Are preferences complete? An experimental measurement of indecisiveness under risk*

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Abstract

We propose an experimental design allowing a behavioral test of the axiom of completeness of individual preferences. The central feature of our design consists in enabling subjects to postpone commitment at a small cost. Our main result is that preferences are significantly incomplete. We use lotteries as choice alternatives and we find that risk aversion is globally robust to preference incompleteness.

Keywords: Incomplete preferences, preference for flexibility, risk aversion, indecisiveness, indifference.
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1 Introduction

Most of decision theory, game theory, and economics relies on the assumption that agents have *complete* preferences meaning that they are always able to judge which options leave them better off. The quasi-systematic use of this assumption seems paradoxical since, from the beginning, modern decision theory acknowledged that agents may not possess firm judgments about their well-being and may therefore remain indecisive on occasion (von Neumann and Morgenstern, 1944). In fact, several authors defend the position that completeness is not a fundamental rationality tenet the way transitivity is (Aumann, 1962; Bewley, 1986; Mandler, 2001, 2005). Moreover, incomplete preference theory has shown the feasability and interest of doing away with the completeness axiom (Dubra, Maccheroni, and Ok, 2004; Rigotti and Shannon, 2005), and some authors have brought out arguments based on the incompleteness of preferences that account for some of the experimentally observed anomalies. For example, Eliaz and Ok (2006) provide choice-theoretic foundations of incomplete preferences which are able to cope with the preference reversal phenomenon whereas Mandler (2004) shows that incomplete preferences may lie behind status quo maintenance. Such approaches yield a unified theory that applies to all choice situations, as opposed to more specialized theories that are particularly designed to "explain" the observed anomalies, and they therefore re-establish the usefulness of rationality as an explanatory tool.

Although the completeness axiom is usually considered intuitively demanding, it has not been empirically tested so far, to the best of our knowledge. What is more, such a test is generally considered incompatible with the methodology of *revealed preference*, according to which one can only observe a person's choice behavior, not her judgements of preference. Indeed, if a person has to choose between two alternatives a and b and is observed selecting a, say, one does not know whether she chose a because she indeed prefers a to b or because she does not know which alternative she prefers but still had to pick something. This has led to the quasi-systematic acceptance of the completeness axiom in the literature.

We propose an experimental design allowing a behavioral test of the completeness axiom, and find that preferences are significantly incomplete on a sample of 137 subjects. The general idea behind our design is that, although one cannot directly determine whether a person knows which of two choice alternatives a and b she prefers by merely making her choose between a and b, preference incompleteness can be indirectly revealed by her behavior in other choice situations involving a and b. More precisely, subjects have to choose between committing to a or b, or maintaining *flexibility*, i.e., keeping both options open. Maintaining flexibility allows more time for introspection (one week, in our case) but no additional objective information. On the other hand, commitment yields a small monetary bonus. We consider that a subject who gives up the bonus in order to maintain flexibility reveals that she does not know which alternative she prefers, for if she did she would better commit to her preferred alternative and get the additional bonus.

Our assumption that postponement of commitment reveals preference incompleteness is discussed in detail. In particular, it links incomplete preferences with the concept of *preference for flexibility* introduced by Koopmans (1964) and is natural in this literature.[1] We also emphasize potential limitations of this assumption, in particular the possibility that a person could intrinsically value her *freedom of choice* (Sen, 1988) and, therefore, choose to maintain flexibility without having incomplete preferences. Although we cannot, by definition, conduct a behavioral test of the hypothesis that maintaining flexibility reveals preference incompleteness, we find partial evidence supporting it against the alternative hypothesis of intrinsic value of freedom of choice, in the sense that most subjects' behavior is compatible with the former but not the latter, to the extent that intrinsic value of freedom of choice is assumed to occur systematically in all choice situations faced by a given subject.

We choose alternatives to be simple monetary *lotteries* (two equiprobable gains). This enables us to define an individual measure of preference incompleteness and, thereby, to provide a *quantitative* test of the completeness axiom, as opposed to only exhibiting an isolated choice situation in which most subjects violate the completeness axiom. Moreover, we are able to compute subjects' *risk premia* for these lotteries, so as to analyze their attitudes toward risk. We also elicit risk premia directly in the usual way and, by comparing the two premia, find that risk aversion is robust to preference incompleteness at the aggregate but not at the individual level.

The rest of the paper is organized as follows. Section 2 presents the theoretical framework of our experiment. Section 3 describes the experimental design. Section 4 contains our data analysis and results. Section 5 concludes. The Appendix contains the experimental instructions and sample software screens, among other things.

[1] As an illustration, consider an individual who has to make a reservation at a restaurant for some given later date, say next Monday (Kreps, 1979). There are only two possible meals, steak and chicken, and three restaurants that only differ by the menu (i.e., set of meals) they offer: one proposes either steak or chicken, a second one has only steak, and the last one has only chicken. If the individual's preferences over (next-Monday) meals are complete, then one would expect her to value any menu exactly as much as its most preferred meal. On the other hand, if she does not know now whether she would better have steak or chicken on next Monday, then she should strictly prefer reserving at the restaurant that proposes either steak or chicken rather than either one of the other two restaurants, in the hope that she would be able to reach a preference judgement by the time of ordering a meal.

2 Theoretical framework

2.1 Incomplete preferences and choice behavior

Consider an individual endowed with a *weak preference* relation $\succcurlyeq$ on a set of choice *alternatives*. Given two alternatives a and b, we interpret $a \succcurlyeq b$ to mean that the individual judges she would be at least as well off with a as with b. If both $a \succcurlyeq b$ and $b \succcurlyeq a$ hold, then the individual is indifferent between a and b which is written $a \sim b$ whereas if $a \succcurlyeq b$ but not $b \succcurlyeq a$, then the individual strictly prefers a to b which is written $a \succ b$. Preferences are said to be *complete* if, for all alternatives a and b, either $a \succcurlyeq b$ or $b \succcurlyeq a$ (possibly both). In this case, one and only one of the three following statements must hold: either $a \succ b$, or $b \succ a$, or $a \sim b$.

However, if preferences are not assumed to be complete then there is a fourth possibility, namely that neither $a \succcurlyeq b$ nor $b \succcurlyeq a$. In this case, the individual is *indecisive* between a and b which is written $a \bowtie b$. Indecisiveness captures an individual's inability to determine which of two alternatives would leave her better off.

At first glance, indecisiveness seems incompatible with the classical methodology of *revealed preferences* (Samuelson, 1938). Indeed, revealed preferences must be complete since the individual can always be induced to choose one of the two alternatives. Concretely, let us denote by $\gamma(a, b)$ the individual's choice between the two alternatives where $\gamma(a, b) = \gamma(b, a)$. Let us assume (for the moment, see Subsection 2.4) that, beside observing the individual's choice, one can observe her willingness to choose either a or b which we denote by $\gamma(a, b) = a\&b$. How does the individual's choice $\gamma(a, b)$ inform us about her preference between a and b? It is reasonable to assume that the individual chooses the alternative she prefers. Hence, if $a \succ b$ (respectively $b \succ a$) then it must be that $\gamma(a, b) = a$ (respectively $\gamma(a, b) = b$). Moreover, if $a \sim b$ then $\gamma(a, b) = a\&b$. Under the completeness axiom, the individual's preferences are then straightforwardly revealed by her choice behavior: $a \succcurlyeq b$ if and only if $\gamma(a, b) \neq b$.

Such a revelation is no longer possible when completeness is not assumed, because any choice set is *a priori* conceivable uncer indecisiveness. For example, observing $\gamma(a, b) = a$ no longer reveals $a \succ b$ because this choice can also result from $a \bowtie b$. Even if it is assumed that $a \bowtie b$ implies $\gamma(a, b) = a\&b$, a common practice in incomplete preference theory, the problem persists because indifference and indecisiveness are behaviorally indistinguishable: $\gamma(a, b) = a\&b$ can result from either $a \sim b$ or $a \bowtie b$.

To sum up, the lack of a behavioral characteristic of indecisiveness precludes observed choice behavior from fully revealing preference. It is therefore necessary to look for such a characteristic in other choice situations than the mere choice between two alternatives.

2.2 Indecisiveness and preference for flexibility

In his axiomatic study of the concept of *preference for flexibility*, introduced by Koopmans (1964), Kreps (1979) gives the following illustrating example. Consider an individual who has to make a reservation at a restaurant for some given later date, say next Monday. There are only two possible meals, a = steak and b = chicken, and three restaurants that only differ by the menu (i.e., set of meals) they offer: one proposes either steak or chicken (menu $\{a, b\}$) whereas a second one has only steak (menu $\{a\}$) and the last one has only chicken (menu $\{b\}$).

Reserving at restaurant $\{a, b\}$ is then the most flexible alternative because it enables the individual to wait until next Monday before choosing between steak or chicken, whereas reserving at restaurant $\{a\}$ (resp., $\{b\}$) entails an immediate commitment to eat steak (resp., chicken) on next Monday. However, if the individual is able to determine now which of the two meals she would better have on next Monday, then this flexibility should be of no interest compared to immediate commitment for her preferred meal. In other words, if her preferences over meals are complete, then one would expect her to value any menu exactly as much as its most preferred meal. On the other hand, if she does not know now whether she would better have steak or chicken on next Monday, then she should strictly prefer reserving at restaurant $\{a, b\}$ rather than either one of the other two restaurants, in the hope that she would be able to reach a preference judgment by the time of ordering a meal.

The general idea is that indecisiveness can be revealed by preference for flexibility. Concretely, the individual's preference between two alternatives a and b is elicited on the basis of her choice between the *menus* $\{a\}$ and $\{a, b\}$ and her choice between $\{b\}$ and $\{a, b\}$, rather than her mere choice between a and b (or, equivalently, $\{a\}$ and $\{b\}$). If $a \succ b$, then the individual is indifferent between $\{a\}$ and $\{a, b\}$ and she strictly prefers $\{a, b\}$ to $\{b\}$, so one should observe $\gamma(\{a\}, \{a, b\}) = \{a\}\&\{a, b\}$ and $\gamma(\{b\}, \{a, b\}) = \{a, b\}$. Similarly, if $b \succ a$, then $\gamma(\{b\}, \{a, b\}) = \{b\}\&\{a, b\}$ and $\gamma(\{a\}, \{a, b\}) = \{a, b\}$. If $a \sim b$, then the individual is indifferent between $\{a\}$, $\{b\}$, and $\{a, b\}$, so one should observe $\gamma(\{a\}, \{a, b\}) = \{a\}\&\{a, b\}$ and $\gamma(\{b\}, \{a, b\}) = \{b\}\&\{a, b\}$. Finally, $a \bowtie b$ is characterized by $\gamma(\{a\}, \{a, b\}) = \gamma(\{b\}, \{a, b\}) = \{a, b\}$. To summarize, $a \succcurlyeq b$ if and only if $\gamma(\{a\}, \{a, b\}) \neq \{a, b\}$.

This link between indecisiveness and preference for flexibility reflects the common interpretation of preference for flexibility in terms of *uncertainty about tastes* (Koopmans, 1964; Kreps, 1979; Dekel, Lipman, and Rustichini, 2001), and is also formally present in this literature (Arlegi and Nieto, 2001; Danan, 2003; Manzini and Mariotti, 2003). Kraus and Sagi (2004) show that it logically follows from a *dynamic consistency* condition. Besides, it is consistent with empirical research in psychology and marketing on *choice deferral* caused by *preference uncertainty*, *tradeoff difficulty* or *conflict* (Tversky and Shafir, 1992; Dhar, 1997; Dhar and Simonson, 2003; Tykocinski and Ruffle, 2003).

The suggested link between indecisiveness and preference for flexibility might be questioned as flexibility can be valued for itself, independently of the fact that it enables the individual to reach a preference judgement. Actually, the literature on *freedom of choice* distinguishes between its *intrinsic* and *instrumental* value (Sen, 1988), similarly to the psychological research on *motivation for choice* which distinguishes between *intrinsic* and *external* motivation (Deci, 1995). If present, the intrinsic value of freedom of choice clearly implies that there is less indecisiveness than preference for flexibility. Note, however, that intrinsic motives for preference for flexibility are, by nature, independent of the particular alternatives at stake and, thereby, distinguishable from instrumental motives for an individual who is faced with several choices between menus of varying instrumental value.[2]

2.3 Measurement of indecisiveness under risk

We now introduce a setup which elicits an individual's preferences between an *elementary lottery*, modelling the toss of a fair coin with monetary payoffs, and sure monetary payoffs. Beside providing a cardinal measure of indecisiveness, this risky choice setup allows the assessment of the individual's risk attitudes by taking into account indecisiveness.

We denote an elementary lottery by $l = (\underline{z}, \overline{z})$, where $\underline{z} \leq \overline{z}$ are the lottery's two equiprobable payoffs. Elementary lotteries have the advantage of being completely ordered in terms of risk, a natural index of a lottery's degree of risk being its *spread* $\sigma = \overline{z} - \underline{z}$ (i.e., σ represents second-order stochastic dominance and is proportional to l's standard deviation). Moreover, we identify the sure payoff c with the elementary lottery (c, c).

