects who scored high on cognitive abilities were more likely to demand flexibility. The demand for flexibility was less likely for former smokers, non-impulsive subjects, those who ate the most preferred bite at the end of the meal, and those who wanted to get rid of the noise as soon as possible.

A final note on gender effects. We report that gender does not correlate with negative time

<sup>19</sup> The sample of 71 subjects includes those who participated in the auction for flexibility (red) and made their choices concerning the exit penalty (green). It excludes 16 subjects that, in treatment 1, listened to noise in session 0 and did not participate in the red and green parts. All 39 subjects compatible with a model of mood uncertainty are included in the sample of 71 subjects.

<sup>20</sup> The average bid for subjects demanding flexibility is 1 euro.

preferences, choice reversals, or demand for flexibility (Tables 3, 4, 6).

Dep. var.: 1=demand for flexibility, 0=otherwise	Full sample		Restricted sample	
Male	0.156	(0.145)	0.116	(0.239)
Economics Major	-0.002	(0.288)	0.247	(0.299)
Humanities Major	0.190	(0.311)	0.691	(0.357)
High score on cognitive abilities	0.423	(0.135)* *	0.744	(0.151)**
Not impulsive	-0.525	(0.108)* *	-0.807	(0.144)**
Former smoker	-0.326	(0.080)* *	-0.304	(0.107)**
Smoker, tried to quit unsuccessfully	0.078	(0.288)	-0.209	(0.258)
Never smoked	0.073	(0.205)	-0.412	(0.407)
Never had unsafe sex	-0.010	(0.134)	-0.065	(0.183)
Better-than-average driver	-0.149	(0.139)	-0.070	(0.172)
Eats the most preferred bite at the end of the meal	-0.401	(0.146)* *	-0.625	(0.188)**
Just listened to noise (yellow auction)	-0.182	(0.161)	-0.224	(0.129)
I wanted to get rid of the noise as soon as possible	-0.509	(0.137)* *	-0.718	(0.142)**
Pseudo R-squared	0.34		0.46	

Table 6 Determinants of the demand for flexibility

*Notes: Probit regressions. Demand for flexibility=1 if auction bid is above 1 euro cent. Number of observations: 71 in full sample, 47 in restricted sample. The table reports the marginal effects, standard errors reported in parentheses; \* significant at 5%; \*\* significant at 1%*

## 5. LITERATURE REVIEW

The canonical model of time preferences formalized in Koopmans (1960) has been questioned by psychologists and experimental economists who have put forward a series of “anomalies” in

intertemporal choice (for a review, see Frederick et al., 2002). A recurrent issue is whether anomalies are generated by present-bias time preferences (Phelps and Pollack, 1968, Laibson, 1997, O'Donoghue and Rabin, 1999, Rubinstein, 2003). To support the argument of present-bias preferences, experimentalists have provided extensive evidence of reversal of choices over time, often attributing the reversals to the temptation of immediate rewards and lack of self-control. In this section, we review the evidence from incentivized experiments with human beings and review a selection of theoretical explanations that have been proposed.

Static choice reversal was widespread in experimental studies with money as a reward (e.g., Kirby, 1995, Benhabib et al., 2006, Casari, 2009). There exists also experimental evidence on choice reversal with nonmonetary stimuli. Among them, Brown et al. (2009) ran experiments with drinking water, Millar and Navarick (1984) with noise, Pender (1996) with rice, and Reuben et al. (2010) with chocolate. The debate on whether time preferences are domain-specific is still open (e.g., Chapman, 1996).

Economists have offered several possible theoretical explanations for choice reversals over time. The most frequently investigated explanation relates to present-bias time preferences (e.g., Phelps and Pollack, 1968, Laibson, 1997, Benabou and Tirole, 2004, Fudenberg and Levine, 2006). Another category of explanations relies on uncertainty about the future. Uncertainty affects intertemporal behavior and can generate time-inconsistent behavior. It may be articulated in many forms. Yaari (1965) study the impact of uncertain lifetime; Sozou (1995) consider discounting as a function of the risk that a delayed reward may not be received; Azfar (1999) studies the role of uncertain discount rates; Fernandez-Villaverde and Mukherji (2002) consider random shocks on consumption preferences; Dasgupta and Maskin (2005) study an uncertain environment where payoff may be realized early; and Halevy (2008) considers both the role of uncertain lifetime and default probability. Interestingly, experimental studies of intertemporal preferences are often carried out under the assumption of a certainty scenario. This assumption facilitates the identification of a point estimate for discount factors but neglects that uncertainty is often an intrinsic feature of intertemporal decisions, even when the experimenter does not explicitly introduce it (for an exception, see Keren and Roelofsma, 1995). The neglect of uncertainty may be one of the sources of the large variability in the estimates of discount factors reported in the literature (Frederick et al., 2002).

Scholars have suggested extensions of the canonical model of time preferences to include

empirically relevant phenomena such as habits and addictions (e.g., Schelling, 1978, Charness and Gneezy, 2010), state-dependent preferences (e.g., Dasgupta and Maskin, 2005, Manzini and Mariotti, 2010), or anticipatory feelings (e.g., Loewenstein, 1987, Caplin and Leahy, 2001), Although not an explanation for choice reversal, anticipatory feelings are often cited as a source of anomalies in intertemporal choice. They may generate negative time preferences (Loewenstein, 1987) and alter the incentive for information acquisition (Caplin and Leahy, 2005).

## 6. DISCUSSION

From the reported evidence, we draw three main conclusions. First, less than 5% of subjects made choices compatible with exponential or quasi-hyperbolic discounting (Prediction 1). In these models, the best option for noise listening is the latest available date and the worst option is now. Moreover, there should be no demand for flexibility and no choice reversal. Only 3 out of 71 subjects fit this prediction.<sup>21</sup> In summary, the empirical evidence does not support an explanation based on models of exponential or quasi-hyperbolic discounting.

Second, about 65% of subjects revealed negative time preferences (Table 1). These subjects chose now as their most preferred date for noise listening and the latest available date as the least preferred. Such a finding is unexpected. This result on negative time preference does not seem an artifact of the lack of economic training.<sup>22</sup> If subjects experience dread or anxiety while waiting for the moment of noise listening, anticipating it may be optimal: the best date for noise listening may be now, and the worst date may be the one furthest away (Prediction 4). A model of anticipatory feelings explains about one third of the individual choices elicited at date 0 (28/71=39.4%). This suggests that anticipatory feelings can be an important drive behind intertemporal choices, although not the only one leading to negative time preferences. Van der Pol and Cairns (2000) report that some subjects, although not the majority, exhibit negative or zero discount rates when facing hypothetical choices over health conditions involving moderate

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<sup>21</sup> We classified subjects into three categories plus a residual. For N=71 the criteria are: best ranking is 210 and no demand for flexibility (discounters, N=3/71); best ranking is 012 and no demand for flexibility (anticipatory feelings, N=28/71); best ranking is not 102 or 201 and demand for flexibility (uncertainty, N=21/71). The residual category includes 19 subjects. For N=47, information on the absence of dynamic and calendar choice reversal can be used for discounters and anticipatory feelings. Subjects classified as discounters are 2/47, subjects with anticipatory feelings are 13/47; for uncertainty 12/47. The residual category includes 20 subjects.

