Risk behavior for gain, loss, and mixed prospects

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Abstract This study extends experimental tests of (cumulative) prospect theory (PT) over prospects with more than three outcomes and tests second-order stochastic dominance principles (Levy and Levy, Management Science 48:1334–1349, 2002; Baucells and Heukamp, Management Science 52:1409–1423, 2006). It considers choice behavior of people facing prospects of three different types: gain prospects (losing is not possible), loss prospects (gaining is not possible), and mixed prospects (both gaining and losing are possible). The data supports the distinction of risk behavior into these three categories of prospects. Further, probability weighting and diminishing sensitivity of utility as predicted by PT are observed. Loss aversion is, however, less pronounced, except for choices where one prospect is degenerate. The data suggests that the probability of losing may be relevant for loss aversion.

Keywords Binary choice · Loss aversion · Prospect theory · Probability weighting · Second-order stochastic dominance

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1 Introduction

Dominance criteria play an important role for decision making as they are used to eliminate inferior options and strategies. These principles are used in economics, finance, management science and in many related disciplines (see Bawa 1982 for a listing of early literature, and the review of Levy 1992). We designed an experiment to study stochastic dominance principles and, within that design, to test for features of prospect theory (PT), currently the most popular descriptive decision theory for risk and uncertainty (Starmer 2000; Wakker 2010). PT incorporates reference dependence (i.e., outcomes are coded as gains and losses relative to a reference point), sign-dependence (i.e., probability weighting depends on the sign of outcomes), and loss aversion (LA) (losses weigh heavier than similar size gains). These features paired with extensive empirical evidence lead to predictions for binary choice that may disagree with traditional dominance criteria.

In this paper we focus on second-order stochastic dominance (SSD) rules. SSD has been introduced by Rothschild and Stiglitz (1970) and Hadar and Russell (1969) to develop a measure of “prospect $Q$ is more risky than $P$.” If $Q$, compared to $P$, assigns more probability mass to at least one lower ranked outcome and does not sufficiently compensate by assigning more probability mass to better ranked outcomes, $Q$ is regarded as more risky, and thus is dominated by $P$ in the SSD-sense. The theoretical implications of SSD are well understood for expected utility theory (an increasing and concave utility function; see Levy 1992) and for rank-dependent utility theory (Quiggin 1982; increasing and concave utility, and increasing and convex probability weighting function; see Chew et al. 1987; Ryan 2006). Schmidt and Zank (2008) provide an analysis of SSD under general PT: for gains, utility is concave and the probability weighting function is convex; for losses, utility is concave and the probability weighting function is concave.

The theoretical implications of SSD for PT do not fit well with the empirical evidence on choice behavior, which suggests that utility is concave for gains but convex for losses and that the weighting functions have an inverse $S$-shape, being concave for small decumulative probabilities and convex for large ones (see Abdellaoui et al. (2007) and Wakker (2010) for summaries and discussions of recent empirical evidence). However, the theoretical implications of SSD emerge naturally as the prop-

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1 Experimental analyses for dominance criteria of higher order are discussed elsewhere (e.g., Deck and Schlesinger 2010). The independence axiom of expected utility entails itself a dominance principle that is appealing: first-order stochastic dominance (FSD) requires that the prospect should be preferred that has higher decumulative probability among all outcomes than a second prospect. FSD is a simple criterion, people agree with this principle and apply it in simple situations. However, in non-transparent choice situations many violate this dominance criterion; see Birnbaum and Navarrete (1998) and Birnbaum (2005) for experimental evidence. The aforementioned biases have little influence on FSD.

2 See also Hogarth and Einhorn (1990), Tversky and Kahneman (1992), Wu and Gonzalez (1996), Gonzalez and Wu (1999), Abdellaoui (2000), Bleichrodt and Pinto (2000), Bleichrodt et al. (2001), Etchart-Vincent (2004), Abdellaoui et al. (2005), and Abdellaoui et al. (2011).
Risk behavior for gain, loss, and mixed prospects

Risk behavior for gain, loss, and mixed prospects requires a global form of risk aversion. Under PT risk behavior is not globally consistent in the former sense as outcomes are not interpreted as final wealth positions but, instead, as deviations from a reference point. A distinction between risk behavior for gain prospects and separately the risk behavior for loss prospects is meaningful. Additionally, for mixed prospects containing gains and losses, LA may imply additional aversion to increases in risk when gains are traded off against losses of similar size (Brooks and Zank 2005; Abdellaoui et al. 2007, 2008).

Accounting for the empirical evidence regarding utility curvature for gains and that for losses, Levy and Levy (2002) proposed restrictions to the general SSD principle. Prospect stochastic dominance (PSD) requires SSD for the gain part of prospects but for the loss part of prospects the opposite of SSD (i.e., a preference for the dominated prospect) is demanded. Markowitz stochastic dominance (MSD), inspired by the utility curvature proposed in Markowitz (1952), requires SSD for the loss part of prospects and the opposite of SSD for the gain part of prospects. For prospects with equal means PSD predicts the opposite of MSD, but this may not hold for prospects that have different means. Levy and Levy ran experiments involving mixed prospects containing both gains and losses and interpreted their results as evidence for MSD and, hence, as evidence against PT. Accounting for probability weighting as in the modern PT model of Tversky and Kahneman (1992); Wakker (2003) demonstrated that the choice behavior observed by Levy and Levy is, however, consistent with PT. A similar result was found in the study of Baucells and Heukamp (2004). The latter authors argued for further adjustments of PSD that take into account inverse S probability weighting and also LA (Baucells and Heukamp 2006).

While the study of Levy and Levy (2002) is inconclusive about violations of modern PT, the findings of Baltussen et al. (2006) show that choice behavior between mixed prospects may not always be in agreement with PT predictions. They reconsider a specific choice task of Levy and Levy that involved a choice between a mixed prospect \( F \) and a second one, \( G \), that results from \( F \) through simultaneous increases in risk for the gain and the loss part of \( F \). They design an “intermediate” mixed prospect, \( H \), that agrees with \( F \) on the gain part but has increases in risk that only involve losses. As a result they obtain additional information about risk behavior among mixed prospects with common gains and among mixed prospects with common losses. This way they identify descriptive inaccuracies of PT and provide evidence regarding the PSD and MSD principles of Levy and Levy (2002).

This paper presents new empirical tests of SSD and its restrictions PSD and MSD taking account of the empirical evidence regarding probability weighting and LA, and compares the findings with the predictions based on PT. We present data from a laboratory experiment involving binary choices over small to moderate scale prospects that involve real stakes. The 90 participants had to decide between a prospect and an SSD-dominated transformation of that prospect in 95 binary choices. We consider three broader conditions within which further refinements are identified. The broad conditions involve: (i) the gain condition: choices among prospects where no outcomes are losses, (ii) the loss condition: choices among prospects that involve no gains, and (iii) the mixed condition: choices among prospects that involve gains and losses of similar size. It is well-known that SSD implies aversion to mean preserving spreads (MPS), also known as strong risk aversion (the latter requiring SSD only if the prospects have
the same mean). Within a choice task we present prospects that have the same mean, hence we obtain evidence about aversion to MPSs (Rothschild and Stiglitz 1970), and information about how this behavior may be affected by the nature of prospects (i.e., gain, loss, or mixed). Additionally our study accounts for potential biases caused by probability weighting, which is an important component of risk behavior (see Wakker 2001, 2010) and a key innovation of modern PT. Accordingly, within each broader condition, we employ MPSs which use small, medium and large decumulated probabilities. Our analysis, therefore, provides new evidence concerning the validity of the SSD criteria of Levy and Levy (2002) as discussed and extended in Baucells and Heukamp (2006).