How do an individual's preferences between lottery l and sure payoffs $c \in [\underline{z}, \overline{z}]$

[2]It can also be objected that an individual who is indecisive between two alternatives a and b might not necessarily exhibit a preference for flexibility if she has no hope of resolving her indecisiveness by the time of choosing within the menu $\{a, b\}$. In fact, there is empirical evidence that increasing the number of alternatives in a menu induces a *complexity* effect which can lead individuals to reject additional flexibility (Sonsino and Mandelbaum, 2001; Iyengar, Jiang, and Huberman, 2004). Note, however, that this effect is minimized in our experimental setting because no menu containing more than two alternatives needs to be considered (and it will be further minimized by considering only very simple alternatives, see Subsection 2.3). In any case, the complexity effect can only imply that there is more indecisiveness than preference for flexibility, without undermining the interpretation of the observed preference for flexibility as reflecting indecisiveness.

typically look like?[3] A natural assumption is that preferences are *monotonic* with respect to money, i.e., if $c \not\succcurlyeq l$ then $c' \succ l$ for any $c' > c$ and, similarly, if $l \not\succcurlyeq c$ then $l \succ c''$ for any $c'' < c$. Accordingly, there exist two sure payoffs $\underline{c}^* \leq \overline{c}^*$, the *lower* and *upper certainty equivalents* of l, such that $c \succ l$ for any $c > \overline{c}^*$, $l \succ c$ for any $c < \underline{c}^*$, and $l \bowtie c$ for any c between $\underline{c}^*$ and $\overline{c}^*$. Completeness is then characterized by $\underline{c}^* = \overline{c}^* = c^*$, the *certainty equivalent* of l (to simplify the exposition, we assume that $\overline{c}^* \succ l \succ \underline{c}^*$ if $\overline{c}^* > \underline{c}^*$ and $l \sim c^*$ if $\overline{c}^* = \underline{c}^* = c^*$, but our experimental setting does not rely on this continuity property). A natural measure of indecisiveness ν can therefore be associated to the lottery l:

$$\nu = \frac{\overline{c}^* - \underline{c}^*}{\sigma} \in [0, 1].$$

Thus, ν is an index ranging between 0 (completeness) and 1 (full incompleteness), measuring the degree to which an individual is indecisive between the lottery l and sure payoffs. Normalizing ν with respect to the spread σ enables us to compare the degree of preference incompleteness across different lotteries.

2.4 Indifferent selection and monetary bonuses

So far we assumed that, when indifferent between two alternatives, the individual does not select one alternative but is rather willing to choose either one of them (concretely, she would choose to randomize or delegate her choice, if offered this possibility). Although convenient, this assumption is difficult to justify: why could an individual who is indifferent between a and b not decide to select a instead of randomizing between a and b? Indifference precisely means that the individual judges such a selection (*a priori*) inconsequential for her well-being.

This problem of *indifferent selection* might bias upwards the estimation of the indecisiveness measure ν. Indeed, the upper certainty equivalent $\overline{c}^*$ of an elementary lottery l is characterized by the fact that the individual is indifferent between $\{c'\}$ and $\{l, c'\}$ for any $c' > \overline{c}^*$ and strictly prefers $\{l, c'\}$ to $\{c'\}$ for any $c' < \overline{c}^*$. But if the individual makes the indifferent selection $\gamma(\{c'\}, \{l, c'\}) = \{l, c'\}$ for some $c' > \overline{c}^*$, then the aforementioned assumption leads to the inference that she strictly prefers $\{l, c'\}$ to $\{c'\}$. Consequently, the upper certainty equivalent inferred from the individual's choices is biased upwards (a similar argument shows that the inferred lower certainty equivalent

[3] Note that if $c > \overline{z}$ then c dominates l (in the sense of first-order stochastic dominance) so, by any account, it must be that $c \succ l$. Similarly, if $c < \underline{z}$ then l dominates c so one must have $l \succ c$. Hence, for a given lottery l, it is sufficient to observe the choices $\gamma(\{l\}, \{l, c\})$ and $\gamma(\{c\}, \{l, c\})$ for sure payoffs c between $\underline{z}$ and $\overline{z}$.

	c		$\gamma(\{l+\varepsilon\},\{l,c\})$	$\gamma(\{c+\varepsilon\},\{l,c\})$
	$\overline{z}$			
		$c \succ l$	$\{l,c\}$	$\{c+\varepsilon\}$
	$\overline{c}^*$			
l		$l \bowtie c$ $\frac{1}{2}$	$\{l,c\}$	$\{l,c\}$
	$\underline{c}^*$			
		$l \succ c$	$\{l+\varepsilon\}$	$\{l,c\}$
	$\underline{z}$			

Figure 1. Elicitation of preferences.

might be biased downwards).

In his pioneering work on decision-making under uncertainty, Savage (1954) argued that if $a \sim b$ then, for any monetary bonus ε added to b, one should have $b+\varepsilon \succ a$ and, hence, $\gamma(a, b+\varepsilon) = b+\varepsilon$ where $b+\varepsilon$ denotes the alternative b with an additional bonus ε. On the other hand, if $a \succ b$ then there should exist a small enough monetary bonus ε added to b such that one still has $a \succ b+\varepsilon$ and, hence, $\gamma(a, b+\epsilon) = a$. In line with this approach, we amend the behavioral characterization of preference between an elementary lottery l and sure payoffs c in the following way (Danan, 2003): $l \succcurlyeq c$ (respectively $c \succcurlyeq l$) if and only if for any $\varepsilon > 0$, $\gamma(\{l+\varepsilon\},\{l,c\}) = \{l+\varepsilon\}$ (respectively $\gamma(\{c+\varepsilon\},\{l,c\}) = \{c+\varepsilon\}$). Figure 1 summarizes our elicitation method for a given elementary lottery $l = (\underline{z}, \overline{z})$ and a small monetary bonus ε.

2.5 Attitudes towards risk

For complete (and monotonic) preferences, the assessment of risk attitudes is usually achieved by computing the individual's *risk premium* for a given lottery $l = (\underline{z}, \overline{z})$ which corresponds to the difference between the expected value of the lottery $e = (\underline{z} + \overline{z})/2$ and its certainty equivalent c^*. The individual is said to be *risk averse* (respectively *risk attracted* or *risk neutral*) if the risk premium is positive (respectively negative or null).

A distinctive feature of incomplete preferences is that they don't fully determine the individual's choice behavior. This indeterminacy gives rise to a potential discrepancy between the individual's attitude towards risk in terms of preference and her attitude towards risk in terms of behavior. For example, if $\gamma(l, c) = c$ whenever $l \bowtie c$, then the individual is more risk averse in terms of behavior than in terms of preference. Henceforth, we distinguish between the individual's *preferential* risk premium for a given lottery l and her *behavioral* risk premium for l.

We define the individual's (normalized) preferential risk premium π for the lottery l by

$$\pi = \frac{(\overline{z} - \overline{c}^*) - (\underline{c}^* - \underline{z})}{\sigma} = \frac{2e - \overline{c}^* - \underline{c}^*}{\sigma} \in [-1, 1],$$

which is a natural generalization of the risk premium to incomplete preferences since $2(e - c^*) = (\overline{z} - c^*) - (c^* - \underline{z})$. Note that, although indecisiveness sets an upper bound to the absolute value of the risk premium, namely $|\pi| \leq 1 - \nu$, the value of ν does not determine the sign of π (except for $\nu = 1$ which entails $\pi = 0$), and $e \succcurlyeq l$ (respectively $l \succcurlyeq e$) is equivalent to $\pi \geq \nu$ (respectively $\pi \leq -\nu$).[4]

To define the behavioral risk premium, we assume that choice behavior is *monotonic* with respect to money: if $\gamma(l, c) = c$ then $\gamma(l, c') = c'$ for any $c' > c$ whereas if $\gamma(l, c) = l$ then $\gamma(l, c') = l$ for any $c' < c$. Accordingly, there exists a sure payoff $\hat{c}$ between $\underline{c}^*$ and $\overline{c}^*$, named the *behavioral* certainty equivalent of l, such that $\gamma(l, c') = c'$ for any $c' > \hat{c}$ and $\gamma(l, c'') = l$ for any $c'' < \hat{c}$, and we define the individual's (normalized) behavioral risk premium $\hat{\pi}$ for l by

$$\hat{\pi} = \frac{(\overline{z} - \hat{c}) - (\hat{c} - \underline{z})}{\sigma} = \frac{2(e - \hat{c})}{\sigma} \in [-1, 1].$$

The individual is said to be *preferentially risk averse* (respectively *attracted* or *neutral*) if π is positive (respectively negative or null). Similarly, the individual is said to be *behaviorally risk averse* (respectively *attracted* or *neutral*) if $\hat{\pi}$ is positive (respectively negative or null). Reflecting the fact that $\hat{c}$ must lie between $\underline{c}^*$ and $\overline{c}^*$, preference incompleness sets an upper bound to the absolute difference between the behavioral and preferential risk premia (formally, $|\hat{\pi} - \pi| \leq \nu$), but the value of ν yields no presumption about the sign of this difference unless $\nu = 0$.

3 Experimental design

3.1 General features

Subjects have to participate in two experimental sessions, taking place on the same day and at the same time of two consecutive weeks. During the first session, subjects choose between menus while during the second session they select alternatives within their chosen menus. For each decision, subjects have to select one and only one menu

[4]Whenever $\nu > 0$, $\pi = 0$ implies $e \bowtie l$ ($\pi = 0$ implies $e \sim l$ only if $\nu = 0$).

or alternative.

During the first session, subjects make series of choices between two menus. Each menu contains either a single element which can be a sure payoff (*sure commitment menu*) or an elementary lottery (*risky commitment menu*), or it contains both elements (*flexible menu*), i.e., it consists of a sure payoff and an elementary lottery. In order to avoid intertemporal tradeoffs, subjects' choices are only paid after the second session even when they choose commitment menus during the first session. Subjects leave the first session without any document about the experimental procedures or their choices. For, in the contrary case, subjects may express a preference for flexibility simply in order to leave the first session earlier and make their choices at their most preferred time between the two sessions.

The data collected during the first session enable us to elicit subjects' present preferences over alternatives materializing in one week. The data collected during the second session are not relevant for eliciting these preferences and, therefore, are not analyzed. Each subject is assigned one elementary lottery $l = (\underline{z}, \overline{z})$, and the subject's preferences between l and sure payoffs are elicited by means of *choice bracketing* procedures.

Choice bracketings

Each subject goes through three successive choice bracketings over a sure payoff c ranging from $\underline{z}$ to $\overline{z}$, always in the following order:

1. Choices between the risky commitment menu $\{l\}$ and the sure commitment menus $\{c\}$, yielding $\gamma(\{l\}, \{c\})$.
2. Choices between the risky commitment menu $\{l + \varepsilon\}$, in which the lottery l is augmented by a bonus $\varepsilon = 0.10$ euro, and the flexible menus $\{l, c\}$, yielding $\gamma(\{l + \varepsilon\}, \{l, c\})$.
3. Choices between the sure commitment menus $\{c + \varepsilon\}$, in which the sure payoff c is augmented by a bonus $\varepsilon = 0.10$ euro, and the flexible menus $\{l, c\}$, yielding $\gamma(\{c + \varepsilon\}, \{l, c\})$.

The second (respectively third) bracketing yields the lower (respectively upper) certainty equivalent of the lottery. Hence, the last two bracketings are sufficient to elicit subjects' preferences. By going through the first bracketing, subjects have the possibility to introspect their preferences between the same lottery and sure payoffs they are going to face in the next two bracketings. We believe that such a procedure eliminates potential indecisiveness arising from mere unfamiliarity with the objects of choice. Moreover, the first bracketing yields the behavioral certainty equivalent of the lottery and, thereby, enables us to compare subjects' behavioral and preferential attitudes towards risk.

Lottery (l)	Low payoff ($\underline{z}$)	High payoff ($\overline{z}$)	Spread (σ)	Bracketing step (τ)	Bracketing length
l_1	0	40	40	2	21 choices
l_2	4	36	32	2	17 choices
l_3	10	30	20	1	21 choices
l_4	12	28	16	1	17 choices
l_5	17	23	6	0.50	13 choices
l_6	18	22	4	0.50	9 choices

Table 1. Lotteries and bracketing procedures (euros).

Choices in the first bracketing are the simplest since they involve two commitment menus and, therefore, amount to ordinary choices between two alternatives: a lottery and a sure payoff. In the second bracketing, flexible menus aree introduced as well as the monetary bonus which is attached to the risky commitment menu. Still, the commitment menu remains fixed throughout the second bracketing. Finally, in the third bracketing, the risky commitment menu is replaced by the sure commitment menu and, therefore, varying the sure payoff c affects both menus simultaneously.

We chose $\varepsilon = 0.10$ euro to act as a small monetary bonus. There is arbitrariness in this choice because, in theory, one should use an infinitely small ε, which is obviously impossible in practice. Note, however, that any particular value of ε leads to the underestimation of the measure of incompleteness.[5]

Lotteries

Our experimental design relies on six different elementary lotteries (see Table 1). All lotteries' payoffs (as well as all sure payoffs) are gains between 0 and 40 euros. All lotteries have the same expected value of 20 euros and, hence, they only vary in risk (spread). In fact, three groups of lotteries can be distinguished: the *high spread* group (lotteries l_1 and l_2), the *medium spread* group (lotteries l_3 and l_4), and the *low spread* group (lotteries l_5 and l_6). By considering three different spread groups, we can evaluate the impact of the degree of risk on the measure of incompleteness.