<sup>22</sup> One would expect the behavior of Economics majors to be close to the standard economic models and, eventually, the behavior of Humanities majors to be less close. The probit regressions reported in Tables 3, 4, and 6 draw a different picture. Economics majors are not significantly different than others, while Humanities majors are less likely to exhibit negative time preferences.

pain or discomfort. Loewenstein (1987) presents suggestive evidence of negative time preferences based on hypothetical choices in various domains. He attributes this pattern to anticipatory feelings. As discussed below, there is evidence that state-uncertainty about the future plays also an important role.

Third, about half of the subjects reversed their choices according to at least one of our definitions. Most of the experimental literature on intertemporal choices interprets choice reversals as a consequence of temptation from present-biased agents. In our setup, temptation cannot lead to choice reversals. Hence there must exist other sources of choice reversal over time beyond temptation. We have proved that, within a certainty scenario, the results on choice reversal are predicted neither by an exponential model, nor by a quasi-hyperbolic model, nor by anticipatory feelings. On the contrary, a simple model of mood uncertainty can go a long way in explaining the data. Mood uncertainty is compatible with negative time preferences as well as with choice reversal. According to Sozou (1998), Casari (2009), and Manzini and Mariotti (2010), choice reversals may also originate from uncertainty. Looking at the data, there are two cues to detect whether uncertainty plays a role in intertemporal choices. One is demand for flexibility and another is dynamic choice reversal. A demand for flexibility is direct evidence that the subject fears future shocks. Dynamic choice reversal may occur in case of unpredicted events. In the restricted sample, 27 out of 47 subjects either demanded flexibility or displayed dynamic choice reversal (57%). This evidence points toward a substantive impact of uncertainty in intertemporal choices.<sup>23</sup> This evidence is not a statement that undermines the validity of a model of exponential or present-bias preferences; rather, it suggests that uncertainty and anticipatory feelings also contribute to explain intertemporal choices.

A final note is on the real-effort task. The experiment involved choices over annoying noise, which had the advantage of addressing serious methodological concerns related to the storability and tradability of monetary rewards. As it was to be administered in a non-divisible package, it had the additional advantage that the predictions for an agent that discounts the future did not rely on a specific form of the utility and of the discounting function. Note that whether the stimulus is a good or a bad has no influence on the prediction that the best profile according to a discounting model corresponds to the worst profile for an agent experiencing anticipatory

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<sup>23</sup> Calendar choice reversal appears to be the effect of random shocks, which is consistent with an explanation based on mood uncertainty. See the probit regressions reported in Table 6.

feelings (in a certainty scenario). There is, however, an issue on whether time preferences are domain-specific. It is left for further research to assess whether our conclusions hold both for monetary and nonmonetary rewards and both in the gain and loss domains.

## 7. CONCLUSIONS

We have studied time preferences and time consistency in an experiment with a real-effort task. This paper makes three contributions. First, it documents widespread “negative time preferences” in a controlled, incentivized setting. Second, it offers explanations for these experimental results at the individual level. Third, it provides a systematic analysis of time consistency through the definition and measurement of choice reversals.

In our experiment, subjects faced a decision between a sooner reward and a later reward of the *same amount*. It is the simplest task we could think of to study intertemporal choice. In most intertemporal choice experiments, the task usually involves two dimensions: amount and timing. Typically, subjects face a decision between a smaller sooner reward and a larger later reward. In our setting, there is no trade-off between amounts and timings of consumption because the only dimension is timing. As a consequence, the prediction on the optimal choice is straightforward: any participant who discounts the future wishes to bring forward rewards to an earlier point in time and defer costs to a later point in time. In the experiment, choices are made over a one-month horizon and have a *dynamic* structure in the sense that subjects make decisions at multiple points in time, i.e., today and then again two weeks later.

We report that two thirds of the subjects exhibit negative time preferences. To the best of our knowledge, our study is the first incentivized experiment that presents such an overwhelming evidence of negative time preferences. Exponential or quasi-hyperbolic discounting are at odds with negative time preferences. To explain these results, we consider a set of simple models. For each model, we put forward predictions on the timing of consumption, demand for flexibility, and possible choice reversal. The empirical evidence is broadly compatible with economic theory if one is willing to admit state-dependent preferences and anticipatory feelings. More specifically, between 53% and 69% of subjects fit the predictions of either a state-dependent or an anticipatory feelings model.

Less than 5% of subjects fit the predictions of exponential or quasi-hyperbolic discounting models. However, this evidence does not suggest that impatience and temptation play no role in

intertemporal choices. First, their role has already been convincingly documented in several empirical studies. Second, our experiment neutralizes the influence of temptation in order to detect other drives. The design is such that exponential and quasi-hyperbolic discounters are predicted to behave in the same way. Therefore, any deviation from these predictions simply suggests that there exist additional drives behind intertemporal choices. Our conclusion is that we cannot expect the canonical exponential model or the quasi-hyperbolic model to fit all empirical evidence, either experimental or field evidence. Other drives will need to be taken into, especially uncertainty.

Another main contribution of this study concerns time inconsistency. Static choice reversal occurred for about a third of the individuals. This result is novel because it occurred without being triggered by temptation, implying that – besides present-biased preferences – there also exist other potential causes for choice reversals. In addition, a novel aspect of the experiment is the measurement of three distinct notions of choice reversal over time. The literature on time consistency, as well as most anecdotes about self-control, rely on subjects taking decisions at multiple points in time. By contrast, the majority of experimental studies rely on a one-point measurement of time preferences. This static measurement captures some relevant aspects of the issue, although it differs from the dynamic measurement studied by, e.g., Strotz (1955). Importantly, the presence of static choice reversal does not necessarily imply the presence of dynamic choice reversal, nor vice versa. We can measure the frequency of dynamic choice reversal in the data because of our multi-stage design. The vast majority of experiments in intertemporal choice cannot or do not record dynamic choice reversal. We report that several subjects exhibit dynamic choice reversal over time. The frequency with which this occurred is comparable to the frequency of static choice reversal, although the two types of choice reversal are not necessarily driven by the same factors.

This study aims neither to obtain quantitative estimates of discount factors nor to disentangle exponential from quasi-hyperbolic discounting. Instead, the aim is to discover if there are other motivations for intertemporal choices besides impatience and temptation. Empirical studies of time preferences are methodologically difficult because of the intermingling of impatience, temptation, risk, uncertainty, and anticipatory feelings. With its dynamic design and real-effort task, this study takes a step toward understanding intertemporal choices. The evidence presented calls for models of intertemporal choice with a wider range of motivations, where impatience

and temptation are complemented by state-dependent preferences and anticipatory feelings.

### APPENDIX: PROOFS

Before presenting proofs of Propositions 1, 2, and 3, we first introduce some notation. Let  $v_{30} := v(30)$  be the instantaneous utility from receiving 30 euros for listening to the noise, and  $v_e := v(e)$ , with  $e = 0, 5, 10$ , and  $15$ , the utility from the exit payment a subject receives if she completes the experiment, but does not listen to the noise when required. By design,  $v_{30} > v_e > 0$ .