Most experimental studies on PT have focused on prospects with at most three outcomes and clear empirical evidence supporting inverse S probability weighting has been obtained (see Wakker 2010). To test PSD and MSD we require prospects with more than three outcomes. For this domain it is unclear if the shape of probability weighting functions and LA are as pronounced as the existing evidence suggests. For example, (Camerer, 1995, p. 637), suggested that the performance of nonlinear probability weighting for prospects with a larger number of outcomes is an unsettled and fundamental empirical question. Lopes (1984) and Fennema and Wakker (1997) also used multiple outcome prospects and found support for inverse S probability weighting while the data of Payne (2005) suggests that an extension of the original PT-version of Kahneman and Tversky (1979), where actual instead of cumulated probabilities are transformed, gives a better fit. Baltussen et al. (2006) suggest that probability weighting for mixed prospects may be different than for gain or loss prospects (Baltussen et al., p. 1290) and call for more experimental tests in the domain of mixed prospects with more than three outcomes. Our study uses five outcome prospects and allows for comparison across the domains of gain, loss, and mixed prospects, thereby supplementing the existing scarce evidence on probability weighting under PT on the domain of multiple outcome prospects. A further feature of our study is that it provides results at the aggregate level as well as at the individual level, as this distinction may be relevant when comparing behavior across domains (see Zeisberger et al. 2012).

Our results indicate that behavior as predicted by PT extends to the domain of gain and loss prospects but not necessarily to the domain of mixed prospects. We find that MSD and PSD do not perform well but that the extension of PSD by Baucells and Heukamp (2006) gives better predictions. For mixed prospects we find some evidence that the sign of common outcomes and, hence, the likelihood of losing, plays a significant role for choice behavior, complementing results of Payne (2005) and Brooks and Zank (2005).

The next section presents notation and is followed by a section with details of the experiment. The results are presented in Sect. 5, with a discussion provided in Sect. 6. Concluding remarks are presented in Sect. 7.

2 Notation

In this section we introduce the general notation for prospect theory and the stochastic dominance properties tested in our experiment.
2.1 Prospect theory

A *prospect* is a simple distribution over monetary outcomes. In general, we write $P = (p_1 : x_1, \ldots, p_n : x_n)$ for the prospect that gives outcome $x_i \in \mathbb{R}$ with probability $p_i$ for $i = 1, \ldots, n$, where $n$ is a natural number, $p_i \geq 0$, and $\sum_{i=1}^{n} p_i = 1$. We assume that outcomes in a prospect are ordered from best to worst, i.e., $x_1 \geq \cdots \geq x_k \geq 0 > x_{k+1} \geq \cdots \geq x_n$. Let $0 \in \mathbb{R}$ be the reference point. Positive outcomes are *gains* and negative outcomes are *losses*. Accordingly, if a prospect has no losses it is a *gain prospect* and if it has no gains it is a *loss prospect*, otherwise it is a *mixed prospect*.

A probability *weighting function* $(w : [0, 1] \rightarrow [0, 1])$ is a strictly increasing function that maps the probability interval into itself, with at least two fixed points, one at 0 and one at 1. Empirically founded probability weighting functions are inverse $S$-shaped, i.e., concave for small probabilities with overweighting (optimism), flat and close to linear for intermediate probabilities (insensitivity), and convex for large probabilities with underweighting (pessimism). They have an additional fixed point in the $(0, 1)$ interval.

A preference relation $\succeq$ is assumed on the set of prospects. As usual, $P \succsim Q$ indicates weak preference; the symbols $\succ$ and $\sim$ denote strict preference and indifference, respectively ($\preceq$ and $\prec$ are as usual). PT holds if prospects are ranked using the PT-functional explained next: There exists a continuous strictly increasing utility function $u : \mathbb{R} \rightarrow \mathbb{R}$ with $u(0) = 0$, and two weighting functions $w^+$ and $w^-$ such that the prospect $P = (p_1 : x_1, \ldots, p_n : x_n)$ is evaluated according to

$$PT(P) = \sum_{i=1}^{k} \pi_i^+ u(x_i) + \sum_{i=k+1}^{n} \pi_i^- u(x_i),$$

(1)

with decision weights, $\pi_i^+, \pi_i^-$, $i = 1, \ldots, n$, determined through

$$\pi_i^+ = w^+ \left( \sum_{j=1}^{i} p_j \right) - w^+ \left( \sum_{j=1}^{i-1} p_j \right)$$

and

$$\pi_i^- = w^- \left( \sum_{j=i}^{n} p_j \right) - w^- \left( \sum_{j=i+1}^{n} p_j \right).$$

Under PT the weighting functions are uniquely determined and the utility function is unique up to multiplication by a positive number (i.e., utility is a ratio scale). Foundations for PT and discussions of the related literature can be found in Wakker (2010). For recent foundations of PT with an endogenously determined reference point see Schmidt and Zank (2012) and Werner and Zank (2012).

As degenerate lotteries are identified with the corresponding outcome, the prospect $(p_1:0, \ldots, p_n:0)$, that has no gains and no losses, is identified with the reference outcome zero.

4 See Tversky and Kahneman (1992), Goldstein and Einhorn (1987), Prelec (1998), Diecidue et al. (2009), or Abdellaoui et al. (2010) for parametric specifications incorporating optimism, insensitivity, and pessimism.
Both the empirically founded curvature of utility and that of the probability weighting functions under PT have implications for risk behavior. Risk seeking is implied for gain prospects offering large gains with low cumulated probability. Then, optimism captured through large decision weights for those large gains dominates the risk attitude effects captured by concave utility for gains. Risk seeking is also observed for loss prospects offering losses with high cumulated probability. In this case the combination of optimism (large decision weights for small losses) and convex utility is the dominating effect for behavior. In contrast, for gain prospects with high cumulated probability gains risk aversion is observed. Then, the combination of pessimism (relatively low decision weight for gains) and concave utility is the dominating effect on risk behavior. Risk aversion is also observed for loss prospects with low probability losses. In that case the pessimism captured by a large decision weight for the low probability loss is dominating the effect of risk attitude implied by the convex utility for losses. For evidence on this fourfold pattern of risk attitude see Tversky and Kahneman (1992) and, more recently, Harbaugh et al. (2009). Hence, if optimism and pessimism are sufficiently powerful to overturn the implications for risk attitude captured by utility, one can expect that probability weighting influences choice behavior when testing the SSD principles to which we turn next.