All subjects in a given experimental session are assigned the same lottery $l = (\underline{z}, \overline{z})$. Half of them start all three bracketings with the sure payoff $\underline{z}$ whereas the other half start all three bracketings with $\overline{z}$. By doing so, we hope to eliminate the potential

[5] We could have chosen the smallest practically implementable bonus $\varepsilon = 0.01$ euro but we were concerned that this would lead subjects to merely ignore the bonus. As already mentioned, the bonus plays a crucial role in our setup because it enables us to disentangle between indifference and strict preference in the second and third bracketings. A bonus is neither necessary nor useful in the first bracketing because there is presumably no more than one value of c for which $\{l\} \sim \{c\}$.

influence of a bracketing's starting value. The *step* τ of a bracketing depends on the considered lottery but, whatever the spread group, it is always significantly larger than the monetary bonus. Consequently, bracketings in the low spread group are shorter than in the medium and high spread groups.

Let us illustrate our elicitation method with the example of a subject who has been assigned the lottery l_1 and the starting value $\overline{z}$. In the first bracketing, the subject first has to choose between the risky commitment menu $\{(0, 40)\}$ and the sure commitment menu $\{40\}$, then between $\{(0, 40)\}$ and $\{0\}$, then between $\{(0, 40)\}$ and $\{38\}$, ..., and finally between $\{(0, 40)\}$ and $\{20\}$. In the second bracketing, she first has to choose between the risky commitment menu $\{(0, 40)+0.10\}$ and the flexible menu $\{(0, 40), 40\}$, ..., and finally between $\{(0, 40) + 0.10\}$ and $\{(0, 40), 20\}$. In the third bracketing, she first has to choose between the sure commitment menu $\{40 + 0.10\}$ and the flexible menu $\{(0, 40), 40\}$, ..., and finally between $\{20 + 0.10\}$ and $\{(0, 40), 20\}$. In all three bracketings, the subject has to make 21 choices.

3.2 Practical procedures

All subjects were undergraduate students from various disciplines at Friedrich Schiller University in Jena. The experimental sessions were conducted in small groups of nine to sixteen subjects using the computerized network of the Max Planck Research Laboratory. Twelve pairs of sessions were organized between February and June 2004. As such a procedure is very unusual, the invitation email emphasized that participation in two sessions, separated by one week, was compulsory. 171 subjects were recruited to participate in the experiment.[6] Among them, 15 either did not show up or signaled at the beginning of the first session that they could not attend the second session taking place one week later and, consequently, were not allowed to take part in the experiment. Each subject took part in only one pair of sessions.

First session

Subjects were randomly assigned to a computer terminal, which was physically isolated from other terminals. Communication between subjects was not allowed. Subjects first had to read a set of instructions privately (see Appendix C). They could ask questions by raising their hand at any time during the reading of instructions, and the questions were answered privately. After having read the instructions, each subject had to answer a short on-screen questionnaire, two multiple-choice questions (see Appendix D), in

[6]Subjects were recruited and invited using ORSEE (Greiner, 2003). They belonged to a subject pool comprising more than one thousand students.

order to check her understanding of the experimental procedures. Any mistake in the questionnaire implied the exclusion from the experiment. Subjects' understanding of the procedures was good with about 10% of the subjects making one mistake in the questionnaire and a single subject making two mistakes. In total, 137 subjects answered the questionnaire correctly and all of them were present at the second session.

For half of these 137 participants, each bracketing started with $c = \overline{z}$ whereas, for the other half, each bracketing started with $c = \underline{z}$. The subjects' allocation was performed by the laboratory server after subjects had completed the questionnaire. After the questionnaire phase, each subject went through three training bracketings, corresponding to one training lottery. Subjects' choices were not payoff-relevant in this training phase. Subjects were told to take their time and they were encouraged to go at their own pace. The training lotteries for the high, medium, and low spread groups were $(0, 32)$, $(8, 24)$, and $(14, 18)$, respectively. The step of each training lottery was chosen so that each bracketing had a length of 9 choices. After the training phase, each subject went through the three payoff-relevant bracketings.[7]

During the second and third bracketings, the monetary bonus and the alternative to which it was attached were displayed as separate items on subjects' computer screens. For example, the risky commitment menu $\{l + \varepsilon\}$ was displayed as the sum of the two items $l = (\underline{z}, \overline{z})$ and ε rather than as the lottery $(\underline{z} + \varepsilon, \overline{z} + \varepsilon)$ (see Appendix B). This was done in order to highlight the monetary benefit of commitment with respect to flexibility.

Before leaving the room, each subject was asked to provide a password so that her choices could be recovered from the laboratory server at the beginning of the second session. Once all passwords had been provided, each subject was paid 2.50 euros for participation. Subjects were not allowed to leave the first session with any document, in particular concerning the choices they were to be presented in the second session. Each first session took between 30 and 45 minutes.

Second session

One week later, subjects went through the menus they had chosen during the first session and selected one alternative from each menu. After the subject made all her choices,

[7]The respective lengths of the training and payoff-relevant phases were decided after carrying out a pilot experiment with 12 subjects in January 2004. During the first session of this pilot experiment, subjects had to go through nine payoff-relevant bracketing procedures, corresponding to three different lotteries, and the training phase was only made up of three single choices. The data collected from both the first three and the last three bracketings were inconsistent (violations of monotonicity) to a much greater extent than those from the three middle bracketings. Accordingly, we decided to reduce the number of payoff-relevant bracketings to three in the final study, corresponding to one single lottery, but included a longer training phase.

her final earnings were determined according to one of the following three *incentive schemes*:

– Random Selection of One Choice for Payment (*Pay One*): Only one of the subject's choices was selected at random and the subject received the corresponding payoff.
– Random Selection of Three Choices for Payment (*Pay Three*): Three of the subject's choices were selected at random (one choice per bracketing) and the subject received one third of the sum of the three corresponding payoffs.
– Payment of All Choices (*Pay All*): All the subject's choices were paid and the subject received the sum of the corresponding payoffs divided by the total number of choices.

If a lottery was part of the alternative which had been selected for payment, a subsequent random draw was made to determine its outcome. All random draws were equiprobable and done manually by each subject herself.

Pay One is a widely used incentive scheme usually referred to as the *random lottery incentive system*. Under the assumption that subjects treat each choice in isolation, just as if it were the only choice, the random lottery incentive system neutralises both portfolio effects and wealth effects which might otherwise interfere with the interpretation of subjects' choices. This desirable property of the incentive scheme has been questionned (Holt, 1986) but several experimental studies have established its validity in simple pairwise choices (Starmer and Sugden, 1991; Beattie and Loomes, 1997; Cubitt, Starmer, and Sugden, 1998). In the same vein, Laury (2005) reports a lottery choice experiment where payoff scale effects have been demonstrated to matter (Holt and Laury, 2002) and addresses the question of whether subjects whose payments are determined by a single decision make choices as they would when they are paid for all decisions. More risk averse choices are observed under *Pay One* than under *Pay All* which indicates that subjects do not view random payment for one choice as a decrease in stakes for each choice that is presented. By using three different incentive schemes to motivate subjects, we investigate: i) whether the nature of incentives has an impact upon the measure of indecisiveness; and ii) whether subjects whose payments are determined by a single choice exhibit similar risk attitudes as those subjects who are paid for either three or all choices *when the assessment of risk attitudes takes into account indecisiveness.*

After all subjects' earnings had been determined, subjects were asked to leave the room and they had to wait in front of the laboratory for about ten minutes. Subjects then took part in another, and unrelated, experiment. We included an unrelated experiment at the end of each second session in order to prevent subjects from believing that the menus they selected in the first session, which would arguably influence the time needed to make their choices in the second session, could thereby influence the time at which they would be allowed to leave the laboratory.

Table 3 in Appendix A provides details about the schedule of the experimental sessions and the associated number of participants. Sessions A_i, A_i', A_i'' are the first sessions for the lottery l_i (see Table 1) and sessions B_i, B_i', B_i'' are the corresponding second sessions. In each first session, participants are those invited subjects who showed up and confirmed that they could attend the second session. Thus, the difference between the number of participants in the first session and the number of invitations in the second session is the number of subjects who made at least one mistake in the questionnaire (e.g., $1 \times 2, 1 \times 1$ indicates that one subject made two mistakes and one subject made one mistake). Our dataset comprises all first-session, payoff-relevant choices of the 137 subjects who successfully completed the questionnaire.

4 Results

Throughout our theoretical framework, we assumed that preferences are monotonic with respect to money. A small fraction of choices in our data set however violate the monotonicity assumption. Such inconsistent choices suggest that stochastic variation is an essential feature of decision-making behavior and cannot be completely eliminated even in a tightly-controlled experiment (special issue of *Experimental Economics*, vol. 8, number 4, edited by Chris Starmer and Nicholas Bardsley in December 2005 and the references therein). Though modelling the stochastic element in decision making is beyond the scope of this paper, we first introduce in this section generalized definitions of the indecisiveness measure and the risk premia which do not rely on monotonicity. These generalized measures reflect our attempt to take into account the stochastic component of experimental data and, consequently, they allow us to base our statistical analyses on the entire set of observed choices. Second, we present the results of a statistical analysis which assesses the validity of the assumption that flexibility is valued instrumentally rather than intrinsically. Third, we estimate the degree of indecisiveness revealed by the subjects' choices. Finally, we evaluate the relationship between the behavioral and the preferential risk premium both at the aggregate and the individual level.

4.1 Generalized measures of indecisiveness and risk attitudes

Consider a subject assigned the elementary lottery $l = (\underline{z}, \overline{z})$ with spread σ and bracketing step τ. In each of the three bracketings, the subject makes one choice for each sure payoff c in the set $X = \{\underline{z}, \underline{z} + \tau, \ldots, \overline{z} - \tau, \overline{z}\}$. We encode her choice behavior by means of three indicator functions defined on X:

c	10	...	15	16	17	18	19	20	21	22	23	24	25	...	30
$\phi_1(c)$	0	...	0	0	0	0	0	1	1	1	1	1	1	...	1
$\phi_2(c)$	0	...	0	0	1	1	1	1	1	1	1	1	1	...	1
$\phi_3(c)$	1	...	1	1	1	1	1	1	1	0	0	0	0	...	0

Table 2. Data example.

1. $\phi_1(c) = \begin{cases} 1 \text{ if } \gamma(\{l\}, \{c\}) = \{c\}; \\ 0 \text{ otherwise.} \end{cases}$
2. $\phi_2(c) = \begin{cases} 1 \text{ if } \gamma(\{l + \varepsilon\}, \{l, c\}) = \{l, c\}; \\ 0 \text{ otherwise.} \end{cases}$
3. $\phi_3(c) = \begin{cases} 1 \text{ if } \gamma(\{c + \varepsilon\}, \{l, c\}) = \{l, c\}; \\ 0 \text{ otherwise.} \end{cases}$

For each $c \in X$, $\phi_1(c) = 1$ indicates that the subject chooses the sure commitment menu in the first bracketing, while $\phi_2(c) = 1$ and $\phi_3(c) = 1$ indicate that she chooses the flexible menu in the second and third bracketings, respectively. As an illustration, Table 2 summarizes the choice behavior of one of our subjects who had been assigned the lottery $(10, 30)$. Note that monotonicity is satisfied in all bracketings and that $\phi_2(10) = \phi_3(30) = 0$ whereas $\phi_2(30) = \phi_3(10) = 1$. Accordingly, the flexible menu is chosen over a commitment menu if and only if the added alternative is valuable enough which suggests that flexibility is valued instrumentally rather than intrinsically.

Generalized measure of indecisiveness

Based on the last two indicator functions, we now introduce a generalized measure of indecisiveness which is defined whether monotonicity is satisfied or not. This enables us to include in our statistical analyses the choices of ten subjects who violate monotonicity in the second and/or third bracketing and therefore prevent us from computing either $\underline{c}^*$, or $\overline{c}^*$, or both. The (generalized) measure of indecisiveness relies on the number of occurences of $\phi_2(c) = 1$ and $\phi_3(c) = 1$ and is given by

$$\nu = \frac{\sum_{c \in X} \rho(c)[\phi_2(c) + \phi_3(c) - 1]}{\sigma} \in [-1, 1], \text{ where } \rho(c) = \begin{cases} \tau & \text{if } c \neq \underline{z} \text{ and } c \neq \overline{z}, \\ \dfrac{\tau}{2} & \text{if } c = \underline{z} \text{ or } c = \overline{z}. \end{cases}$$

Note that we allow for negative measures of indecisiveness. Indeed, the observed behavior leading us to elicit $\underline{c}^* > \overline{c}^*$ is compatible with our theoretical framework provided that choices are perturbed by errors. Although it seems natural to assume that errors compensate each other, our measure of indecisiveness could be biased upwards in case we would exclude those subjects with a negative measure.[8]

Obviously, if a subject's choices satisfy monotonicity then her measure of indecisiveness can be computed in a more straightforward but equivalent way. Let us consider the last two rows of Table 2. The subject's choices are compatible with any monotonic preferences such that $\underline{c}^* \in [16, 17]$ and $\overline{c}^* \in [21, 22]$. The two certainty equivalents are obtained by taking the midpoints of these intervals, i.e., $\underline{c}^* = 16.5$ and $\overline{c}^* = 21.5$, which leads to $\nu = (21.5 - 16.5)/20 = 0.25$.