Let  $t > 0$  be the transportation cost to be paid to go to the lab at date 1 and 2, and let  $c > 0$  be the cost of noise listening at date 0, 1 and 2. Figure 1.A. presents the decision tree faced by a subject that discount the future and must choose her preferred profile for noise listening.

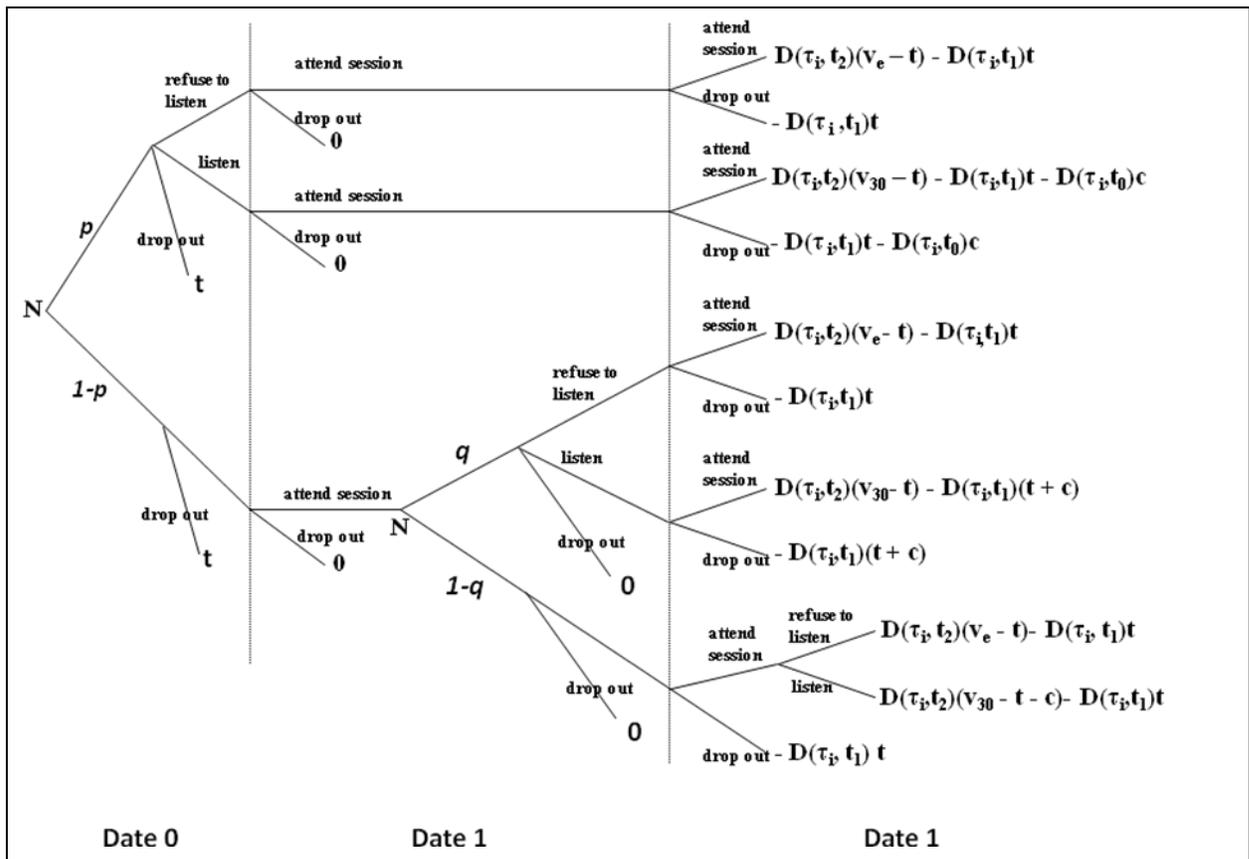


Figure 1.A: Decisional tree;  $i=0,1,2$ .

Notes: Transportation costs at date 0 are sunk and not considered.

Let the show-up fee for dropping out during a session be equal to the transportation cost. This

assumption implies that a subject is indifferent between not going to the lab and going to the lab for cashing the show-up fee. Note that, since at date 0 the transportation cost is sunk, dropping at date 0 and receiving the show up fee dominates later drops out. This allows ignoring all dropout options available during sessions 1 and 2.

Let  $p$  be the probability of being asked to listen to the noise in 0,  $(1-p)q$  the probability of being required to listen to the noise in 1 and  $(1-p)(1-q)$  the probability of being required to listen in 2 (Fig. 1.A). Table 2.A lists the values of  $p$  and  $q$  associated to the six available rankings, and the probability of listening at each date, given the ranking revealed in 0.

Ranking code	$p$	$q$	Probability of noise listening		
			Session 0	Session 1	Session 2
012	6/10	2/3	.60	.27	.13
021	6/10	1/3	.60	.13	.27
210	1/10	1/3	.10	.30	.60
120	1/10	2/3	.10	.60	.30
201	3/10	1/3	.30	.23	.47
102	3/10	2/3	.30	.47	.23

Table 2.A: Probability of listening to noise given the ranking revealed in 0

**Proof of Prediction 1.** We use the notion of subgame perfection to first show the conditions under which a subject is either a solid or a casual fulfiller. Then we determine the optimal strategy profile associated to each set of conditions.

The subject is a solid fulfiller if, for a given  $v_e, v_{30} > \text{Max}\{V_5, L_0\}$ . In such a case she attends all sessions and is willing to listen when required. To assess her preferred profile, we compute the discounted utility profiles associated to being required to listen in 0, 1 and 2. If required to listen in 0 (probability =  $p$ ) the subject receives  $-c - \beta\delta t + \beta\delta^2 (v_{30} - t)$ ; if required to listen in 1 (probability  $pq$ ) she receives  $-\beta\delta (c + t) + \beta\delta^2 (v_{30} - t)$ ; and if required to listen in 2 (probability  $p(1-q)$ ) she receives  $-\beta\delta t + \beta\delta^2 (v_{30} - t - c)$ . At 0, later listening is preferred to earlier noise listening. Ranking 210 yields the highest probability to being required to listen in 2, and the lowest probability to listen in date 0 (Table 2.A), hence it is the preferred choice for a solid fulfiller.

**Proof of Prediction 2.** Note that, if a subject is willing to listen in 0, she is also willing to listen at all previous dates and attend all sessions. If this is not the case, then she may be a casual fulfiller, provided she is willing to listen at least at date 2. Table 3.A lists the threshold values that are used to determine the preferred ranking for an exponential and a hyperbolic discounter. Based on the threshold values defined in Table 3.A, the best profile for each of the cases indicated in Table 4.A is determined by comparing the payoff accruing to each of the three branches of the decision tree. As stated in Prediction 2, listening in 2 is preferred for all casual fulfillers.

$L_0 = v_e + c/(\beta\delta^2)$	$V_2 = t + (c + t)/(\beta\delta)$
$L_1 = v_e + c/(\beta\delta)$	$V_3 = c(\delta + q - \delta q)/\delta + (1 + \delta)t/\delta + t/(\beta\delta^2)$
$L_2 = v_e + c$	$V_4 = c + (1 + 1/\delta)t + t/[\beta\delta^2(1 - q)]$
$O_1 = t + t/(\beta\delta)$	$V_5 = t + t/\delta + (c + t)/(\beta\delta^2)$
$O_2 = t + t/\delta + t/(\beta\delta^2)$	$V_6 = c + [1 + \beta\delta(1 + \delta)]t/[\beta\delta^2(1 - q)] - qv_e/(1 - q)$
$V_1 = c/\delta + t + t/(\beta\delta^2) + t/\delta$	

Table 3.A. Threshold values.