2.2 Second-order stochastic dominance principles

This section formalizes the proposed variants of second-order stochastic dominance (SSD) of Levy and Levy (2002) and Baucells and Heukamp (2006). To simplify the exposition and to relate the implications to the experiment and the testable hypotheses of this paper we restrict attention to prospects with five equally likely outcomes. Hence, we suppress probabilities from the further notation and write \( P = (x_1, \ldots, x_5) \). In our experiment we consider only binary choices among prospects with the same expected value in order to restrict attention to mean-preserving spreads (MPS) and to discuss the implications of the various variants of preference or aversion to MPSs for PT. For prospect \( P = (x_1, \ldots, x_5) \) and \( i \in \{1, \ldots, 5\} \) we write \( y_i P \) for the prospect where we have replaced outcome \( x_i \) with \( y \). Whenever we use this notation it is implicit that \( x_{i-1} \geq y \geq x_{i+1} \), that is, the ranking of outcomes from best to worst is maintained for the new prospect. For \( \varepsilon > 0 \) we define a mean-preserving spread (MPS) of \( P \) as the prospect \((x_i + \varepsilon)_i (x_j - \varepsilon)_j P\) for some \( i, j \in \{1, \ldots, 5\} \) with \( i < j \).

A preference \( \succeq \) satisfies second-order stochastic dominance (SSD) if \( P \succeq (x_i + \varepsilon)_i (x_j - \varepsilon)_j P \) for all \( P \).\(^6\) Such a preference exhibits aversion to MPSs; a preference for MPSs requires \( P \preceq (x_i + \varepsilon)_i (x_j - \varepsilon)_j P \) for all \( P \); and neutrality means \( P \sim (x_i + \varepsilon)_i (x_j - \varepsilon)_j P \) for all \( P \). Levy and Levy (2002) proposed adjustments for SSD

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\(^5\) In the experiment we use prospects in which each outcome has probability 1/5; for prospects with equal outcomes the latter are displayed with the coalesced probabilities, e.g., two 1/5 chances of obtaining £5 are presented as a single 2/5 chance for £5.

\(^6\) As we restrict attention to prospects that have the same mean this definition makes sense. SSD is, in general, also defined for prospects without equal means. The more general definition implies our definition used here but the reverse implication does not hold.
to account for the S-shape form of utility as suggested by Kahneman and Tversky (1979) and for the inverse S-shape form of utility as suggested by Markowitz (1952). A preference $≽$ satisfies PSD if $P ≽ (x_i + \varepsilon)_i(x_j - \varepsilon)_j P$ for all $P$ with $x_j - \varepsilon \geq 0$ and $P ≼ (x_i + \varepsilon)_i(x_j - \varepsilon)_j P$ for all $P$ with $x_i + \varepsilon \leq 0$. PSD implies SSD for gain prospects and the opposite of SSD for loss prospects. The opposite of PSD, called (MSD), requires $P ≼ (x_i + \varepsilon)_i(x_j - \varepsilon)_j P$ for all $P$ with $x_j - \varepsilon \geq 0$ and $P ≽ (x_i + \varepsilon)_i(x_j - \varepsilon)_j P$ for all $P$ with $x_i + \varepsilon \leq 0$.

The SSD, PSD, and MSD principles have implications for the probability weighting functions that are not in line with the fourfold pattern of risk attitudes under PT (Tversky and Kahneman 1992). For example, while PSD implies convex utility for losses and concave utility for gains, it restricts the gain and loss probability functions to be convex. The empirically based inverse S pattern is not allowed. To account for the latter, Baucells and Heukamp (2006) proposed further adjustments to PSD. They note that most inverse S-shaped probability weighting functions can be described by two parameters $0 \leq c \leq d \leq 1$ such that concavity of the weighting function holds on $[0, d]$ and convexity holds on $[c, 1]$. The case $c = d$ is particularly interesting as this parameter denotes the inflection point of the weighting function which has a natural interpretation as measure for elevation as discussed in Gonzalez and Wu (1999) and Abdellaoui et al. (2010).7 Baucells and Heukamp (2006) propose prospect weighted stochastic dominance (PBSD), which requires PSD only if the cumulative probability of gain $x_i$ is above some $c^+ \in (0, 1)$ if $x_j - \varepsilon \geq 0$ and the cumulative probability of loss $x_j$ is below some $c^- \in (0, 1)$ if $x_i + \varepsilon \leq 0$. Under PT the implications of PBSD for utility are similar to those of PSD, but the shape of weighting functions is determined only for probabilities in the range $[c^+, 1]$ for gain probabilities (where it is convex), respectively, $[0, c^-]$ for loss probabilities (where it is concave). Hence, inverse S-shaped probability weighting functions are no longer excluded. The dual analog principle of Markowitz-weighted stochastic dominance (MWSD) requires MSD only if the cumulative probability of $x_j$ is below some $d^+ \in (0, 1)$, the parameter for gain probabilities, if $x_j - \varepsilon \geq 0$ and the cumulative probability of $x_i$ is above some $d^- \in (0, 1)$, the parameter for loss probabilities, if $x_i + \varepsilon \leq 0$, respectively. MWSD has similar but dual implications for utility and the probability weighting functions under PT.

Thus far we have not discussed preference or aversion to MPSs which involve a transfer of $\varepsilon$ from a gain to a loss. Schmidt and Zank (2005) discussed a related principle: loss aversion (LA) holds if $P \succ (x_i + \varepsilon)_i(x_j - \varepsilon)_j P$ for all $P$ with $x_j \geq 0 \geq x_j$ and $x_i = |x_j|$. The opposite of LA is called gain seeking (GS). Schmidt and Zank showed that LA holds if utility for losses is steeper than the utility for gains adjusted by a ratio of decision weights for gains and losses. This LA condition was tested in an experiment involving small stakes by Brooks and Zank (2005) where it was confirmed for probabilities 1/3 and 1/4 of the extreme outcomes (i.e., the largest gains and losses) within a prospect. In those cases the empirically estimated corresponding

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7 The case $c = d$ occurs naturally in the parametric probability weighting functions of Goldstein and Einhorn (1987), Tversky and Kahneman (1992), Lattimore et al. (1992), Prelec (1998), and Diecidue et al. (2009).
decision weights for gain and loss probabilities do not differ significantly\(^8\) and choice behavior is mainly driven by attitude towards outcomes. Indeed, in the literature LA is mostly understood as a component captured by utility alone. In this paper we test the condition of Schmidt and Zank for MPS involving extreme and intermediate symmetric outcomes. Further, we look at choice behavior when the MPS involve gains and losses that are not symmetric. There, one expects decision weighting to influence the choice behavior significantly in addition to utility curvature.

3 Experiment

3.1 Experimental design

3.1.1 Participants

Ninety (28 female and 62 male) graduate and undergraduate students in economics from the University of Manchester took part in this study. They were initially sent an e-mail message in which the nature of the experiment was briefly described. The message contained a link to a web page that presented information about the experiment, which were the instructions.\(^9\) The students were asked to respond if they intended to participate in this experiment. This message was sent to all students enrolled in economics or a related subject in 2004 (approximately 1,000 students). Those who responded were asked to attend the experiment, which was held in groups in a computer room during March 2004 (with sessions varying from 2 to 13 individuals). Participants attended one experimental session, which took approximately 40 min on average to complete.