Generalized risk premia

We now provide generalized definitions of the two risk premia in order to include in our statistical analyses the three subjects who violated monotonicity in the first bracketing:[9]

$$\begin{cases} \pi = \alpha_3 - \alpha_2 \in [-1, 1], \\ \hat{\pi} = 1 - 2\alpha_1 \in [-1, 1], \end{cases} \text{where } \alpha_i = \frac{\sum_{c \in X} \rho(c)[1 - \phi_i(c)]}{\sigma} \in [0, 1] \ (i = 1, 2, 3).$$

If a subject's choices satisfy monotonicity then her two risk premia can be computed according to the two definitions provided in Subsection 2.5. Continuing the example in Table 2, we can compute the preferential risk premium $\pi = (2 \times 20 - 21.5 - 16.5)/20 = 0.1$, from which we conclude that the subject is slightly preferentially risk averse for $(10, 30)$. Note that this is the case even though $(10, 30) \bowtie 20$ (indeed, $\pi < \nu$): the subject is risk averse in the sense that $c \succcurlyeq (10, 30)$ happens more often that $(10, 30) \succcurlyeq c$ where $c \in \{10, 11, \ldots, 29, 30\}$ (equivalently, her indecisiveness interval $[16.5, 21.5]$ is centered below the expected value of the lottery). Similarly, we use the midpoint method in the first bracketing to elicit the behavioral certainty equivalent $\hat{c} = 19.5$ and compute the behavioral risk premium $\hat{\pi} = (2(20 - 19.5))/20 = 0.05$, from which we conclude that the subject is very slightly behaviorally risk averse for $(10, 30)$ (we could never obtain $\hat{\pi} = 0$ because our design and elicitation method imply $e \in X$ and $\hat{c} \notin X$). Note that π and $\hat{\pi}$ are almost equal, indicating that $\gamma(\{(10, 30)\}, \{c\}) = \{(10, 30)\}$ and $\gamma(\{(10, 30)\}, \{c\}) = \{c\}$, $c \in \{10, 11, \ldots, 29, 30\}$, happen about equally as often when $(10, 30) \bowtie c$ (this is not guaranteed *a priori*, e.g., if $\hat{c} = \underline{c}^* = 16.5$ then $\hat{\pi} = 0.35$ and, hence, $\hat{\pi} - \pi = 0.25 = \nu$, i.e., more behavioral than preferential risk aversion).

[8] If a subject has complete and monotonic preferences such that $\underline{c}^* = \overline{c}^* = c^* \in X$ and chooses without error, then we observe $\phi_2(c^*) = \phi_3(c^*) = 0$ and, hence, we mistakenly elicit a slightly negative measure of indecisiveness ($\nu = -\frac{\tau}{\sigma}$). We cannot, however, correct this potential downwards bias because such choices could also be attributed to a subject with a lower $\underline{c}^*$ or a higher $\overline{c}^*$ who makes errors.

[9] All three subjects also violated monotonicity either in the second or in the third bracketing.

4.2 Preference for flexibility

As already mentioned, our preference elicitation method relies on the assumption that flexibility is valued instrumentally rather than intrinsically. We now provide evidence in support of this assumption.

Intrinsic value of flexibility is, by nature, independent of the particular alternatives at stake. Accordingly, a subject who values flexibility intrinsically should choose, for a given lottery $l = (\underline{z}, \overline{z})$, the flexible menu $\{l, \underline{z}\}$ over the risky commitment menu $\{l + \varepsilon\}$ in the second bracketing. On the other hand, a subject who doesn't value flexibility intrinsically would presumably choose $\{l+\varepsilon\}$ because the lottery l dominates its low payoff $\underline{z}$ (in the sense of first-order stochastic dominance). The choice behavior $\gamma(\{\overline{z} + \varepsilon\}, \{l, \overline{z}\}) = \{l, \overline{z}\}$ can similarly be used to detect subjects who value flexibility intrinsically in the third bracketing. More generally, we assess the relative importance of intrinsic and instrumental value of flexibility in the second and third bracketings by estimating the relationship between the propensity to choose the flexible menu $\{l, c\}$ and the value of the sure payoff $c \in [\underline{z}, \overline{z}]$.

Result 1 (Flexibility is chosen for its instrumental value). In the second and third bracketings, the propensity to choose the flexible menu $\{l, c\}$ is highly sensitive to the value of the sure payoff c. Very few subjects choose the flexibility gained by adding a dominated alternative whereas almost all of them choose the flexibility gained by adding a dominating alternative.

Support. We first note that only 10 subjects (7%) choose the flexible menu for $c = \underline{z}$ in the second bracketing, and only 7 subjects (5%) choose the flexible menu for $c = \overline{z}$ in the third bracketing. On the other hand, all 137 subjects choose the flexible menu for $c = \overline{z}$ in the second bracketing and for $c = \underline{z}$ in the third bracketing. Moreover, 127 subjects (93%) satisfy monotonicity in the second and third bracketings, a property that logically follows from instrumental value of flexibility but bears no particular relationship with its intrinsic value.

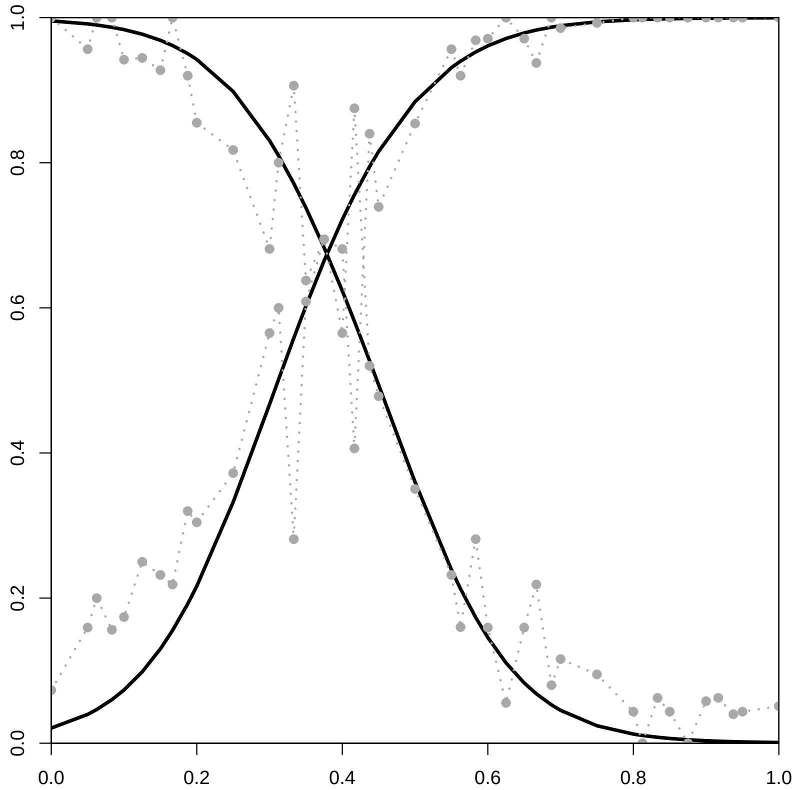
We then carry out an econometric analysis in order to estimate subjects' propensity to choose the flexible menu. Our sample consists of all 4778 choices made by the 137 subjects in the second and third bracketings. We estimate a logit mixed effects model in which the dependent variable takes value 1 if the flexible menu is chosen and 0 otherwise. The fixed effects are the normalized sure payoff $c_{norm} = (c - \underline{z})/\sigma \in [0, 1]$, the two experimental factors *Spread*, which takes the value *High*, *Medium*, or *Low*, and *Incentive scheme*, which takes the value *Pay One*, *Pay Three*, or *Pay All*, and a dummy variable for the bracketing.

We start by estimating the full model, i.e., including all possible interaction effects, and then sequentially drop variables that are insignificant at a 1% level according to likelihood ratio tests (we rely on penalized quasi-likelihood to approximate the log-likelihood of subsequent models, as the log-likelihood of a generalized linear mixed effects model does not have a closed form expression). Random effects both in the intercept and in the linear term for each subject are included in the final model and they are assumed to be distributed independently and normally with a zero mean. Random effects represent between-subject variations and they allow for correlations between the choices of the same subject.

Table 4 in Appendix A displays the final regression results. As the final model still contains numerous interaction terms, we provide several graphical representations of the propensity to choose the flexible menu in order to facilitate the interpretation of our regression results. Each graphical representation is generated by relying *only* on the variables which are significant at a 1% level. We first plot the mean estimated propensities as a function of c_{norm} (see Figure 2; we average across combinations of the two experimental factors *Spread* and *Incentive scheme* based on the corresponding numbers of subjects). Clearly, the overall propensity to choose the flexible menu in the second and third bracketings is highly sensitive to the value of the sure payoff. This propensity is increasing in the second bracketing (c_{norm} is significantly positive at a 1% level) and decreasing in the third bracketing (the interaction term c_{norm}:*Third Bracketing* is significantly negative at a 1% level and twice as large as c_{norm}). Moreover, the relatively small standard deviations of the random effects indicate that a large majority of our subjects exhibit such a relationship between the propensity to choose the flexible menu and the value of the sure payoff.[10]

In order to analyze the effect of the two experimental factors, we plot the mean estimated propensities as a function of c_{norm} separately for each spread group and each incentive scheme (see Figure 5 in Appendix A). We first note that these curves exhibit a common pattern irrespective of the spread group or the incentive scheme: increasing from 0 (or almost 0) to 1 in the second bracketing and decreasing from 1 to 0 in the third bracketing. Second, in *Pay One* and *Pay Three*, there is a common order between the three spread groups: in the second bracketing, the propensity to choose the flexible menu is the highest in the high spread group and it is the lowest in the low spread group. The reversed order is observed in the third bracketing. Apparently, increasing the spread makes risk less attractive in the sense of increasing the value of flexibility

[10]Needless to say, the non-negligible standard deviations of the random effects also point out the substantial variation in the strength of this relationship. Actually, 8 subjects always chose the flexible menu in the second bracketing and, among them, two always chose the flexible menu in the third bracketing. All subjects chose at least once the flexible menu in both bracketings.



Solid (resp., dotted) curves: estimated (resp., empirical) propensities.
Increasing (resp., decreasing) curves: second (resp., third) bracketing.

Figure 2. Average propensities to choose the flexible menu as a function of c_{norm}.

gained by adding a sure payoff to a lottery and decreasing the value of flexibility gained by adding a lottery to a sure payoff, although this effect is clearer for the high spread group. Finally, in *Pay All*, the propensity to choose the flexible menu is generally lower than in *Pay One* and *Pay Three* for the second bracketing and higher for the third bracketing. Thus, it seems that paying all choices makes risk more attractive in the same sense as above, although this effect is only salient for the high spread group. □

We view this evidence as supporting the assumption that preference for flexibility reveals indecisiveness. Still, this evidence is only preliminary as it itself relies on the assumption that flexibility cannot be intrinsically valued for some values of the sure payoff and not others. While this assumption appears to us as the most natural way of distinguishing between intrinsic and instrumental value of flexibility, testing for more sophisticated patterns of intrinsic value that would just happen to be correlated with instrumental value without being caused by it goes beyond the scope of the present study.

4.3 Measure of indecisiveness

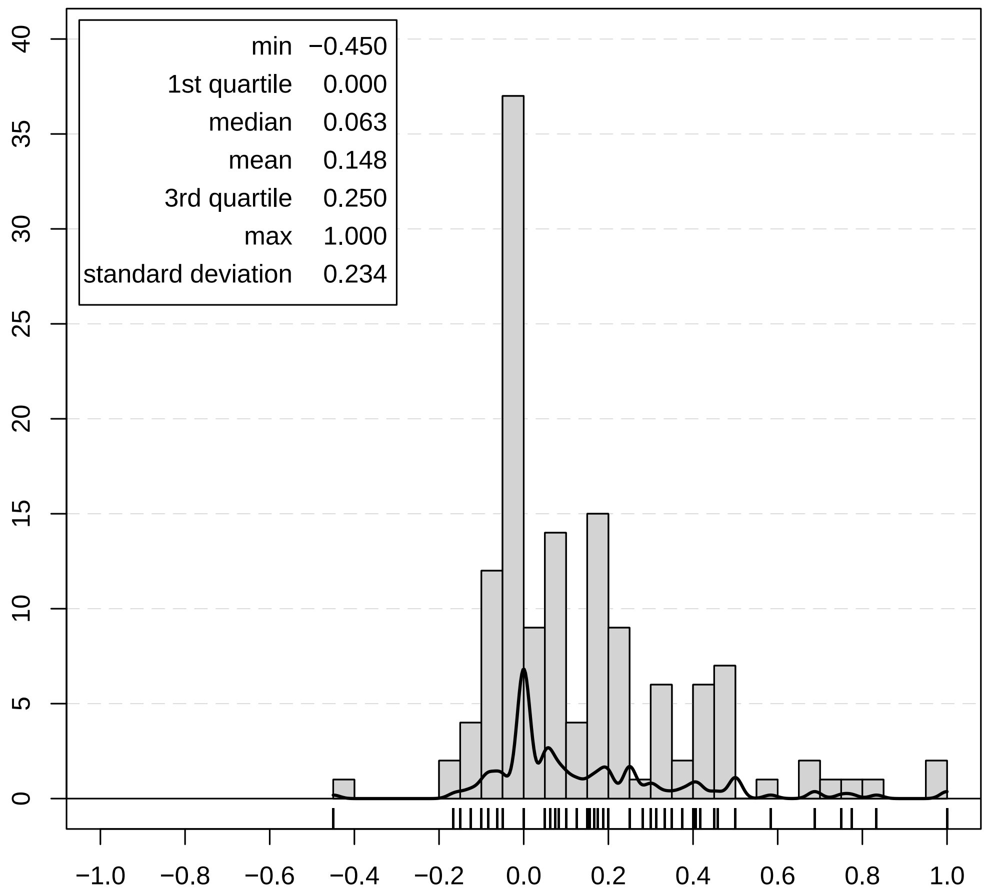
Our second and main result challenges the descriptive power of the completeness axiom in preference theory as a majority of our subjects violate this axiom.