Strategy profile	Preferred ranking	Conditions
Opts out in 0, listens in 1 and 2	210	$v_e > O_2, L_1 < v_{30} < L_0$
Opts out in 1 and 0, listens in 2	210 ~ 201	$v_e > O_2, L_2 < v_{30} < L_1$
Drops out in 0, listens in 1 and 2	210	$v_e < O_2, V_1 < v_{30} < V_5, v_{30} > l_1$
	201	$v_e < O_2, V_3 < v_{30} < V_1, v_{30} > l_1$
Drops out in 0 and 1, listens in 2	210 ~ 201	$v_e < O_1, V_4 < v_{30} < V_2$
Drops out in 0, opts out in 1, listens in 2	201	$v_e > O_2, V_6 < v_{30} < L_1$

Table 4.A. Casual fulfillers, preferred rankings and conditions.

**Proof of Prediction 3.** With perfectly patient agents, the decision problem on the ranking of dates depends reduces to the choice between the sure disutility of immediate noise listening,  $-y$ , and the expected disutility of future noise listening, given by  $-(c(x) + f\lambda)$ . The sure disutility  $y$  is

$c(x)$  if the agent is currently in good mood, and  $c(x) + \lambda$  if in bad mood. Given the assumption of a weakly concave utility function, when in good mood the sure amount is the best choice because  $y = c(x) < c(x) + f\lambda$ . Listening immediately is the best choice and the subject is indifferent between profiles 012 and 021. Profile 021 reveals static choice reversal. Symmetrically, when in bad mood the sure amount is the worst choice, because  $y = c(x) + \lambda > c(x) + f\lambda$ .

Let  $k$  be the probability of choosing 021 over 012 and 210 over 120. Tie-breaking between pairs of indifferent profiles depends on the value of the parameter  $k$ . An agent in 1 chooses 12 when in good mood, and 21 when in bad mood. Static choice reversal choice reversal is detected if the subject either chooses 120 when in bad mood (occurs with probability  $f(1-k)$ ), or 021 when in good mood (occurs with probability  $(1-f)k$ ). Summing up yields the overall probability of static choice reversal. Calendar choice reversal occurs if the subject chooses: (i) 210 and 12 (prob.=  $fk(1-f)$ ), (ii) 120 and 12 (prob.=  $(1-k)(1-f)f$ ), (iii) 012 and 21 (prob.=  $(1-k)(1-f)f$ ), and (iv) 021 and 21 (prob.=  $(1-f)kf$ ). Summing up the probabilities the above four cases can occur, the expected probability of choice reversal is  $2f(1-f)$ . The expected probability of dynamic choice reversal is  $f(1-2k)+k$ .<sup>24</sup>

**Demand for flexibility when future disutility is uncertain.** At date 0, consider the utility the subject can obtain at date 1 and 2. Recall that  $f$  is the probability of being in bad mood at 1 and 2. At date 1, let  $q_1$  be the probability of being required to listen to the noise when in good mood. Analogously, let  $q_2$  be the probability of being required to listen when in bad mood. At date 0, six cases are possible, depending on the (future) mood at 1 and on the date in which noise listening is required by the experimenters (Fig. 2.A).

Given  $q_1$  and  $q_2$ , at date 0 the expected disutility cost of the lottery  $L(q_1, q_2)$  is  $c + f\lambda [1 - (1-f)(q_1 - q_2)]$ .<sup>25</sup> Not buying flexibility corresponds to the case where  $q_1$  and  $q_2$  cannot be conditioned on mood at date 1. This implies  $q_1 = q_2$ . Given our design, when revealing her ranking at date 0 the subject can choose only between *two* lotteries,  $L(1/3, 1/3)$  or  $L(2/3, 2/3)$ . For both lotteries the expected disutility cost is  $c + f\lambda$ .

---

<sup>24</sup> Discounting allows breaking the above ties. When future moods are uncertain, an exponential agent will rank noise listening according to her current mood. When currently in good mood, the agent's revealed ranking is 012. When currently in bad mood, the agent's revealed ranking is either 210.

<sup>25</sup> Note that  $L(q_1, q_2)$  is linearly decreasing in  $q_1$  and increasing in  $q_2$ . Thus it is minimized for high values of  $q_1$  and low values of  $q_2$ . This is consistent with intuition: when in good mood, one wants to listen to the noise with the highest probability, when in bad mood the smallest probability is preferred.

A subject that buys flexibility, instead, can choose at date 1 the best probability of noise listening depending on her current mood. Given our design, with flexibility the subject can choose between *four* lotteries  $L(2/3, 2/3)$ ,  $L(2/3, 1/3)$ ,  $L(1/3, 2/3)$ , and  $L(1/3, 1/3)$ . The expected cost is minimized by lottery  $L(2/3, 1/3)$ , whose value is  $c + f \lambda [1 - (1-f)/3]$ . Let  $F$  be the price of the flexibility option. The maximum price the agent is willing to pay for flexibility is given by the difference between  $L(2/3, 1/3)$  and  $L(1/3, 1/3) = L(2/3, 2/3)$ .

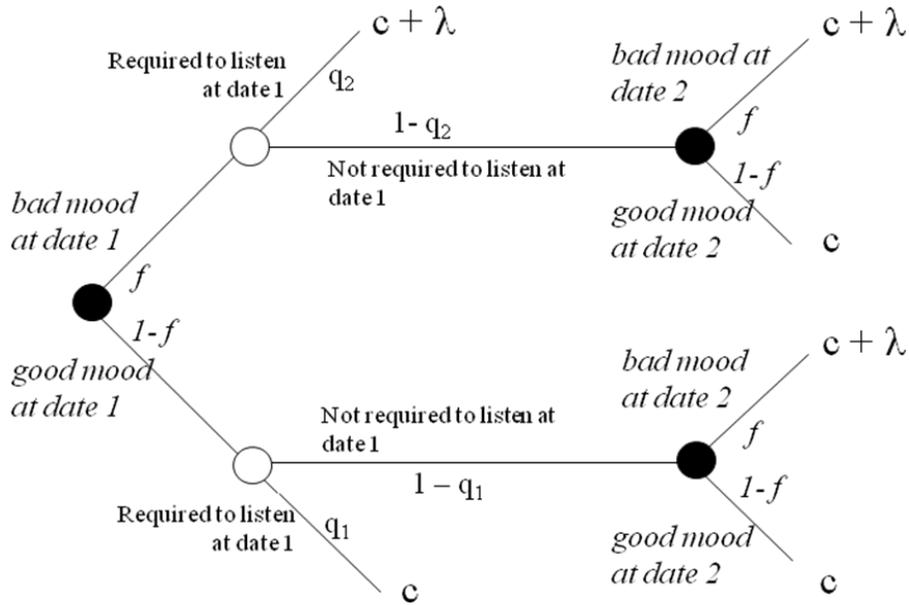


Figure 2.A. Decision tree for an agent that buys flexibility at date 0.