3.1.2 Incentives

The experiment consisted of several binary choices between a prospect and an MPS of that prospect. The majority of prospects in the experiment involved losses, and a difficulty with real losses concerns their implementation. Benartzi and Thaler (1999) offered participants the option of earning money (i.e., a temporary job) if losses from the experiment would exceed a certain level. A more common practice is to give participants an initial endowment. This endowment can be a flat payment for participation\(^10\) or earned otherwise during the experiment (see Laury and Holt 2000). It is then assumed that participants (instantly) integrate that payment into their wealth and

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\(^8\) Based on the aggregate data of Abdellaoui (2000) the decision weights of 0.33 (0.25) are approximately 0.33 for gains and 0.35 for losses (0.29 for gains and 0.29 for losses) for the one-parameter Tversky and Kahneman (1992) probability weighting function. For the two-parameter Goldstein and Einhorn (1987) probability weighting function we have \(w^+(0.33) \approx 0.30\) and \(w^-(0.33) \approx 0.35\) (\(w^+(0.25) \approx 0.3\) and \(w^-(0.25) \approx 0.29\))

\(^9\) See Appendix 1.

\(^10\) See Cohen et al. (1985), Camerer (1989), Battalio et al. (1990), Harless (1992), Harless and Camerer (1994), Myagkov and Plott (1997), Di Mauro and Maffioletti (2002), Smith et al. (2002), Mason et al. (2005), and Brooks and Zank (2005).
that subsequent choices will not be affected by this income. Typically, the payment and therefore the stakes in those experiments range from small to moderate. The design of our study was similar in that the flat payment plus the outcome of a randomly chosen prospect was promised (and subsequently given) to each subject for completing the experiment.

The fixed payment in this study was £17 (approximately US $30 at the time of the experiment) and the stakes in the prospects varied from £−15 to £15. Similar stakes have been used, for example, in Camerer (1989), Starmer and Sugden (1989), Battalio et al. (1990), Hogarth and Einhorn (1990), Hey and Orme (1994), Beattie and Loomes (1997), and Brooks and Zank (2005), and have generated meaningful results. The actual payments at the end of the experiment ranged between £2 and £32 (including the fixed payment), with the average of actual payments being £13.69.

### 3.1.3 Presentation and framing of prospects

The experiment was held on computers, using an interface supported by a standard web browser familiar to students. Participants, seated at reasonable distance between themselves, were directed to a web page containing the instructions which the experimenter read aloud. Participants were informed that they had to respond to 105 tasks (the last ten tasks consisted of repeated randomly chosen tasks, but this was not mentioned to the participants). It was explained that a task consisted of choosing between two prospects (called gambles in the instructions), and that indifference was not allowed. Each of the first 95 tasks in the experiment consisted of choosing between one prospect and a second one that dominated the first in the SSD-sense. To account for the distinction into gains and losses, we implemented a gain condition (22 choices where neither prospect involves losses), a loss condition (22 choices where neither prospect involves gains), and a mixed condition (51 choices where each prospect contains both gains and losses). Each participant received the tasks in an individually randomized order. The position of the riskier prospect (R) on the computer screen was determined according to whether the time on the computer was indicating seconds 01–30 (left position) or 31–00 (right position) on submission of the preceding choice. The prospects did not have outcomes ranked from best to worst or outcomes ranked from worst to best.

A prospect was framed as picking a ball from a bag that contains 15 balls numbered consecutively from 1 to 15, each equally likely to be drawn. The bag, containing the 15 white table tennis balls, was shown at the beginning of the experiment. On the computer screen, a prospect was presented as 15 colored balls with amounts of money underneath those balls. Identical outcomes were coalesced and corresponded to balls of the same color. Participants were informed about the range of outcomes [−15, 15], and that their final payment was made up of a fixed amount (£17) which they would obtain if they answered all tasks and to which the outcome of a randomly selected choice would be added. That latter prospect was played for real, that is, each participant picked a ball from the bag, the obtained outcome was added to (or, in the case of losses, subtracted from) the fixed payment, and later a cheque was sent to the participant (see Cubitt et al. (1998) for a discussion about the appropriateness of using this random incentive scheme). Details about the address of the participants and the earnings from the experiment were collected on a separate form at the end of the experimental session,
where each participant was also asked to state the minimum they were willing to pay from their own money in order to retake the experiment (see Appendix 2).

### 3.1.4 Subconditions

In addition to the distinction into the gain, the loss, and the mixed conditions, we designed, within each condition, different tasks to test and account for a possible effect of probability weighting. The resultant subconditions are explained next.

*The gain prospects tasks:* The tasks in the gain condition are presented in Table 1. A prospect is displayed as five outcomes of equal likelihood. The probabilities (1/5) are not mentioned in the table. Within a task, the left prospect refers to the more risky one, in the SSD-sense. Outcomes in the table are ranked from best to worst for each prospect.

The highlighted outcomes in Table 1 refer to the outcomes that were affected in the construction of an MPS through a change in their value or in their rank. For a prospect with equally likely outcomes, an elementary MPS can be seen as subtracting $\varepsilon > 0$ from a lower ranked, smaller outcome and simultaneously adding $\varepsilon$ to a higher ranked

| Task No. | Outcomes Riskier Prospect | Outcomes Safer Prospect | No of S-changes | Different from mean | PT-prediction |
|----------|---------------------------|-------------------------|----------------|-------------------|---------------|
| WR-tasks |
| 52       | 15 0 0 0 0                | 5 3 3 3 3               | 56**           | R                 |
| 53       | 10 0 0 0 0                | 2 2 2 2 2               | 51             | R                 |
| 54       | 5 0 0 0 0                | 1 1 1 1 1               | 43 **          | R                 |
| SYM-tasks |
| 55       | 15 10 5 5 0              | 10 10 5 5 5             | 48             | S                 |
| 56       | 10 10 5 0 0              | 10 5 5 5 0             | 58***          | S                 |
| 57       | 5 5 3 0 0               | 5 3 3 2 0             | 65*** **       | S                 |
| STR-tasks |
| 58       | 15 5 5 0 0              | 10 5 5 5 0             | 54**           | R                 |
| 59       | 10 5 5 0 0              | 5 5 5 5 0             | 41 ***         | R                 |
| 60       | 15 15 5 5 0             | 15 10 5 5 5             | 65***          | S                 |
| 61       | 10 10 5 5 0             | 10 5 5 5 5             | 59***          | S                 |
| 62       | 15 5 0 0 0              | 10 5 5 0 0             | 61***          | R                 |
| 63       | 10 5 0 0 0              | 5 5 5 0 0             | 35 ***         | R                 |
| 64       | 15 15 15 5 0           | 15 15 10 5 5          | 66*** **       | S                 |
| 65       | 10 10 10 5 0           | 10 10 5 5 5          | 71*** ***      | S                 |
| GER-tasks |
| 66       | 15 7 2 2 0              | 10 7 5 2 2             | 57**           | S                 |
| 67       | 10 5 1 1 0              | 5 5 5 1 1             | 26 ***         | R                 |
| 68       | 15 11 11 6 0              | 11 11 10 6 5             | 64***          | S                 |
| 69       | 10 6 6 6 0              | 6 6 5 5 5             | 48             | S                 |
| 70       | 15 15 11 2 0          | 15 11 10 5 2             | 53**           | S                 |
| 71       | 11 10 6 2 0          | 11 6 5 5 2             | 54***          | S                 |
| 72       | 15 11 4 0 0          | 11 10 5 4 0             | 62***          | R                 |
| 73       | 10 6 4 0 0          | 6 5 5 4 0             | 62***          | R                 |

Significant deviations from 45 according to a one-tailed binomial test at the 10, 5, and 1 % are designated with *, **, and *** respectively.
outcome without affecting the ranking of outcomes from best to worst. Applying repeatedly four elementary MPS in Tasks 52–54, changes the safe prospects into the risky ones that give a large outcome with probability 1/5 or nothing otherwise. Choice here can provide evidence about risk behavior in the weak sense of preference for expected value. Therefore, this condition is termed weak risk (WR) subcondition.