Result 2 (Preferences are significantly incomplete). The elicited measure of indecisiveness is strictly positive for more than half of our subjects (59%) and it is greater or equal to 0.25 for more than one fourth of our subjects (28%). Neither the spread of the lottery nor the incentive scheme have a systematic impact on the measure of indecisiveness.

Support. The empirical distribution of the measure of indecisiveness is presented in Figure 3. It is clearly skewed to the right, with a mode at 0 corresponding to the 37 subjects (27%) whose observed choice behavior is consistent with complete preferences. The elicited measure is strictly negative for 19 subjects (14%), in line with errors affecting choice but also, for most of them, with an underestimated null measure (see Subsection 4.1). The 81 remaining subjects (59%) exhibit a strictly positive measure, and 39 subjects (28%) exhibit a measure greater or equal to 0.25. According to one-tailed permutation tests at a 5% level, the median is significantly higher than 0.03 ($p < 0.01$) and the mean is significantly higher than 0.11 ($p = 0.031$).

We now assess the impact of the two experimental factors, the spread group and the incentive scheme, on the measure of indecisiveness. Figure 6 in Appendix A shows the nonparametric kernel-density estimation of the measure of indecisiveness separately for each spread group and each incentive scheme. All these distributions are skewed to the right with mean higher than median, except for an almost symmetric distribution in the combination *Low Spread Group-Pay All*. Moreover, all distributions are relatively close to each other, with the exception of *Low Spread Group-Pay One*, which is notably more concentrated.

Overall, neither the spread group nor the incentive scheme seem to have a systematic impact on the measure of indecisiveness. This is confirmed by a Kruskal-Wallis test (one-way analysis of variance by ranks): at a 5% level, we cannot reject the null hypothesis that the nine subsamples (one per combination spread group-incentive scheme) come from identical populations with the same median ($\chi^2 = 3.476, df = 8, p = 0.901$). Similarly for the three subsamples corresponding to the three spread groups ($\chi^2 = 0.606, df = 2, p = 0.739$), and for the three subsamples corresponding to the three incentive schemes ($\chi^2 = 1.100, df = 2, p = 0.577$). □



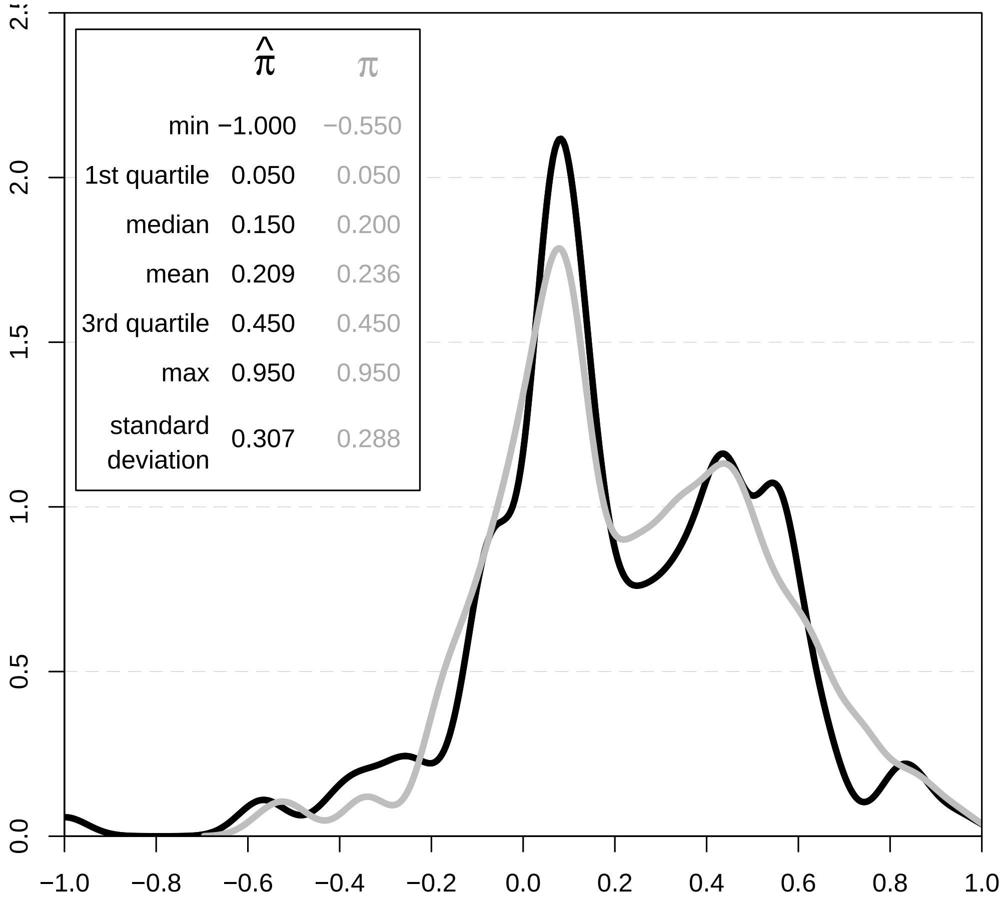
Histogram: frequency (number of subjects).
Black curve: nonparametric kernel-density estimation.
Vertical bars below histogram: measure values.

Figure 3. Empirical distribution of the measure of indecisiveness.

4.4 Risk aversion

In this final results section, we assess subjects' risk attitudes which have been elicited through two experimental methods. First bracketing choices enable us to compute subjects' behavioral risk premium $\hat{\pi}$, corresponding to the usual preference elicitation method neglecting indecisiveness. Second and third bracketing choices yield subjects' preferential risk premium π, according to our elicitation method allowing for preference incompleteness. As it turns out, risk aversion prevails over risk attraction both in a preferential and behavioral sense, and the two elicitation methods lead to a similar pattern of risk attitudes.

Result 3 (Risk aversion is robust). The behavioral and preferential risk premia have similar distributions with more than 75% of the subjects exhibiting risk aversion. Both risk premia increase with the spread of the lottery but decrease when all choices



Black (resp., grey) curve: behavioral (resp., preferential) risk premium.

Figure 4. Nonparametric kernel-density estimations of the two risk premia.

are paid.

Support. Figure 4 presents the nonparametric kernel-density estimations of the behavioral and preferential risk premia. Both risk premia are positive for a vast majority of subjects, with a first quartile at 0.05. Both distributions are bimodal with a first mode around the first quartile, i.e., near risk neutrality, and a second mode around the third quartile (0.45, i.e., risk aversion). The two distributions are remarkably close to each other; according to two-tailed permutation tests for paired replicates, the behavioral and preferential risk premia have equal mean ($p = 0.154$) and median ($p = 0.999$).

In order to investigate the impact of the two experimental factors on the behavioral risk premium, we plot the nonparametric kernel-density estimation of the behavioral risk premium separately for each spread group and each incentive scheme (see Figure 7 in Appendix A). The behavioral risk premium seems to systematically increase with the spread of the lottery. This result is predicted by increasing relative risk aversion and/or decreasing absolute risk aversion (Holt and Laury, 2002). Indeed, increasing a lottery's spread while keeping its expected value constant amounts to multiply all payoffs by a positive constant and then substact a positive constant to all payoffs. As far as the incentive scheme is concerned, distributions in *Pay All* are generally shifted to the left but no systematic difference between *Pay One* and *Pay Three* is observed. Paying all choices apparently led subjects to take more risk which confirms Laury's (2005) findings and suggests that they extend to the case of a random selection procedure where more than one choice is paid. All these patterns are confirmed by one-tailed permutation tests at a 5% significance level, both on the mean and the median.

Similarly, we plot the nonparametric kernel-density estimation of the preferential risk premium separately for each spread group and each incentive scheme (see Figure 8 in Appendix A). We observe the same patterns as for the behavioral risk premium: the preferential risk premium increases with the spread of the lottery but is lower in *Pay All*.[11] These results are generally confirmed by one-tailed permutation tests at a 5% significance level with two exceptions: first, there is no significant difference between the low and the medium spread groups, neither for the mean ($p = 0.061$) nor for the median ($p = 0.180$); second, the incentive scheme *Pay All* does not have a significant impact on the median of the preferential risk premium. □

Our third result seems to suggest that the behavioral risk premium elicited without taking indecisiveness into account is a good approximation of the preferential risk premium. Thus, one might assess risk aversion by means of the usual, simple choice procedure (first bracketing) without fully eliciting preferences. We should note, however, that this is only true globally and not individually, as many subjects turn out to have significantly different behavioral and preferential risk premia, reflecting a variety of behavioral attitudes towards risk under indecisiveness. As an illustration, 12 subjects have a strictly positive preferential risk premium but a strictly negative behavioral risk premium, the absolute difference between the two risk premia averaged over the 12 subjects being equal to 0.37. Another 10 subjects have a strictly negative preferential risk premium but a strictly positive behavioral risk premium, the absolute difference between the two risk premia averaged over the 10 subjects being equal to 0.25. Though the distribution of risk attitudes in the population might not be influenced by the elicitation method, the researcher who is interested in obtaining the risk preferences of a given individual should take indecisiveness into account.

[11] This result is consistent with our former observation about the impact of *Pay All* on the propensity to choose the flexible menu.

5 Conclusion

We propose an experimental design allowing a behavioral test of the axiom of completeness of preferences. Our design is based on the idea of enabling subjects to postpone commitment at a small cost. Beyond our result that preferences are significantly incomplete, the main point we wish to make is that incomplete preferences are not *per se* incompatible with a revealed preference approach and the debate over the completeness axiom can be moved to the lab. We also find it valuable to provide an individual measure of preference incompleteness rather than only exhibiting an isolated situation in which the individual is indecisive. In any case, our results need to be replicated and made more robust, in particular we hope that different experiments could further investigate the various possible sources of the desire for delaying choice.

The alternatives we use are lotteries, which enables us to measure subjects' risk attitudes and find that risk aversion is globally robust to indecisiveness. In order to reach a general assessment of the completeness axiom, it would be necessary to conduct experiment in other choice settings. In particular, we believe that our design can easily be adapted to choice under ambiguity, by giving subjects less precise information about the lotteries' probabilities. This would provide an experimental test of the theoretical relationship between indecisiveness and ambiguity (Bewley, 1986; Rigotti and Shannon, 2005).