Notes: Nature selects good or bad mood (black circles), the agent selects the probability of being required to listen to noise, conditional on current mood (white circles).

## References

- Ainslie, G. and V. Haendel (1983). "The Motives of Will," in E. Gottheil, K. Druley, T. Skolda and H. Waxman (eds.). *Etiologic Aspects of Alcohol and Drug Abuses*, Charles C. Thomas.
- Amador, M. Werning, I. Angeletos, G-M. (2006). "Commitment vs. Flexibility." *Econometrica*, 74, 365-96.
- Azfar, O. (1999). "Rationalizing Hyperbolic Discounting." *Journal of Economic Behavior & Organization*, 38, 245-252.
- Benabou, R. and Tirole, J. (2004). "Willpower and Personal Rules." *Journal of Political Economy*, 112, 848-886.
- Benartzi, S. and Thaler, R. H. (2004). "Save More Tomorrow: Using Behavioral Economics to Increase Employee Saving." *Journal of Political Economy*, CXII, S164-S187.
- Benhabib, J., A. Bisin, and A. Schotter (2006). *Present-Bias, Quasi-Hyperbolic Discounting, and Fixed Costs*, working paper, New York University
- Brown, A. L., Chua Z. E., Camerer, C. F. (2009). "Learning and Visceral Temptation in Dynamic Saving Experiments," *The Quarterly Journal of Economics*, 124, 197-223.
- Caplin, A., Leahy, J. (2001). "Psychological Expected Utility Theory and Anticipatory Feelings." *Quarterly Journal of Economics*, 116, 55-79
- Casari, M. (2009). "Pre-commitment and Flexibility in a Time-decision Experiment." *Journal of Risk and Uncertainty*, 38, 117-141.
- Chapman, G. B. (1996). "Temporal Discounting and Utility for Health and Money." *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 22, 771-91.
- Charness, G., and Gneezy, U. (2009). "Incentives to Exercise." *Econometrica*, 77, 909-931.
- Coller, M., and Williams, M. B. (1999). "Eliciting Individual Discount Rates". *Experimental Economics*, 2, 107-127.
- Cubitt, R. P., and D. Read (2007). "Can Intertemporal Choice Experiments Elicit Time Preferences for Consumption?" *Experimental Economics* 10, 369-389
- Dasgupta, P., and Maskin, E. (2005). "Uncertainty and Hyperbolic Discounting." *American Economic Review*, 95, 1290-1299.
- Fernandez-Villaverde, J. and Mukherji, A. (2000). "Can we really observe hyperbolic discounting?" Unpublished Manuscript, University of Minnesota.

- Frederick, S. (2005). "Cognitive Reflection and Decision Making." *Journal of Economic Perspectives*, 19, 25-42.
- Frederick, S. Loewenstein, G. and O'Donoghue, T. (2002). "Time Discounting and Time Preference: A Critical Review." *Journal of Economic Literature*, XL, 351-401.
- Fudenberg, D. and Levine, D. K. (2006). "A Dual Model of Impulse Control." *American Economic Review* 96, 1449-76.
- Halevy, Y. (2008). "Strotz meets Allais: Diminishing impatience and the certainty effect." *The American Economic Review*, 98, 1145-1162.
- Keren, G., and Roelofsma, P. (1995). "Immediacy and Certainty in Intertemporal Choice." *Organizational Behavior and Human Decision Processes*, 63, 287-297.
- Kirby, K. N. and Herrnstein, R.J. (1995). "Preference Reversals due to Myopic Discounting of Delayed Reward." *Psychological Science*, 6, 83-89.
- Koopmans, T. C. (1960). "Stationary Ordinal Utility and Impatience." *Econometrica*, 28, 287-309.
- Laibson, D. (1997). "Golden Eggs and Hyperbolic Discounting." *Quarterly Journal of Economics*, 112, 443-77.
- Loewenstein, G. (1987). "Anticipation and the Valuation of Delayed Consumption." *Economic Journal*, 97, 666-84.
- Loewenstein, G. and Prelec, D. (1991). "Negative Time Preference." *American Economic Review*, 81, 347-352.
- Mas-Colell, A., Whinston, M. D., and Green, J.R. (1995). *Microeconomic Theory*. Oxford University Press New York
- Manzini, P., and Mariotti, M. (2010). "Moody Choice." IZA Discussion Paper 5005.
- Millar, A. and Navarick, D.J. (1984). "Self-control and Choice in Humans: Effects of video game playing as a positive reinforcer." *Learning and Motivation*, 15, 203-218.
- O'Donoghue, T. and Rabin, M. (1999). "Doing it Now or Later." *American Economic Review*, 89, 1, 103-24.
- Pender, J. L. (1996). "Discount Rates and Credit Markets: Theory and Evidence from Rural India." *Journal of Development Economics*, 50, 257-296.
- Phelps, E.S. and Pollak, R. (1968). "On Second-Best National Saving and Game-Equilibrium Growth." *Review of Economic Studies*, 35, 185-199.

- Rachlin, H. (2000). *The Science of Self-control*. Cambridge, Harvard University Press.
- Read, D. (2001). "Is Time-discounting Hyperbolic or Subadditive?" *Journal of Risk and Uncertainty*, 23, 5-32.
- Reuben, E., Sapienza, P., and Zingales, L. (2010). "Time Discounting for Primary and Monetary Rewards" *Economics Letters*, 106, 125-127
- Rubinstein, A. (2003). "Economics and Psychology? The Case of Hyperbolic Discounting." *International Economic Review*, 44, 1207-1216.
- Samuelson, P. (1937). "A Note on Measurement of Utility." *Review of Economic Studies*, 4, 155-161.
- Schelling, T. C. (1978). "Economics, or the Art of Self-Management," *American Economic Review*, 68, 290-294.
- Sozou, P. D. (1998). "On Hyperbolic Discounting and Uncertain Hazard Rates." *Proceedings of the Royal Society of London: Biological Sciences (Series B)*, 265 (1409), 2015-2020.
- Strotz, R. H. (1955-1956). "Myopia and Inconsistency in Dynamic Utility Maximization." *Review of Economic Studies*, 23, 165-80.
- Thaler, R. H. (1981). "Some Empirical Evidence on Dynamic Inconsistency." *Economics Letters*, 8, 201-7.
- Van Der Pol, M. M., and Cairns, J. A. (2000). "Negative and Zero Time Preference for Health." *Health Economics* 9, 171-175
- Warner, J. T. and Pleeter, S. (2001). "The Personal Discount Rate: Evidence from Military Downsizing Programs." *American Economic Review*, 91, 33-53.
- Yaari, M. (1965). "Uncertain Lifetime, Life Insurance, and the Theory of the Consumer." *Review of Economic Studies*, 32, 137-150.