Tasks 55–57 involve symmetric spreads where $\varepsilon$ is shifted from the worst to the best outcomes (or from the second worst to the second best outcomes), and is referred to as the symmetric increases in risk (SYM) subcondition. These tasks can provide information about the effect of optimism relative to pessimism and information regarding diminishing sensitivity in outcomes.

For Tasks 58–65 the symmetry is deliberately not respected and shifts occur from intermediate (worst) to best (intermediate) outcomes. This is the strong risk (STR) subcondition. If present, the effect of pessimism and optimism is reinforced relative to SYM tasks and can further influence choice behavior in addition to diminishing sensitivity in outcomes.

Tasks 66–73 involve spreads where the shift of the amount $\varepsilon$ changes the ranking of outcomes in the safer prospect. When multiple elementary shifts in outcomes are applied, this makes the amount shifted less transparent and may potentially influence preferences. These tasks are the general increases in risk (GER) subcondition. If present, the effect of probability weighting and diminishing sensitivity in outcomes is further reinforced in these tasks.

The loss prospects tasks: The Tasks 74–95 in the loss condition are presented in Table 2. These tasks result from the gain tasks by multiplying each outcome in a prospect with $-1$. Hence, these tasks correspond to the original gain tasks with prospects reflected around zero. Therefore we have corresponding WR, SYM, STR, and GER subconditions as for gains.

The mixed prospects tasks: Table 3 presents Tasks 1–51 which we call the mixed condition. These tasks are also grouped in WR (Tasks 1–6), SYM (Tasks 7–27), STR (Tasks 28–39), and GER (Tasks 40–51). In this condition the WR tasks are a special cases of SYM tasks.

4 Predictions

The results of the experiment are presented at aggregate and individual level. First, we recall the predictions of the different SSD variants before we provide the predictions of PT.

4.1 PSD, MSD, and LA predictions

SSD predicts a preference for the safer prospect for each task.11 PSD predicts a preference for the safer prospect for all tasks in the gain condition, and a preference for the riskier prospect for all tasks in the loss condition. For choices between our mixed

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11 The descriptions “safer” or “riskier” are short for “safer in the SSD-sense” or “riskier in the SSD-sense,” respectively.
Table 2  Choice tasks in the loss condition

| Task No. | Outcomes Riskier Prospect | Outcomes Safer Prospect | No of S-chances | Different from mean | PT-prediction |
|----------|---------------------------|-------------------------|----------------|-------------------|---------------|
|          |                           |                         | WR-tasks       |                   |               |
| 74       | 0                         | 0                       | 0              | -15               | 29***         | *             | S             |
| 75       | 0                         | 0                       | 0              | -10               | 25***         | **            | S             |
| 76       | 0                         | 0                       | 0              | -5                | 26***         | **            | S             |
|          |                           |                         | SYM-tasks      |                   |               |
| 77       | 0                         | -5                      | -5             | -15               | -5            | 38**          | R             |
| 78       | 0                         | -10                     | -10            | -10               | -5            | 39            | R             |
| 79       | 0                         | -5                      | -5             | -15               | -5            | 24***         | ***           | R             |
|          |                           |                         | STR-tasks      |                   |               |
| 80       | 0                         | -5                      | -5             | -15               | -5            | 39            | S             |
| 81       | 0                         | -5                      | -5             | -10               | 0             | 49            | ***           | S             |
| 82       | 0                         | -5                      | -5             | -15               | -5            | 32***         | *             | R             |
| 83       | 0                         | -5                      | -5             | -10               | -5            | 43            |              | S             |
| 84       | 0                         | 0                       | 0              | -5                | 0             | 58            | ***           | S             |
| 85       | 0                         | 0                       | 0              | -5                | 0             |              | S             |
| 86       | 0                         | -5                      | -5             | -15               | -5            | 33***         |              | R             |
| 87       | 0                         | -5                      | -5             | -10               | -5            | 30***         | ***           | R             |
|          |                           |                         | GER-tasks      |                   |               |
| 88       | 0                         | -2                      | -2             | -15               | -2            | 47            | **            | S             |
| 89       | 0                         | -1                      | -1             | -10               | -1            | 57            | ***           | S             |
| 90       | 0                         | -1                      | -1             | -11               | -1            |              | ***           | S             |
| 91       | 0                         | -6                      | -6             | -10               | -6            | 32***         | *             | R             |
| 92       | 0                         | -2                      | -2             | -11               | -2            | 47            | **            | R             |
| 93       | 0                         | -2                      | -2             | -11               | -2            | 33***         |              | S             |
| 94       | 0                         | 0                       | 0              | -11               | 0             | 32***         | ***           | S             |
| 95       | 0                         | 0                       | 0              | -6                | 0             | 37**          | ***           | S             |

Significant deviations from 45 according to a one-tailed binomial test at the 10, 5, and 1 % are designated with *, **, and ***, respectively.

prospects, PSD makes no prediction. MSD makes the opposite predictions to PSD for tasks in the gain condition and for the tasks in the loss conditions, but no predictions for tasks in the mixed condition. LA predicts a choice of the safer prospect in all mixed tasks, while GS predicts a choice for the riskier prospect in all mixed tasks; LA and GS make no predictions for gain or loss tasks.