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Appendix

A Additional figures and tables

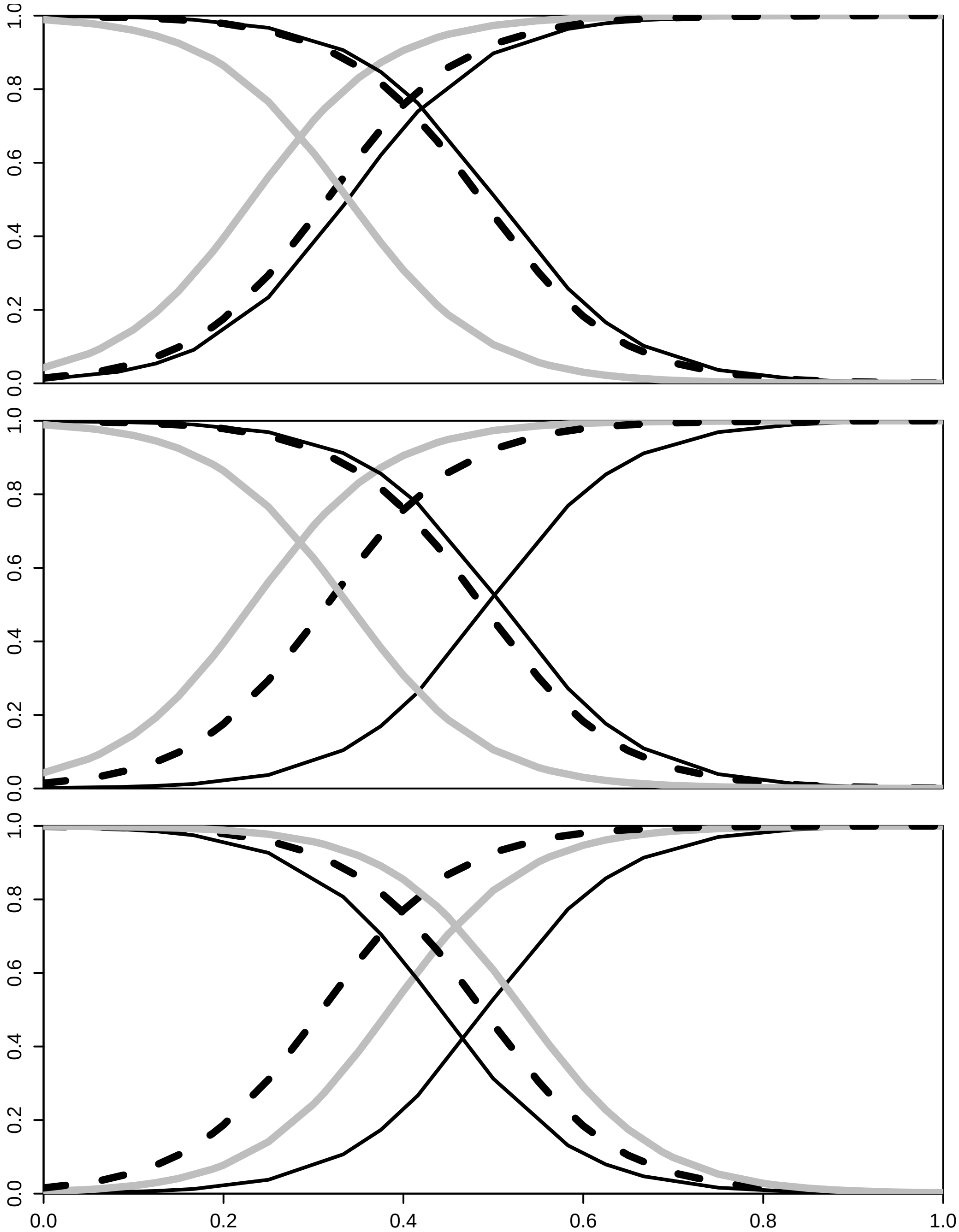
Incentive scheme	Spread group	Session	Date, time	Invitations	Participants	Mistakes
Pay Three	High	A_1	05/02, 12:00	17	16	2×1
		B_1	12/02, 12:00	14	14	—
		A_2	20/02, 10:00	15	14	1×1
		B_2	27/02, 10:00	13	13	—
	Medium	A_3	05/02, 10:00	16	14	1×1
		B_3	12/02, 10:00	13	13	—
		A_4	20/02, 12:00	15	13	1×1
		B_4	27/02, 12:00	12	12	—
	Low	A_5	05/02, 14:00	15	14	1×2, 1×1
		B_5	12/02, 14:00	12	12	—
		A_6	20/02, 14:00	15	14	3×1
		B_6	27/02, 14:00	11	11	—
Pay One	High	A'_1	10/06, 11:00	14	13	1×1
		B'_1	17/06, 11:00	12	12	—
	Medium	A'_3	10/06, 12:30	12	12	3×1
		B'_3	17/06, 12:30	9	9	—
	Low	A'_5	10/06, 14:00	13	10	1×1
		B'_5	17/06, 14:00	9	9	—
Pay All	High	A''_1	15/06, 11:00	13	12	1×1
		B''_1	22/06, 11:00	11	11	—
	Medium	A''_3	15/06, 12:30	14	12	2×1
		B''_3	22/06, 12:30	10	10	—
	Low	A''_5	15/06, 14:00	12	12	1×1
		B''_5	22/06, 14:00	11	11	—
Total A_i+A'_i+A''_i				171	156	1×2, 18×1
Total B_i+B'_i+B''_i				137	137	—

Table 3. Experimental sessions.

	Estimate	Std error	z-statistic	p-value
Intercept	-3.108	0.232	-13.384	< 0.01
Pay One	0.831	0.351	2.363	0.018
Pay All	-2.054	0.345	-5.957	< 0.01
c_{norm}	13.420	0.473	28.399	< 0.01
Low Spread	-1.432	0.324	-4.416	< 0.01
Medium Spread	-1.122	0.278	-4.041	< 0.01
Third Bracketing	7.617	0.294	25.943	< 0.01
Pay One:*Low Spread*	-2.081	0.583	-3.571	< 0.01
Pay All:*Low Spread*	1.320	0.543	2.431	0.015
Pay One:*Medium Spread*	-0.749	0.513	-1.461	0.144
Pay All:*Medium Spread*	2.130	0.502	4.246	< 0.01
Pay One:*Third Bracketing*	-0.696	0.397	-1.751	0.080
Pay All:*Third Bracketing*	4.634	0.417	11.112	< 0.01
c_{norm}:*Third Bracketing*	-26.718	0.618	-43.249	< 0.01
Low Spread:*Third Bracketing*	3.619	0.406	8.923	< 0.01
Medium Spread:*Third Bracketing*	3.091	0.336	9.199	< 0.01
Pay One:*Low Spread*:*Third Bracketing*	2.154	0.701	3.075	< 0.01
Pay All:*Low Spread*:*Third Bracketing*	-3.416	0.677	-5.043	< 0.01
Pay One:*Medium Spread*:*Third Bracketing*	-0.331	0.592	-0.559	0.576
Pay All:*Medium Spread*:*Third Bracketing*	-4.697	0.597	-7.862	< 0.01
Standard deviation of random effects	*Intercept*: 2.3258; c_{norm}: 4.4089			
Number of observations	4778			
Number of subjects	137			
Log-likelihood at zero	-3248.145			
Log-likelihood at convergence	-1315.214			

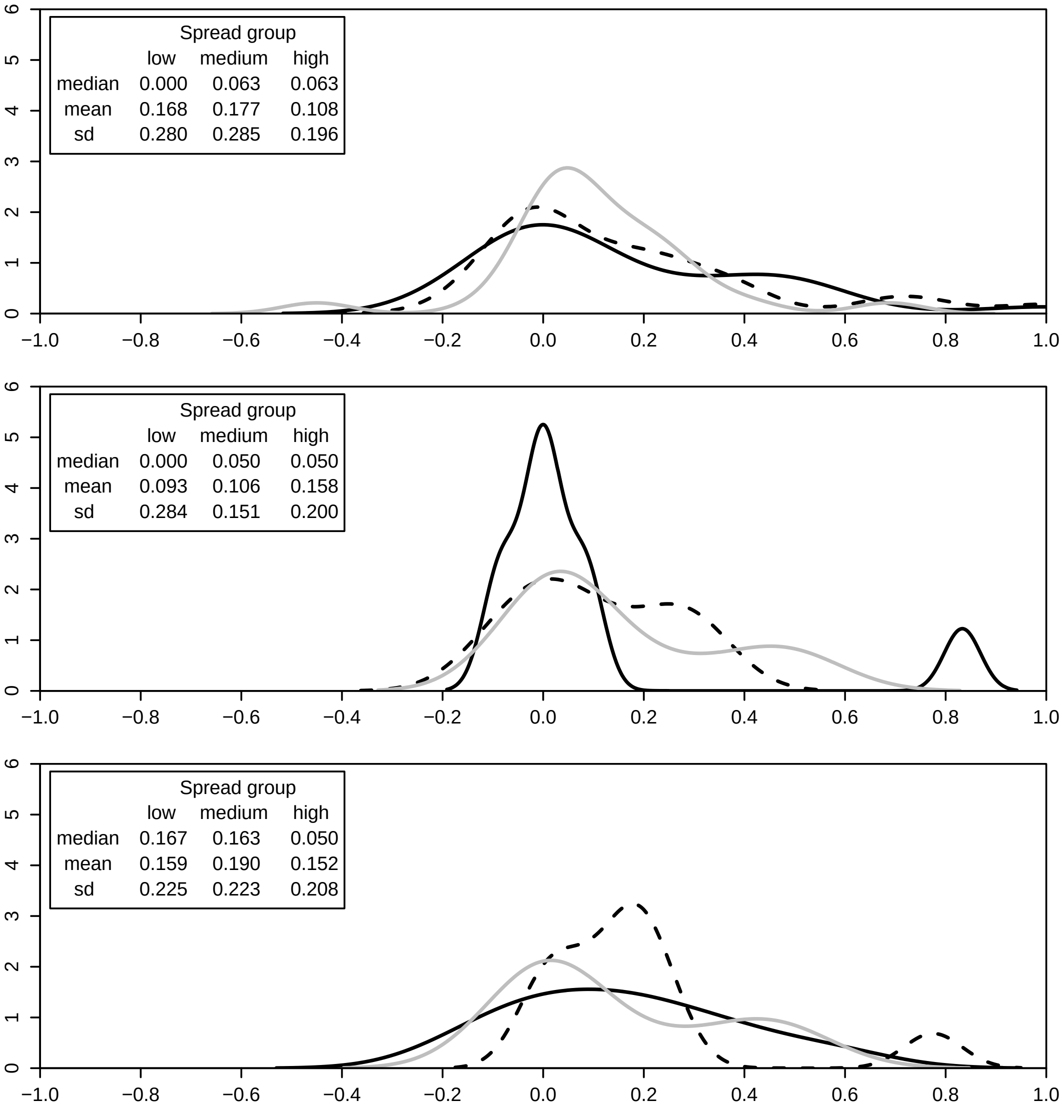
Note: We denote an interaction between two fixed effects by ':'.

Table 4. Logit estimation of the propensity to choose the flexible menu.



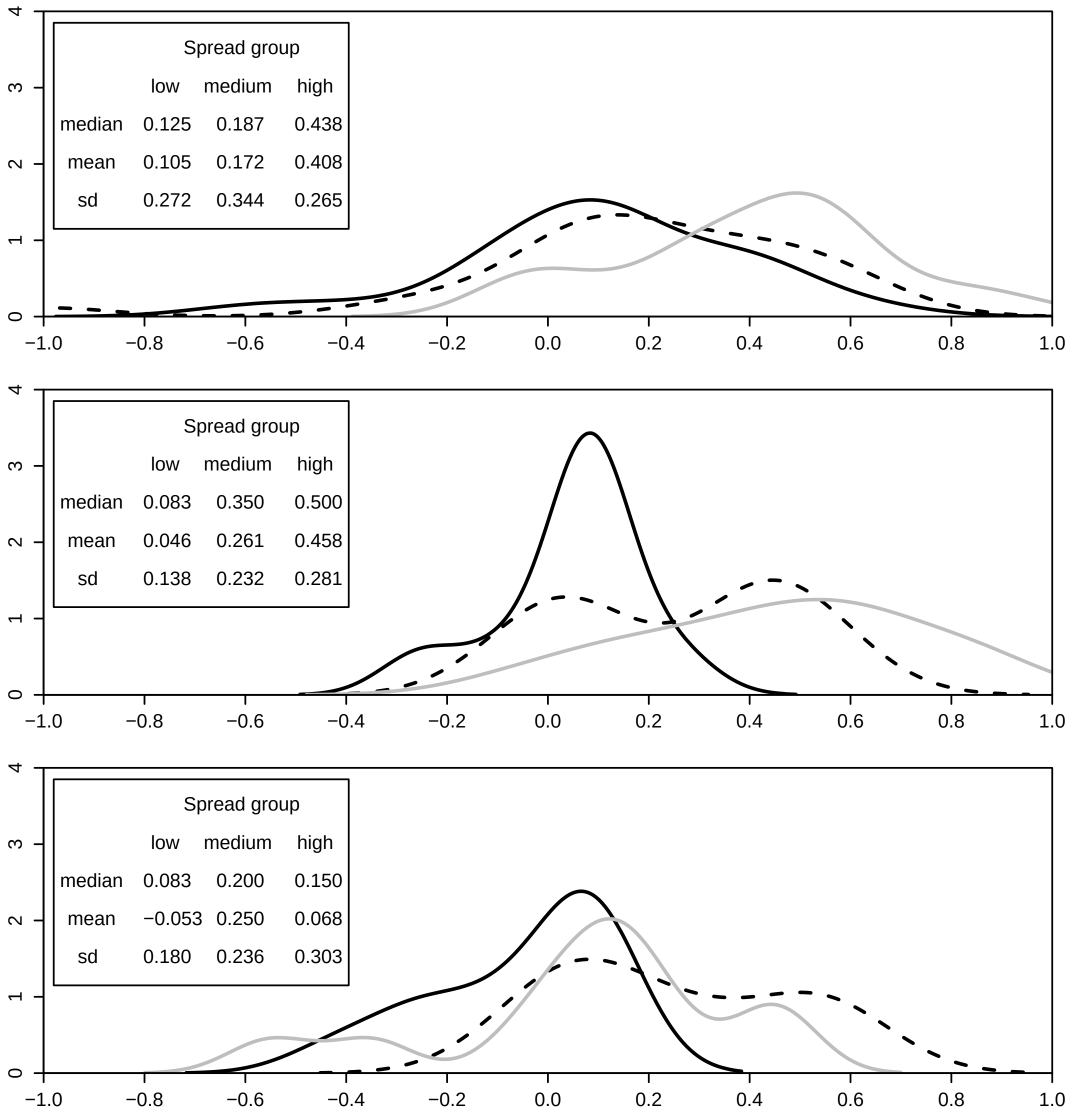
Top (resp., middle, bottom) graph: Pay Three (resp., Pay One, Pay All).
Increasing (resp., decreasing) curves: Second (resp., Third) Bracketing.
Grey (resp., dashed, black) curves: High (resp., Medium, Low) Spread Group.

Figure 5. Detailed estimated propensities to choose the flexible menu as a function of c_{norm}.