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APPENDIX for “Impatience, Anticipatory Feelings and Uncertainty”

**B. ADDITIONAL DATA ANALYSIS**

Ranking in 0	Ranking in 1	Subjects’ choice (no.)	Static choice reversal	Calendar choice reversal	Dynamic choice reversal	Compatible with discounting	Compatible with state dependent utility	Compatible with anticipatory feelings
012	12	19					Y	Y
120	12	5	Y	Y			Y	
102	12	5	Y	Y				
012	21	4		Y	Y		Y	
210	21	3				Y	Y	
120	21	3	Y		Y		Y	
210	12	2		Y	Y		Y	
021	12	2	Y		Y		Y	
201	21	2	Y	Y				
102	21	1	Y		Y			
021	21	1	Y	Y			Y	
201	12	0	Y		Y			
Total (no.)		47	<b>19</b>	<b>19</b>	<b>12</b>	<b>3</b>	<b>39</b>	<b>19</b>

Table 1.B: Rankings and choice reversals, restricted sample only (N=47).

From Table 1.B one can see that either no choice reversal can be detected or exactly two. Suppose a static choice reversal is detected. This occurs when at time 0 the subject reveals the following preferences: either (i)  $0 > 1$  and  $1 < 2$ , or (ii)  $0 < 1$  and  $1 > 2$ . Without loss of generality, consider the case where (i) holds. At decision time 1 two cases are possible: either the subject prefers to postpone (in C:  $2 > 1$ ), or to anticipate (in C:  $2 < 1$ ). If the subject prefers to postpone, she exhibits calendar choice reversal, but no dynamic choice reversal. If the subject prefers to anticipate, she exhibits dynamic choice reversal, but no calendar choice reversal. Analogously, if case (ii) holds it can be shown that, if there is one form of choice reversal, there is also another one, but not two. This is stated in Proposition 1.

Ranking code	Subjects' choice in 0 (no.)	Subjects that in 1 prefer immediate listening (no.)
210	5	2
102	6	5
012	23	19
201	2	0
120	8	5
021	3	2
Total	47	33

Table 2.B: Subjects that prefer immediate listening in both 0 and 1 are 21, restricted sample only (N=47)

Variable	Obs	Mean	Std. Dev.	Min	Max
Male	87	0.57	0.50	0	1
Economics Major	87	0.61	0.49	0	1
Humanities Major	87	0.31	0.47	0	1
High score on cognitive abilities	87	0.44	0.50	0	1
Not impulsive	87	0.33	0.47	0	1
Smoker, tried to quit unsuccessfully	87	0.18	0.39	0	1
Never smoked	87	0.69	0.47	0	1
Never had unsafe sex	87	0.55	0.50	0	1
Better-than- average driver	87	0.41	0.50	0	1
Eats the most preferred bite at the end of the meal	87	0.52	0.50	0	1
Just listened to noise (yellow auction)	87	0.11	0.32	0	1
Prefers ranking 012	87	0.66	0.48	0	1
Static choice reversal	87	0.29	0.46	0	1
Calendar choice reversal	47	0.40	0.50	0	1
Dynamic choice reversal	47	0.26	0.44	0	1
Demand for flexibility	71	0.38	0.49	0	1
Willing to increase exit penalty	71	0.23	0.42	0	1

Table 3.B. Summary statistics

	Male	Economics Major	Humanities Major	High score on cognitive abilities	Not impulsive	Smoker, tried to quit unsuccessfully
Male	1					
Economics Major	-0.2125*	1				
Humanities Major	0.2755*	-0.8375*	1			
High score on cognitive abilities	-0.0862	0.0879	-0.0898	1		
Not impulsive	-0.3288*	0.0666	-0.0527	0.2622*	1	
Smoker, tried to quit unsuccessfully	-0.1918	-0.0454	0.0663	-0.0591	0.1678	1
Never smoked	0.1768	0.0228	-0.0333	0.1399	-0.1054	-0.7077*
Never had unsafe sex	0.0661	0.0833	0.0052	-0.1382	0.0000	0.0699
Better-than- average driver	-0.1742	0.0511	-0.1600	0.1071	0.2475*	0.0831
Eats preferred bite at the end of the meal	-0.1332	0.0276	0.0514	-0.0304	0.0000	0.1024
Just listened to noise (yellow auction)	-0.2002	0.2148*	-0.2417*	-0.0267	0.0510	-0.0781
Prefers ranking 012	0.0607	-0.0359	-0.0360	-0.0437	-0.0513	0.1571
Static choice reversal	-0.0703	-0.0120	0.0682	0.0553	0.0359	-0.1048
Calendar choice reversal	0.0427	-0.0115	-0.0625	0.1126	0.0115	-0.1104
Dynamic choice reversal	-0.1608	0.2377	-0.2747	-0.3053*	-0.1361	0.1725
Demand for flexibility	0.2166	-0.0709	0.0438	0.2007	-0.3144*	-0.0965
Willing to increase exit penalty	0.2283	-0.1369	0.1330	-0.2323	-0.3142*	-0.0979
	Never smoked	Never unsafe sex	Better-than-average driver	Eats preferred bite at the end of the meal	Just listened to noise (yellow auction)	Best ranking is 012
Never smoked	1					
Never had unsafe sex	-0.0052	1				
Better-than- average driver	-0.0417	0.1473	1			
Eats the most preferred bite at the end of the meal	-0.1012	-0.1308	-0.1224	1		
Just listened to noise (yellow auction)	0.1639	0.1799	-0.1564	-0.0124	1	
Best ranking is 012	-0.1208	-0.0704	-0.0779	-0.0718	-0.2693*	1
Static choice reversal	0.1515	0.1127	0.0338	0.1052	0.3286*	-0.8753*
Calendar choice reversal	0.0059	0.1645	0.0802	0.1645	0.0746	-0.4595*
Dynamic choice reversal	-0.2272	-0.2330	0.0882	0.0603	0.0684	-0.1828
Demand for flexibility	0.0857	0.0320	-0.1197	-0.1783	-0.0294	-0.0438
Willing to increase exit penalty	-0.0031	0.2323	-0.0367	-0.0228	-0.0427	-0.2025
	Static choice reversal	Calendar choice reversal	Dynamic choice reversal	Demand for flexibility	Willing to increase exit penalty	
Static choice reversal	1					
Calendar choice reversal	0.4699*	1				
Dynamic choice reversal	0.1142	0.1142	1			
Demand for flexibility	0.0398	0.2429	-0.1602	1		
Willing to increase exit penalty	0.2218	0.1271	0.0454	0.0636	1	

Table 4.B. Pairwise correlations, \* significant at 5%

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## C. INSTRUCTIONS

*Notes: translation from the original instructions for treatment 1.*

### INSTRUCTIONS FOR SESSION 0

Welcome. This study is funded by (omissis) and by the University of (omissis) with the aim of understanding how people make decisions concerning money and noisy environments. This study consists of three sessions: one **today**, the next one in **two weeks**, and the last one in **four weeks**. You have agreed to participate to all sessions. Each session's duration is the same for everyone and does not depend on your choices. If you attend all three sessions, you will receive 30 euros upon completion. The final payment may be higher or lower depending on your choices during the three sessions. Some of the choices will be paid at the end of today's session.



Today's session has five parts, and in each part you will be asked to make some choices.