4.2 PWSD and MWSD predictions

The predictions of PWSD (MWSD) require assumptions about the parameters $c^+, c^- (d^+, d^-)$. Given the design of our study we set $c^+ = c^- = 0.2 (d^+, d^- = 0.8)$. For the gain condition, Tasks 56 and 57, 60 and 61, 64 and 65, and 70 and 71 provide information on PWSD: in all these tasks PWSD predicts a preference for the safer prospect. For the loss condition, Tasks 78 and 79, 82 and 83, 86 and 87, and 92 and 93 provide evidence on PWSD: in all choices a preference for the riskier prospect is predicted. For further reference we combine these tasks as the PWSD-subcondition. In gain tasks 56 and 57, 58 and 59, 62 and 63, and 72 and 73 and in loss Tasks 78 and 79, 80 and 81, 84 and 85, and 94 and 95 information about MWSD
Table 3  Choice tasks in the mixed condition

| Task No. | Outcomes Riskier Prospect | Outcomes Safer Prospect | No of S-choices | Different from mean | PT-prediction with LA=1.69 | PT-prediction with LA=1.48 |
|----------|----------------------------|-------------------------|-----------------|---------------------|------------------------|------------------------|
| WR-tasks |                            |                         |                 |                     |                        |                        |
| 1        | 15                         | 15                      | 15              | 15                  | 0                      | 0 0 0 0 0 0            | 48                      | S S                    |
| 2        | 10                         | 10                      | 10              | 10                  | 0                      | 0 0 0 0 0 0            | 38                      | S S                    |
| 3        | 5                          | 5                       | -5              | -5                  | 0                      | 0 0 0 0 0 0            | 47                      | S S                    |
| 4        | 15                         | 0                       | 0               | 0                   | 0                      | 0 0 0 0 0 0            | 45                      | S S                    |
| 5        | 10                         | 0                       | 0               | 0                   | 0                      | 0 0 0 0 0 0            | 30  ***                 | S S                    |
| 6        | 5                          | 0                       | 0               | 0                   | 0                      | 0 0 0 0 0 0            | 40                      | S S                    |
| SYM-tasks |                            |                         |                 |                     |                        |                        |
| 7        | 15                         | 0                       | 0               | 0                   | 0                      | 0 0 0 0 -10           | 47                      | S S                    |
| 8        | 10                         | 0                       | 0               | 0                   | 0                      | 0 0 0 0 -10           | 42                      | S S                    |
| 9        | 5                          | 0                       | 0               | 0                   | 0                      | 0 0 0 0 -2            | 39                      | S S                    |
| 10       | 15                         | 9                       | 0               | 0                   | 0                      | 0 0 0 0 -10           | 51                      | S S                    |
| 11       | 10                         | 3                       | 0               | 0                   | 0                      | 0 0 0 0 -3            | 49                      | S S                    |
| 12       | 5                          | 2                       | 0               | 0                   | 0                      | 0 0 0 0 -2            | 44                      | S S                    |
| 13       | 15                         | 8                       | 5               | 0                   | 0                      | 0 0 0 0 -10           | 42                      | S S                    |
| 14       | 10                         | 4                       | 2               | 0                   | 0                      | 0 0 0 0 -5            | 47                      | S S                    |
| 15       | 5                          | 2                       | 1               | 0                   | 0                      | 2 2 1 0 -2            | 36  *                   | S S                    |
| 16       | 15                         | 0                       | -5              | -5                  | 0                      | 0 0 0 0 -10           | 51                      | S S                    |
| 17       | 10                         | 0                       | -2              | -4                  | 0                      | 0 0 0 0 -5            | 51                      | S S                    |
| 18       | 5                          | 0                       | -1              | -2                  | 0                      | 0 0 0 0 -2            | 53  **                  | S S                    |
| 19       | 15                         | 15                       | 5               | -15                 | 0                      | 15 10 5 -10 -15       | 40                      | S S                    |
| 20       | 10                         | 10                       | 3               | -10                 | 0                      | 10 5 3 -5 -10         | 45                      | S S                    |
| 21       | 5                          | 5                       | 2               | -5                  | 0                      | 5 2 2 -2 -5            | 34  **                  | S S                    |
| 22       | 15                         | 15                       | 0               | -15                 | 0                      | 15 10 0 -10 -15       | 57  ***                 | S S                    |
| 23       | 10                         | 10                       | 0               | -10                 | 0                      | 10 5 0 -5 -10         | 46                      | S S                    |
| 24       | 5                          | 5                       | 0               | -5                  | 0                      | 5 2 0 -2 -5            | 41                      | S S                    |
| 25       | 15                         | 15                       | -5              | -15                 | 0                      | 15 10 -5 -10 -15      | 39                      | S S                    |
| 26       | 10                         | 10                       | -3              | -10                 | 0                      | 10 5 -3 -5 -10        | 47                      | S S                    |
| 27       | 5                          | 5                       | -2              | -5                  | 0                      | 5 2 -2 -2 -5           | 46                      | S S                    |
| STR-tasks |                            |                         |                 |                     |                        |                        |
| 28       | 15                         | 0                       | 0               | -15                 | 0                      | 0 0 0 0 -10           | 44                      | R R                    |
| 29       | 10                         | 0                       | 0               | -12                 | 0                      | 0 0 0 0 -5            | 50                      | R R                    |
| 30       | 5                          | 0                       | 0               | -6                  | 0                      | 0 0 0 0 -2            | 45                      | R R                    |
| 31       | 15                         | 10                       | 0               | 0                   | 0                      | 15 10 0 0 -10         | 50                      | S S                    |
| 32       | 12                         | 10                       | 0               | 0                   | 0                      | 12 5 0 0 -5           | 57  ***                 | S S                    |
| 33       | 6                          | 5                       | 0               | 0                   | 0                      | 6 2 0 0 -2            | 32  ***                 | S S                    |
| 34       | 15                         | 0                       | -15             | -15                 | 0                      | 10 0 0 0 0 0 0 0 -15  | 44                      | R R                    |
| 35       | 10                         | 0                       | -10             | -12                 | 0                      | 5 0 -5 -12 -12         | 47                      | R R                    |
| 36       | 5                          | 0                       | -5              | -6                  | 0                      | 2 0 -2 -6 -6           | 41                      | R R                    |
| 37       | 15                         | 13                       | 0               | 0                   | 0                      | 15 13 0 0 0 0 0 0    | 48                      | S S                    |
| 38       | 12                         | 12                       | 10              | 0                   | 0                      | 12 12 5 0 0 -5        | 50                      | S S                    |
| 39       | 6                          | 6                       | 5               | 0                   | 0                      | 6 6 2 0 0 -2           | 58  ***                 | S S                    |
| GER-tasks |                            |                         |                 |                     |                        |                        |
| 40       | 15                         | 0                       | -12             | -12                 | 0                      | 10 0 -10 -12 -12      | 49                      | S S                    |
| 41       | 10                         | 0                       | -8              | -8                  | 0                      | 5 0 -5 -8 -8           | 41                      | S S                    |
| 42       | 5                          | 0                       | -4              | -4                  | 0                      | 2 0 -2 -4 -4           | 45                      | S S                    |
| 43       | 15                         | 12                       | 12              | 0                   | 0                      | 12 12 10 0 0 -10      | 36                      | S S                    |
| 44       | 10                         | 8                       | 8               | 0                   | 0                      | 8 8 5 0 0 -5           | 59  ***                 | S S                    |
| 45       | 5                          | 4                       | 4               | 0                   | 0                      | 4 4 2 0 0 -2           | 31  ***                 | S S                    |
| 46       | 15                         | 15                       | 12              | -12                 | 0                      | 15 12 10 0 0 0 0 0 -12  | 46                      | S S                    |
| 47       | 12                         | 10                       | 8               | -8                  | 0                      | 12 8 5 -3 -8 54        | **                      | S S                    |
| 48       | 8                          | 5                        | 4               | -4                  | 0                      | 8 4 2 -2 -4            | 47                      | S S                    |
| 49       | 15                         | 12                       | 12              | -15                 | 0                      | 12 10 10 0 -12 -15    | 49                      | S S                    |
| 50       | 10                         | 8                       | -8              | -10                 | 0                      | 8 5 -5 -8 -12          | 52  *                   | S S                    |
| 51       | 5                          | 4                       | -4              | -5                  | 0                      | 4 2 -2 -4 -8           | 24  ***                 | S S                    |

Significant deviations from 45 according to a one-tailed binomial test at the 10, 5, and 1 % are designated with *, **, and ***, respectively.
can be obtained (the MWSD-subcondition): in the former set of choices a preference for the riskier prospect is predicted, while for the latter set of choices a preference for the safer prospect is implied. For the mixed tasks PWD and MWSD make no predictions.