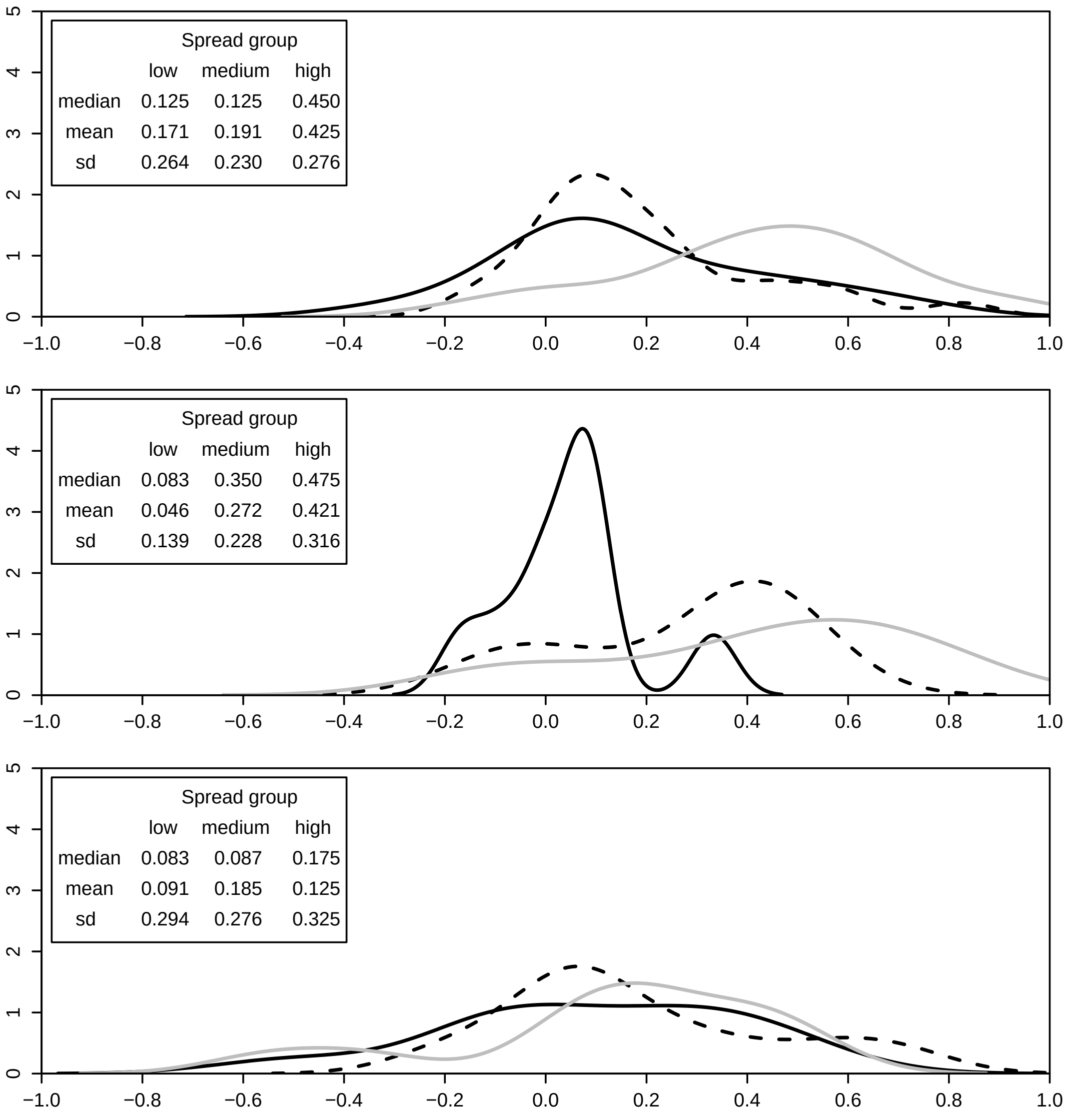
Top (resp., middle, bottom) graph: Pay Three (resp., Pay One, Pay All).
Grey (resp., dashed, black) curves: High (resp., Medium, Low) Spread Group.

Figure 6. Nonparametric kernel-density estimations of the measure of indecisiveness.



Top (resp., middle, bottom) graph: Pay Three (resp., Pay One, Pay All).
Grey (resp., dashed, black) curves: High (resp., Medium, Low) Spread Group.

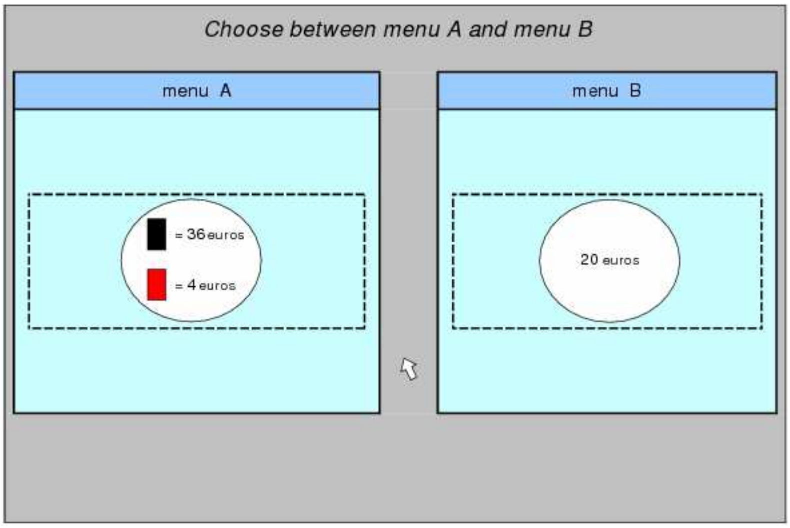
Figure 7. Nonparametric kernel-density estimations of the behavioral risk premium.



Top (resp., middle, bottom) graph: Pay Three (resp., Pay One, Pay All).
Grey (resp., dashed, black) curves: High (resp., Medium, Low) Spread Group.

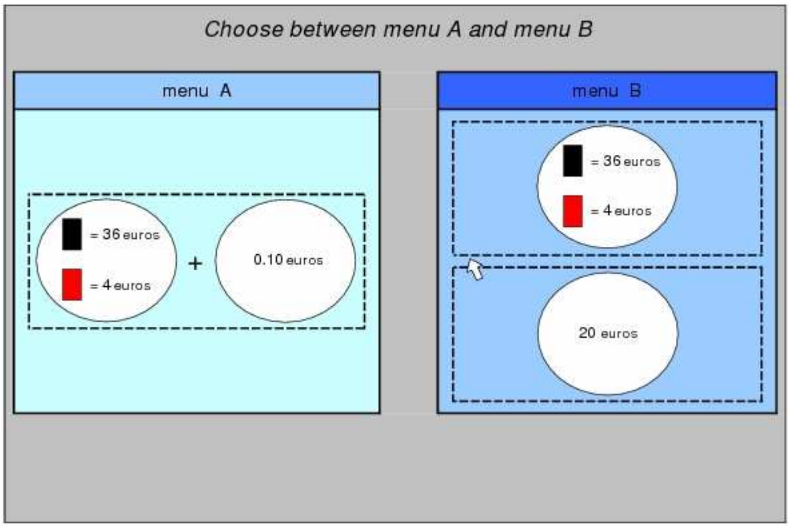
Figure 8. Nonparametric kernel-density estimations of the preferential risk premium.

B Software screens (lottery l_2)



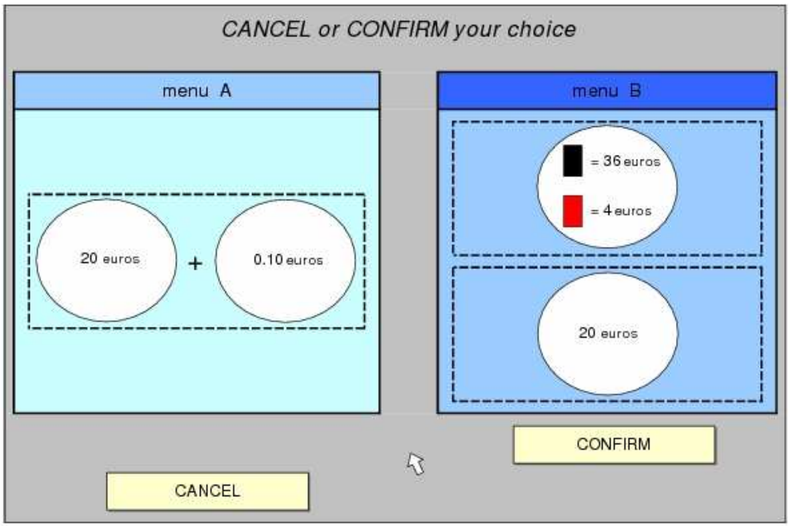
Each option within a menu is delimited by a dashed rectangle. The subject must click on a menu to select it.

Figure 9. First bracketing, last choice.



The bonus is displayed separately from the lottery in order to emphasize it. While the mouse cursor passes over a menu, the whole menu is highlighted.

Figure 10. Second bracketing, last choice.



After clicking on a menu, this menu remains highlighted and the subject must confirm her choice by clicking on the button below.

Figure 11. Third bracketing, last choice.

C Instructions (Friday, February 20, 2004)

Welcome to this experiment.

This experiment consists of two experimental sessions. The first session takes place today while the second session will take place on Friday, February 27, 2004. It is essential that you participate in both sessions, meaning that you have to attend the session on Friday, February 27, 2004.

As a compensation for your participation in both sessions you will receive a fixed payoff of 2.50 euros, which will be paid to you today at the end of the session. By making decisions in both sessions you can earn additional money as explained in the following instructions. Your earnings will be paid to you in cash at the end of the experiment without any other participant obtaining information about the amount you earned.

From now on and until the end of this session you are not allowed to leave your place, talk loudly, or try to communicate with any of your neighbors. If you would like to ask a question, raise your hand and one of the assistants will come to you and answer it individually. At the end of this session, please do not take any written documents with you out of the laboratory (neither these instructions nor the scratch paper).

Once you have read these instructions we will ask you to answer two questions intended to evaluate your comprehension of the instructions. **In order to take part in the experiment you have to answer both control questions correctly.** If one of your answers is wrong we will pay you 2.50 euros and ask you to leave the room. If this is the case you cannot further take part in the experiment, including also the second session.

This experiment is conducted in order to study individual decision-making. There will be no interaction between the participants of this experiment, meaning that your decisions have no influence on the decisions and payoffs of other participants and vice versa.

In the following we provide a detailed description of the procedures of the two sessions.

First session (today)

You will go through 3 decision series consisting of 17 decisions each. In each of the decision series you will have to choose 17 times between a **menu A** and a **menu B**. A menu either consists of one or two elements. The menus you choose today will be again presented to you in the second session on February 27 where you will then be asked to pick an element out of the menu.

If, for a given decision, you choose today a menu that consists of only one element, then you will have to pick this element in the second session. If however the menu you choose today consists of two elements, then you will have the possibility to choose one of the two elements in the second session.

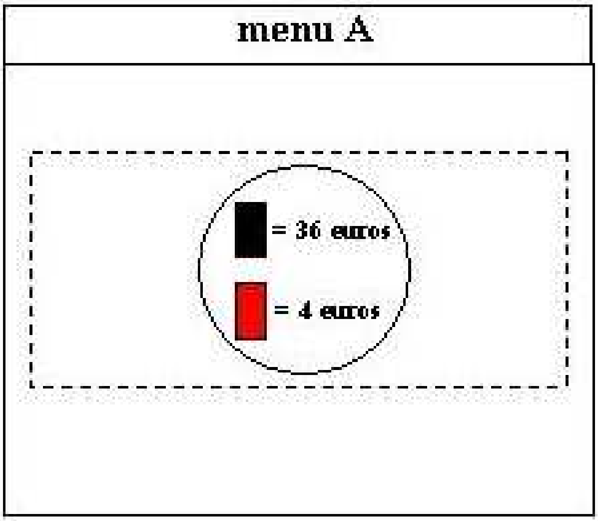
The elements that you pick in the second session determine your payment. Today, you choose the menus out of which you will pick the payoff relevant elements in the second session.

We will now describe - for each of the three decision series - the menus that are up for choice as well as their elements.

1. <u>First decision series</u>

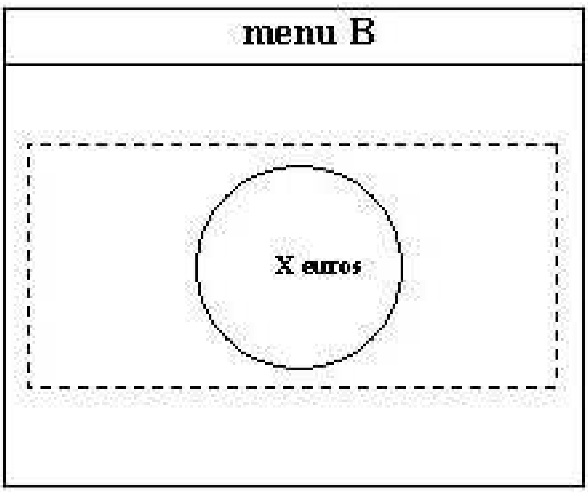
In each of the 17 decisions of the first decision series, **menu A** consists of a single element, namely a **lottery ticket**. **Menu B** consists of a single element, namely a **sure gain**.