### WHITE PART

In the white part there will be an **auction**, which is to be used as an example for the yellow part that will follow. Please, now take the white coupon in front of you and write your pc number. There are some books at the bar downstairs, to be delivered to me. We ask you to write on the coupon how much money you ask to exit this room, go to the bartender and get one of the books. You may write € 0.00 or any positive amount, for example, € 25.09, using also euro cents. If you write € 0.00 means you are willing to take the book without compensation

When all bids are made, we will gather all coupons, shuffle them, and separate them into groups of four. We will take a group of coupons at a time, and the person who asked for **the lowest bid in each group** will be asked to leave the room and get the book from the bartender, while the others will wait here. The person who brings a book **will be paid the SECOND lowest bid in the group**. The other persons will stay here and will not receive any payment.

The payment will take place today, at the end of the session. Let's make an example. If the bids in the group are € 0.00, € 0.30, € 8.80, and € 25.09, the person who offered € 0.00 (the lowest bid) will fetch the book and will be paid € 0.30 (the second lowest bid). Ties will be solved by random draw. Any question?

Note that, in general, those who bring a book will be paid more than they asked for. Also, if your discount is too low, you are unlikely to win the auction. For these reasons, **the best strategy** is to indicate the maximum discount you are willing to offer to carry out the task.

You can now write your discount on the white coupon. Since this auction is used as an example, we will publicly reveal all offers to clarify how the auction works.



**Important:** from now on, and until the conclusion of the study, it is important that you do not

speak with the other participants. For any question, raise your hand and one of us will privately answer.

### YELLOW PART

In the yellow part we will use the same **auction** we have just shown to ask your willingness to listen to noise. Now there will be a listening trial of 3 minutes to understand what kind of noise it is. You can wear the headphones. For each participant, we will initialize the track to be listened.



Please now take the yellow coupon in front of you and write your pc number. We now offer to listen to 20 minutes of noise like the one you have just listened to. We now ask you to write on the yellow coupon how much money you ask to listen to these 20 minutes of noise. We will then proceed according to the auction rule we have already seen in the white part.

When all choices are made, we will collect all coupons, shuffle them, and collect them into groups of four. We will take a group of four at a time, and the person who made **the lowest bid in the group** will listen to 20 minutes of noise, while the others are free to listen to the music, reading or studying. Who listens to the noise **will receive the SECOND lowest bid in the group**, while the others receive nothing. Ties will be broken by a random draw.

The payment will occur today, at the end of the session. Any question?

As before, please note that the **best strategy** is to ask the lowest compensation you are willing to accept to listen to 20 minutes of noise.

You can now write your bid on the yellow coupon.



People whose pc numbers will be announced must wear the headphones. For each participant, we will be in charge of starting the track to be listened. It is very important that you do not move the headphones from the ears until the noise is over. Removing the headphones for whatever reason before the 20 minutes results in the loss of your payment. For the next 20 minutes, those who do not listen to the noise may engage in any activity they like.



### BLUE PART

In this study, we will ask each of you (including those who have just listened to the noise) to listen to 20 minutes of noise. In the blue part we ask you to choose **when** you want to listen to these 20 minutes of noise. The available dates are three: **today, two weeks from today or four weeks from today**. In addition to these 20 minutes there will be no other noise to listen. Please take the blue coupon in front of you and write your pc number. Write **your own ranking** (i.e. your preference ordering) **about when listening to the noise**, indicating the most preferred date,

the date of intermediate preference, and the least preferred date. There are six possibilities, which we write below:

Most preferred date for noise listening	Intermediate preference for noise listening	Least preferred date for noise listening
Today	Two weeks later	Four weeks later
Two weeks later	Today	Four weeks later
Four weeks later	Two weeks later	Today
Today	Four weeks later	Two weeks later
Two weeks later	Four weeks later	Today
Four weeks later	Today	Two weeks later

The data in which you will be asked to listen to the noise will be chosen at random using a ten-faces die.

- If the die roll is 1, 2, 3, 4, 5, 6, the date for listening will be the one you indicated as most preferred
- If the die roll is 7, 8, 9, the date for listening will be the one you indicated as intermediate choice
- If the die roll is 10, the date for listening will be the one you indicated as least preferred choice

Any questions?

To sum up: how much noise will you listen to and when?

- you will listen to **40 minutes** of noise **today** (and nothing in the remaining sessions) if you have already won the yellow auction and the ten-faces roll determines today as the day for noise listening, or
- you will listen to **20 minutes** of noise **today** (and nothing in the remaining sessions) if you have not won the yellow auction and the ten-faces roll determines today as the day for noise listening, or
- you will listen to **20 minutes** of noise **two weeks later** depending on the die roll, or
- you will listen to **20 minutes** of noise **four weeks later** depending on the die roll.

You can now write down your ranking on the blue coupon.



When all are done, we will roll the ten-faces die to determine whether you will listen to the noise

today, or not. This occurs if

- today is your most preferred choice **and** the die roll is 1, 2, 3, 4, 5, 6;
- today is your intermediate choice **and** the die roll is 7, 8 and 9;
- today is your least preferred choice **and** the die roll is 10.

For each participant, we will be in charge of starting the track to be listened. It is very important that you do not move the headphones from the ears until the noise is over. Removing the headphones for whatever reason before the 20 minutes results in the loss of your payment. **If you are required to listen to the noise today, you can ignore the red and the green part that will be read while you are listening to the noise.**

#### RED PART

**If you are not required to listen to the noise today, please pay attention to the following.** In two weeks we will roll a six-faces die to determine when you will listen to the noise. We will take your blue coupon (where you have just written your ranking on the dates for choice listening) and we will roll the die.

You will listen to the 20 minutes of noise in the next session in the event that:

- you wrote in the blue coupon that you prefer to listen **two weeks later**, rather than four weeks later, **and** the die roll is 1, 2, 3, 4;
- you wrote in the blue coupon that you prefer to listen **four weeks later**, rather than two weeks later, **and** the die roll is 5, and 6.

Otherwise, you will listen to the noise four weeks later.

#### **What happens if in next session you want to change the choices made today?**

In the red part we give the possibility to change the ranking (i.e. the preference ordering) you have written today. This can be done during the session that takes place in two weeks time, for those people that have not listened to the noise yet. Please, now take the red coupon in front of you and write your pc number. We now invite you to buy through an auction the **possibility of changing the ranking on noise listening** during the session that takes place in two weeks time.

In other words you can choose again what is your preferred date for noise listening, depending on your preferences in two weeks time. The date for noise listening depends on your ranking and on the die roll (the die roll will take place during next session, in two weeks time).

Please write on the red coupon the **maximum** amount you are willing to pay to have this opportunity. You can write € 0.00, or any positive amount, i.e. € 25.09, specified in euro cents. If you write € 0.00, it means that you do not value this opportunity and that you do not care about changing the preference ordering you have chosen today.

When everyone will be done, we will collect all coupons, shuffle them, and collect them in pairs. We will take a pair at the time, and the person with **the highest bid in the pair** will fill in, two weeks later, a new blue coupon that will replace the one filled in today. For the other person of the pair, the choice made today is irrevocable, i.e. the blue coupon filled in today will be used to determine the date for listening to the noise. Whoever acquires the opportunity of replacing the blue coupon filled in today with the new one, **will pay the amount offered by the other person.** **This payment will not occur today, but upon completion of all three sessions.** Those who do not purchase this option will pay nothing. Ties will be solved by a random draw.