4.3 PT predictions

To make predictions based on PT we use the specification of a power utility \( u(x) = x^\alpha \) for \( x \geq 0 \) and \( u(x) = -\lambda(-x)^\beta \) and assume the one-parameter probability weighting functions \( w(p) = p^\gamma /[(p^\gamma + (1-p)^\gamma)]^{1/\gamma} \) as in Tversky and Kahneman (1992). We took the estimates for these parameters by Abdellaoui (2000) for \( \alpha = 0.89, \beta = 0.92 \), and the parameters for the weighting function for probabilities of gains \( \gamma^+ = 0.60 \) and for probabilities of losses \( \gamma^- = 0.7 \). For the loss aversion parameter we took the median estimate from Abdellaoui et al. (2007) \( \lambda = 1.69 \), based on the implicit measure used in Tversky and Kahneman (1992), and \( \lambda = 1.48 \), based on the measure of Wakker and Tversky (1993). The reason for these choices are that both Abdellaoui (2000) and Abdellaoui et al. (2007) use similar non-parametric elicitation procedures while obtaining similar parameter estimates for utility and probability weighting functions for gains and losses as in earlier studies. Further, Abdellaoui et al. (2007) provided a comprehensive analysis of various measures for the LA parameter \( \lambda \) (see also Abdellaoui et al. 2008). The last column in Tables 1 and 2, and the last two columns in Table 3 above indicate by the letters “S” or “R” whether, based on this selection of parameters, PT predicts a choice for the safer or for the riskier prospect.

5 Results

5.1 Consistency

5.1.1 Consistency of choices

After completion of the 95 tasks, ten tasks selected at random were repeated. A total of 900 tasks were repeated and of these 625 (69.44 %) matched the initial choices. This is similar to the consistency percentages reported in Camerer (1989), Wakker et al. (1994), Weber and Kirsner (1997), Loomes et al. (2002), and Brooks and Zank (2005). Under the binomial test at the 10 % level, 35 of the 90 participants made six or fewer consistent choices. Looking at the separate conditions we observed that, in the gain condition 197 choices were repeated and 144 (73.10 %) were consistent; 146 (65.77 %) of the 222 repeated choices were consistent in the loss condition; and 335 (69.65 %) of the 481 repeated choices in the mixed condition were consistent.

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12 We have also used the parameters estimates of Abdellaoui (2000) for the two-parameter probability weighting function of Goldstein and Einhorn (1987). These give similar predictions.
Male subjects were more consistent (70.48 %) than female subjects (67.14 %) overall. Similar consistency rates for males and females were observed in the gain condition (73.10 vs. 73.08 %); male subjects were more consistent in the mixed condition (72.34 vs. 63.82 %); and female subjects were more consistent in the loss condition (69.74 vs. 63.70 %).

### 5.1.2 Consistency of PT parameter estimates

Recall that the preference axioms needed to derive PT do not, on their own, impose restrictions on the curvature of utility and of the curvature of the weighting functions (for preference foundations of PT under risk, see Chateauneuf and Wakker (1999), Köbberling and Wakker (2003), Kothiyal et al. (2011), and Werner and Zank (2012)). Such restrictions follow from empirical studies (e.g., Tversky and Kahneman 1992; Abdellaoui 2000) using aggregate data. We have pooled together the data from the loss tasks and the gain tasks and obtained parameter estimates for utility and weighting functions as they were specified in Tversky and Kahneman (1992). Table 4 provides the output of a probit regression using a single agent stochastic choice model over gain and loss tasks, which finds the combination of parameters that best explains the variation in the data (see also Wu and Markle (2008) for a similar model).

The parameter estimates found in the gain and loss domains are comparable to those in previous studies with similar parameter estimates for utility as in Tversky and Kahneman (1992) but larger parameters for the weighting functions.\(^\text{13}\) The parameters estimated in Table 4 suggest that both probability weighting and utility curvature can significantly influence the aggregate choice behavior among multiple outcome prospects.

### 5.2 Choice behavior in the gain condition

This subsection presents results for the gain condition, initially at the aggregate level and then at the individual level.

\(^\text{13}\) Adding the data for the mixed condition and a parameter, \(\lambda\), for LA gives similar estimates. \(\lambda = 0.93\) (SE = 0.059), is found insignificantly different from one.
5.2.1 Aggregate data for gain prospects

First we test whether the observed choices in Table 1 are random (the null hypothesis, \( H_0 : \mu = 45 \)) or not. The alternative hypothesis is that the safer prospect is chosen in line with the prediction of SSD and PSD (i.e., \( H_A : \mu > 45 \)). The second to last column in Table 1 reports significance values for this one-tailed test at 10, 5, and 1 % indicated by *, **, and ***, respectively. For the majority of choices (68 %) the alternative hypothesis is accepted at the 5 % level. This provides evidence against MSD.

There is variation in the number of safer prospects chosen across tasks. The penultimate column in Table 1 reports significant deviations from the overall mean number of safer choices across all tasks according to a two-tailed binomial test (i.e., \( H_0 : \mu - 54.5 = 0 \) vs. \( H_A : \mu - 54.5 \neq 0 \)). In nine tasks we observe significant deviations from the overall mean number of safer choices at the 5 % level. PSD cannot explain this variation. From Table 1 we observe that in all tasks of the PWSD-subcondition a significant majority of subjects chose the safer prospect. In one task (i.e., 63) of the MWSD-subcondition we observe that a significant majority of subjects chose the riskier prospect and that in six tasks a significant majority preferred the safer prospect. There is no support for MWSD in the gain condition. From Table 1 we observe that, except for six tasks (52, 53, 58, 62, 72, and 73), the majority of subjects made choices that agree with the predictions of our PT specification.

**The WR-subcondition:** We observe from Table 1 that in the WR tasks the number of safer choices increase with the largest outcome in the riskier prospect. PSD cannot explain this pattern as it requires consistency in the number of S choices in the WR tasks. PT can accommodate this pattern. The decision weight of the best gain is constant across these tasks. Yet the risk attitude effect captured by a concave utility can explain the variation in the number of safer choices if concavity is less pronounced for small gains compared to larger ones. Support for this finding is obtained from running a simple linear regression of the number of riskier choices on the value of the highest gain in the corresponding task. The null hypothesis \( H_0 : \beta = 0 \) (i.e., the largest gain in a task has no influence on the number of risky choices) is rejected at the 5 % level in favour of the alternative \( H_A : \beta > 0 \) (i.e., the largest gain in a task has a positive effect on the number of risky choices).14

**The SYM-subcondition:** In Tasks 56 and 57 a significant majority of the choices are for the safer prospect. Pessimism seems to generate larger decision weights for the lower ranked gain than optimism does for the symmetrically higher ranked gain. This, together with diminishing sensitivity for gains (concave utility), implies a preference for the safer prospect under PWSD and PT. Relative to pessimism, the effect of optimism appears to be stronger in task 55, where we observe a statistically insignificant majority choosing the safer prospect. This choice behavior is compatible with PWSD and PT.