The element of which menu A consists remains the same for all 17 decisions. Concretely, it is a lottery ticket, which either results in a gain of 4 euros or 36 euros. If you choose menu A you yourself will in the second session draw one out of two cards, one of which is red and the other black. You will not be able to distinguish the colors when drawing the card. Your lottery ticket results in a gain of 4 euros if you draw the red card. Respectively, you will receive 36 euros, if you draw the black card. **Consequently, there is a 50-percentage chance that you receive 36 euros for your lottery ticket and a 50-percentage chance that you receive 4 euros.** In each of the 17 decisions, menu A is graphically represented on your screen in the following way:



The dotted frame indicates that menu A consists of just one element. Looking within the circle you see that this one element is a lottery ticket with a gain of either 4 euros or 36 euros.

The element of which menu B consists varies in the course of the 17 decisions. The element is given by a sure gain of X euros where X is always an amount between 4 and 36 euros. If you choose menu B you receive a sure gain of X euros in the second session. In each of the 17 decisions, menu B is graphically represented on your screen in the following way:

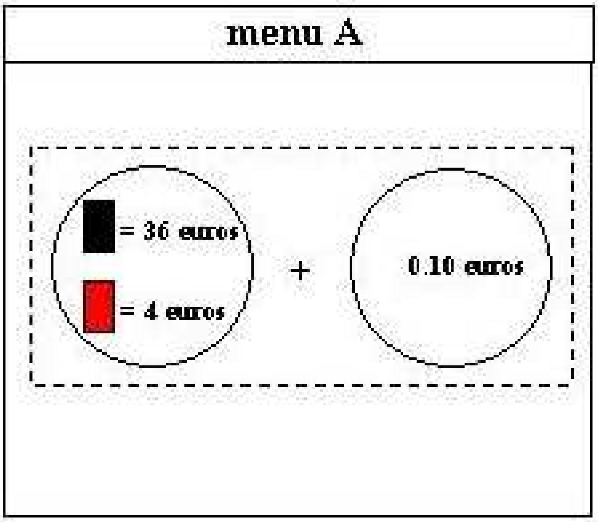


The dotted frame indicates that menu B consists of just one element. Looking within the circle you see that this one element is a sure gain of X euros. X varies in the course of the 17 decisions ranging from 4 euros to 36 euros.

2. Second decision series

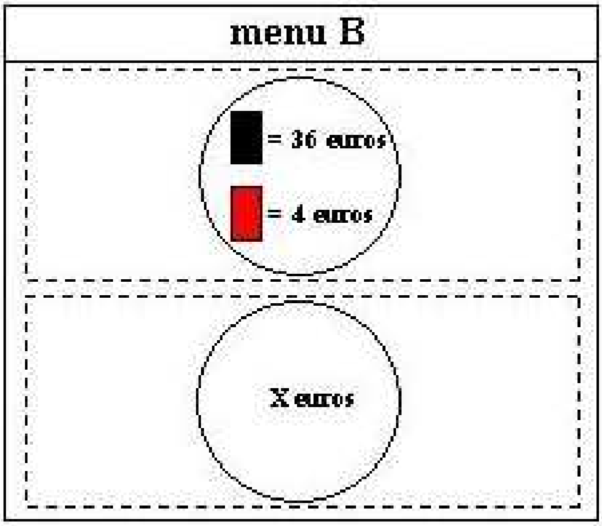
In each of the 17 decisions of the second decision series, **menu A** consists of a single element, namely a **lottery ticket with bonus**. **Menu B** consists of two elements, namely a **lottery ticket** and a **sure gain**.

The element of which menu A consists remains the same for all 17 decisions. Concretely, it is a lottery ticket that either results in a gain of 4 euros or 36 euros, and on top of each result you receive a bonus of 10 cents. Your lottery ticket results in a gain of 4 euros if you draw the red card and of 36 euros if you draw the black card. Independently of which card you draw you receive a bonus of 10 cents. In each of the 17 decisions, menu A is graphically represented on your screen in the following way:



The dotted frame indicates that menu A consists of just one element. Looking within the circles you see that this element consists of a lottery ticket (which either results in a gain of 4 euros or 36 euros) and a bonus of 10 cents.

The top element of menu B remains the same for all 17 decisions. It is a lottery ticket that results in a gain of either 4 euros or 36 euros. The bottom element of menu B is a sure gain of X euros, where X ranges from 4 to 36 euros. If you choose menu B you will have to choose between **the lottery ticket and the sure gain** in the second session. In each of the 17 decisions, menu B is graphically represented on your screen in the following way:

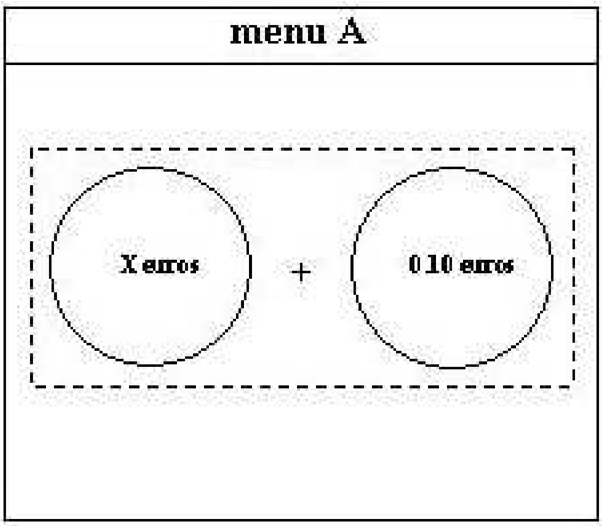


The two dotted frames indicate that menu B consists of two elements. Looking within the circle of each frame you see that one of them is a lottery ticket and the other is a sure gain of X euros. X varies in the course of the 17 decisions ranging from 4 euros to 36 euros.

2. Third decision series

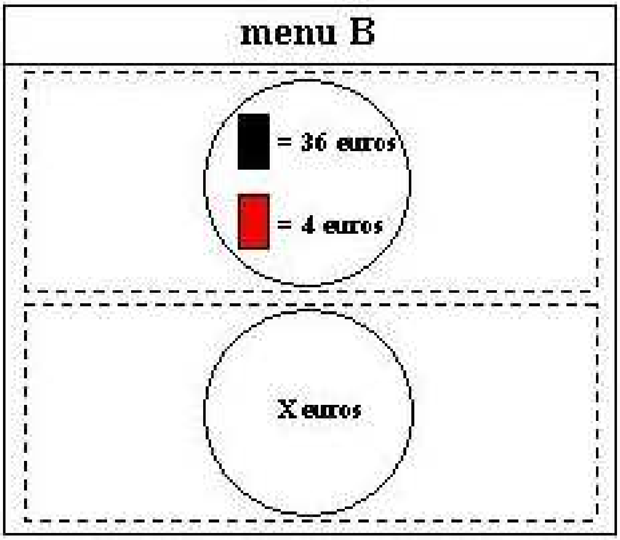
In each of the 17 decisions of the third decision series, **menu A** consists of a single element, namely a **sure gain with bonus**. **Menu B** consists of two elements, namely a **lottery ticket** and a **sure gain**.

The element of which menu A consists is given by a sure gain of X euros, where X ranges from 4 euros to 36 euros, in addition to which you receive a bonus of 10 cents. In each of the 17 decisions, menu A is graphically represented on your screen in the following way:



The dotted frame indicates that menu A consists of just one element. Looking within the circles you see that this element consists of a sure gain of X euros and a bonus of 10 cents. X varies in the course of the 17 decisions ranging from 4 euros to 36 euros.

The top element of menu B remains the same for all 17 decisions. It is a lottery ticket that results in a gain of either 4 euros or 36 euros. The bottom element of menu B is a sure gain of X euros, where X ranges from 4 to 36 euros. If you choose menu B you will have to choose between **the lottery ticket and the sure gain** in the second session. In each of the 17 decisions, menu B is graphically represented on your screen in the following way:



The two dotted frames indicate that menu B consists of two elements. Looking within the circle of each frame you see that one of them is a lottery ticket and the other is a sure gain of X euros. X varies in the course of the 17 decisions ranging from 4 euros to 36 euros.

For each of the 17 decisions in each of the three decision series, a menu A and a menu B will be displayed on your screen. You will be asked to choose one between the two displayed menus by clicking on it and to confirm your choice. Each participant proceeds at his own speed. Once you have completed the three decision series, please remain seated and silent, and abstain from communicating with your neighbors until one of the assistants signals that all participants have made all their decisions.

Second Session (Friday, February 27, 2004)

In the second session you will once more go through 3 decision series with 17 decisions each. But this time you will not choose between a menu A and a menu B. Instead, only one menu will be displayed on your screen and you will be asked to pick one of its elements. The menus that will be displayed on your screen are those that you choose today.

As both menus in today's first decision series only consist of one element you will have to pick this element in the first decision series of the second session. If a menu displayed on your screen in the second or third decision series of the second session consists of only one element you will have to pick this element. If instead the menu displayed on your screen consists of two elements you will have to pick one of the two elements.

After you completed the three decision series with 17 decisions each, all your decisions of the first decision series are displayed on your screen. You are asked to randomly draw one of these 17 decisions and **are paid 1/3 of its value**. Then your decisions of the second decision series are displayed on your screen. You are asked to randomly draw one of these decisions and **are paid 1/3 of its value**. Finally, your decisions of the third decision series are displayed on the screen and you again randomly draw one of them and **are paid 1/3 of its value**.

For each decision series you conduct the random draw that determines the payoff-relevant decision yourself. Concretely, you draw one card out of a pile of cards that are consecutively numbered from 1 to 17. The numbers of the cards are not visible to you when you make the random draw. If the card you draw bears number 1 then the first decision in the respective decision series is paid (if this is the lottery ticket you are then asked to draw one of two cards, one of which is red and the other black). Independently of the decision series in question, **all your decisions have the same chance to be paid**. In total, **three of your decisions (namely one out of each decision series) are paid out**.

After the completion of the second session and after having received your payoff you will be asked to participate in another experiment which is unrelated to this one. For your participation in this experiment you will receive an additional payoff between 2.50 euros and 12.50 euros.

****

Once you have read these instructions we will ask you to answer two questions that test your understanding of these instructions. **In order to be allowed to take part in this experiment you have to answer both control questions correctly.** If you correctly answer both questions you will go through three training series that are not payoff-relevant. The three training series are very similar to the payoff-relevant series that are following them. If you have any questions please raise your hand. One of the assistants will then come to you. Finally, two important remarks:

- **A choice of either menu A or menu B is never good or bad, right or wrong, but just a personal decision.**
- **The time you take to make a decision is neither limited nor do we keep track of it. The only thing that counts is your decision. So, take your time.**

D Questionnaire (*Pay Three*)

Subjects see a screen with two menus as in Figure 10 (but with different payoffs), and are asked the two following questions on-screen:

1. Suppose that, among the two menus below, you have chosen menu A. If this choice is payoff-relevant in the second session, then:
   - You will be asked to draw one out of two cards, one of which is red and the other is black. You will not be able to distinguish the colours when you draw the card. If you draw the red card your gain from the lottery ticket will be LOW euros whereas if you draw the black card your gain from the lottery ticket will be HIGH euros. On top of the gain you receive from the lottery ticket you will get a bonus of 0.10 euros. One third of your overall gain will be paid to you.
   - You will be asked to draw one out of two cards, one of which is red and the other is black. You will not be able to distinguish the colours when you draw the card. If you draw the red card your gain from the lottery ticket will be LOW euros whereas if you draw the black card your gain from the lottery ticket will be HIGH euros. After having drawn the card, you will be asked to choose between the gain from the lottery ticket and the bonus of 0.10 euros. One third of the amount you will have chosen will be paid to you.
   - You will be asked to choose between the lottery ticket and the bonus of 0.10 euros. If you choose the bonus of 0.10 euros, one third of 0.10 euros will be paid to you. If you choose the lottery ticket, you will be asked to draw one out of two cards, one of which is red and the other is black. You will not be able to distinguish the colours when you draw the card. If you draw the red card your gain from the lottery ticket will be LOW euros whereas if you draw the black card your gain from the lottery ticket will be HIGH euros. One third of the gain of the lottery ticket will be paid to you.
2. Suppose that, among the two menus below, you have chosen menu B. If this choice is payoff-relevant in the second session, then:

– If during the second session, you have chosen the top element of menu B, then you will be asked to draw one out of two cards, one of which is red and the other is black. You will not be able to distinguish the colours when you draw the card. If you draw the red card your gain from the lottery ticket will be LOW euros whereas if you draw the black card your gain from the lottery ticket will be HIGH euros. One third of the gain from the lottery ticket will be paid to you. If during the second session, you have chosen the bottom element of menu B, then one third of 20 euros will be paid to you.
– Whatever element of menu B you have chosen during the second session, you will be asked to draw one out of two cards, one of which is red and the other is black. You will not be able to distinguish the colours when you draw the card. If you draw the red card your gain from the lottery ticket will be LOW euros whereas if you draw the black card your gain from the lottery ticket will be HIGH euros. You will then be asked to choose between the gain from the lottery ticket and the 20 euros. One third of the amount you will have chosen will be paid to you.
– Whatever element of menu B you have chosen during the second session, you will be asked to draw one out of two cards, one of which is red and the other is black. You will not be able to distinguish the colours when you draw the card. If you draw the red card your gain from the lottery ticket will be LOW euros whereas if you draw the black card your gain from the lottery ticket will be HIGH euros. One third of the gain from the lottery ticket on top of which the 20 euros have been added will be paid to you.

For both questions, the correct answer is the first one.