Please note that the **best strategy** is to offer the **maximum amount** you are willing to pay to acquire the option to update the rankings in the next session. Any question?

When you have filled in the red coupon, please record your choice also on the summary sheet. The results of the red part will be announced during the next session.



### GREEN PART

The green part concerns the case in which you **renounce to participate**. This can happen in two ways:

- 1) you drop out from the experiment. It is an option that you have at any time, in which case you will receive 3 €;
- 2) you take part to all three sessions, but **refuse to listen to the 20 minutes of noise when requested**. In this case, the payment you receive is chosen by you among the four following options. Please take the green coupon in front of you and write your pc number. We ask you to choose what payment you want to receive in case you refuse to listen to the noise. You can choose between the following amounts: **€ 15, € 10, € 5, € 0**.

Note that, whatever your choice on the green coupon is, by participating in all sessions and listening to the noise (when you will be required to do so), you will receive € 30. Your choice on the green coupon only concerns the payment in case you participate to all sessions, but refuse to listen to the noise.

Why choosing a low payment on the green coupon? Some people choose a low payment to force them to listen to the 20 minutes of noise, when required to do so. In this way they ensure the final payment of 30 € instead of € 15, € 10, € 5 or € 0.

Please write on the green coupon the payment you choose from the above list.

After filling in the green coupon, please record your decision also on the summary sheet.



Once the green coupon is completed, you can complete the questionnaire we are distributing.

Next session will be in this room in two weeks, and will approximately take one hour. Please be on time. Goodbye.

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### INSTRUCTIONS FOR SESSION 1

Welcome to the second session of this study. Please note that the study will be concluded in the next session, to be held two weeks from today, in which you will receive the payment for your participation.



Sessions duration is the same for everyone and does not depend on your choices.

From now on, and until the conclusion of the study, it is important that you do not speak with other participants.

For any question, raise your hand and one of us will answer in private.

Today's session has **three** parts (yellow, blue and green), but it can happen that in some part you do not have to take any decision. In such a case, you can simply ignore the instructions of that part and do any activity you like until we move on to the next part.

### YELLOW PART

Two weeks ago, you made choices about listening to twenty minutes of noise. We want to remind you what it was about with a listening test of one minute. You can wear the headphones. We will be in charge of starting the track to be listened for each participant.



### BLUE PART

In the last session you wrote on the blue coupon **when** you preferred to listen to 20 minutes of a noise similar to the one you have just listened to.

Please now take the new blue coupon in front of you and write your pc number.

- If **you have already listened** to the noise in the last session, write **ALREADY LISTENED** on the coupon and ignore the following instructions

- If you have **not** listened to the noise yet, we ask you to write again when you prefer listening to the noise, choosing between the session of **today** and the session that will take place **two weeks from today**.

**Why do we ask you again when you prefer listening to the noise?**

Because during last session you participated to an auction to obtain the possibility of changing, your ranking on the preferred dates for listening to the noise, during today's session.

If you won the auction, today you can use this possibility and update your ranking on the new blue coupon in front of you.

If you did not win the auction, instead, the ranking written during last session is the relevant one.

We will proceed as follows:

1. You will fill in a new blue coupon, indicating whether you prefer to listen to the noise today or two weeks later. Once everybody is done, we will collect all blue coupons.
2. We will announce who are the red auction winners (in this case the relevant coupon is **the new blue one**) and those who are not (in this case the relevant coupon is **the old blue one**)
3. We will go to each of you and you will roll a six-faces die to determine whether you are required to listen to the 20 minutes of noise today. We will ask you to listen to the noise today in the following cases:
  - (i) if your preferred session is today (indicated by the relevant blue coupon, depending on the outcome of the red auction) **and** the roll of the die is 1, 2, 3 or 4,

(ii) if your preferred session is two weeks from today (indicated by the relevant blue coupon, depending on the outcome of the auction) **and** the roll of the die is 5 or 6. Otherwise we will ask you to listen to the noise two weeks from today. Any question?

You can now write when you prefer to listen to the 20 minutes of noise on the new blue coupon. **If you have to listen to the noise today, pay attention to the green part.** Otherwise you can engage in any activity you like until the end of the session (about thirty minutes)



### GREEN PART

The green part concerns the case in which you are asked to listen to the noise today. Remember that if you attend all three sessions, and listen to the noise when required, you will receive 30 Euros in the next session. If, however, you attend all three sessions, but **refuse to listen** to the noise when required, you will receive the payment you indicated on the green coupon in the last session.

Now, take the **new** green coupon and write your pc number.

On the green coupon you will write LISTEN or REFUSE

- If you write LISTEN, it means that you are willing to listen today to the 20 minutes of noise, if requested to do so, and that in two weeks you will receive the € 30 payment for taking part to this study.
- If you write REFUSE, it means that you are not willing to listen today to the 20 minutes of noise, if requested to do so, and that in two weeks you will receive the payment you chose in the **last** session.

Remember that the payment will be only given upon attendance to all three sessions.

After the green coupons are filled in, we will collect them and we will start the track to be listened for those who wrote LISTEN. It is very important not to move the headphones before the noise is finished and not to change the volume settings. Removing the headphones for whatever reason before the 20 minutes results in the loss of the payment.

Now please fill in the green coupon.



The next session will be in this room in two weeks, and it will last less than an hour. Please be on time. Goodbye.

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### INSTRUCTIONS FOR SESSION 2

Welcome to the third and final session of this study. After the session you will privately receive the payment for your participation.



Session's duration is the same for everyone and does not depend on your choices. From now on, and until the conclusion of the study, it is important that you do not to speak with the other participants. For any question, raise your hand and one of us will privately assist you.

If in one of the previous sessions **you already listened** to the 20 minutes of noise (blue part, where you wrote your ranking on the dates for noise listening) you can ignore the following instructions and engage in other activities until the end of the session.

If in the previous sessions **you have not yet listened** to the 20 minutes of noise (blue part, where you wrote your ranking on the dates for noise listening), today we ask you to do so.

Please take the green coupon in front of you. In the first session you wrote on this coupon the payment you were willing to receive in case you had refused to listen to the noise, when required to do so. Now we ask you to write LISTEN or REFUSE on the green coupon.

- If you write LISTEN, today you will listen to the 20 minutes of noise and receive € 30, at the end of the session, for participating in this study.
- If you write REFUSE, you will not listen to the noise and you will receive, at the end of the session, the payment for participation (15 €, 10 €, 5 € or 0 €) you indicated.

When the green coupons will be completed, we will collect them and play the track with the noise for those who wrote LISTEN. It is very important not to remove the headphones before the noise is over. Removing the headphones for whatever reason before the 20 minutes result in the loss of the payment.

Any question? Now please fill in the coupon.



Please, fill in the questionnaire that was distributed. When everybody is done, we will proceed to pay each participant. The payment will be:

- a participation fee of € 30 if you listened to the blue part when requested, or
- a participation fee of 15 €, 10 €, 5 €, € 0 (the number you specified in the green part), if you refused to listen to the noise when required.

In both cases, if in the first session you won the auction to acquire the opportunity of changing the ranking on noise listening (red part), we will subtract the corresponding sum of money from your payment.

Thank you for participating in this study.