**The STR-subcondition:** In Tasks 60 and 61 and 64 and 65 a significant majority of subjects chose the safer prospect. This can be explained by PT if the effect of pessimism

14 The estimated value for the slope of the regression line, \( \hat{\beta} = 1.3 \), has a standard error of 0.1732. This results in a test statistic value of 7.506 while the upper 5 % critical value of the \( t_1 \) distribution is 6.314. The intercept for this regression line takes the value of 37 with a standard error of 1.8707.
is combined with diminishing sensitivity for gains. The effect of optimism may imply a choice for the riskier prospect in Tasks 58 and 59 and in 62 and 63. This, however, depends on the degree of diminishing sensitivity for gains. For MPSs that involve smaller outcomes the effect of optimism is stronger than that of diminishing sensitivity in gains, however, for MPSs that involve larger gains diminishing sensitivity may the dominating effect. This is what we observe. In Tasks 59 and 63 a significant majority of subject choose the riskier prospect while in Tasks 58 and 62 a significant majority chooses the safer prospect. Taking Tasks 60, 61, 64, and 65 as base line group $G_0$, Tasks 58 and 62 as group $G_1$ and Tasks 59 and 63 as group $G_2$, we test if the proportion of S-choices (denoted $p_{G_0}$, $p_{G_1}$, and $p_{G_2}$) in the different groups are different:

$$H_0 : p_{G_1} - p_{G_0} = 0 \text{ vs. } H_A : p_{G_1} < p_{G_0}$$

$$H_0 : p_{G_2} - p_{G_0} = 0 \text{ vs. } H_A : p_{G_2} < p_{G_0}$$

$$H_0 : p_{G_2} - p_{G_1} = 0 \text{ vs. } H_A : p_{G_2} < p_{G_1}.$$ 

The corresponding values for the proportions test statistic are $-2.05$, $-6.85$, and $-4.12$ (to two decimal places). As the 5% and 1% critical values for this test are $-1.65$ and $-2.33$, the latter two statistics are significant at the 1% level, and the former at the 5% level, so that we can accept the alternative hypotheses. This choice behavior is compatible with both PWSD and PT.

The **GER-subcondition**: The effects in the STR-condition are confirmed except for task 72 and 73 where the effect of optimism seems weaker than that of diminishing sensitivity for gains.

### 5.2.2 Data for gain prospects at the level of individuals

Next we are testing if the findings in the previous subsection are replicated at the individual level. For this we classify individuals as PSD (MSD) if across all gain tasks they chose the safer (riskier) prospect significantly more often than the riskier (safer) prospect according to a binomial test at the 5% level. Similarly, we classify individuals as PWSD (MWSD) if across PWSD-gain tasks (MWSD-gain tasks) they chose the safer (riskier) prospect significantly more often than the riskier (safer) prospect according to a binomial test at the 5% level.

Table 5 confirms that the majority of individuals are unclassified, that a large number of individuals choose significantly more often a safer prospect, and that very few individuals choose significantly more often the riskier prospect. We can reject MSD or MWSD behavior for the large majority of individuals.

| Tasks gain/choices | Majority safe | Majority risky | Unclassified |
|--------------------|---------------|----------------|--------------|
| All tasks          | 32            | 6              | 52           |
| PWSD tasks         | 31            | 1              | 58           |
| MWSD tasks         | 26            | 6              | 58           |
5.3 Choice behavior in the loss condition

Similarly to the results for gain prospects, this subsection presents results first at the aggregate level followed by findings at the individual level.

5.3.1 Aggregate data for loss prospects

We test whether the observed choices in Table 2 are random (the null hypothesis, $H_0 : \mu = 45$) or not. The alternative hypothesis is that the riskier prospect is chosen in line with the prediction of PSD (i.e., $H_A : \mu < 45$). The third to last column in Table 2 reports significance values for this test at 10, 5, and 1 % indicated by *, **, and ***, respectively. For the majority of choices (59 %) the alternative hypothesis is accepted at the 5 % level. This provides evidence against MSD.

We observe some variation in the number of riskier prospects chosen across loss tasks. The penultimate column in Table 2 reports significant deviations from the overall mean number of safe choices across all tasks according to a two-tailed binomial test (i.e., $H_0 : \mu - 32.72 = 0$ vs. $H_A : \mu - 32.72 \neq 0$). In eight tasks we observe significant deviations from the overall mean number of safer choices at the 5 % level. PSD cannot explain this variation. From Table 2 we observe that in all the PWSD-loss tasks (78 and 79, 82 and 83, 86 and 87, and 92 and 93) a majority of subjects chose the riskier prospect with significant majorities in six tasks, in agreement with PWSD. In the MWSD-loss tasks (78 and 79, 80 and 81, 84 and 85, and 94 and 95) we observe that in two tasks a majority (in one case significant) of subjects chose the safer prospect while in three tasks a significant majority prefers the riskier prospect. We conclude that there is little support for MWSD in the loss condition. Except for eight tasks, the majority of subjects chose in agreement with the PT predictions based on the specification used (last column of Table 2).

The WR-subcondition: The number of choices for the safer prospect is low and stable. This is in line with PSD, PWSD, and PT with a convex utility. The effect of optimism captured in the relatively large decision weight of the zero loss in the riskier prospect when combined by the effect of diminishing sensitivity in outcomes (convex utility for losses) can explain this behavior.

The SYM-subcondition: In all tasks the majority of choices is for the riskier prospect. This is significant at the 10 %-level in Task 77 and at the 1 % level in Task 79. The difference between Tasks 78 and 79 cannot be explained by probability weighting alone. If subjects exhibit sufficient diminishing sensitivity for losses, this choice behavior can be explained by PT. This choice behavior is compatible with PWSD but not with PSD.

The STR-subcondition: A significant majority of subjects chose the riskier prospect in Tasks 82 and 83 and 86 and 87. This can be explained by the combined effect of optimism with diminishing sensitivity in losses. In Tasks 80 and 81 and 84 and 85 we observe fewer choices for the riskier prospect. In Task 81 the majority of subjects chose the safer prospect and similarly in Task 85, where this majority is significant at the 1 % level. Overall, this choice behavior is in line with PWSD and PT predictions. Taking Tasks 82, 83, 86, and 87 as base line group $L_0$, Tasks 80 and 84 as group $L_1$ and Tasks 81 and 85 as group $S2$, we test if the proportion of S choices (denoted $p_{L_0}$, $p_{L_1}$, and $p_{L_2}$) in the different groups are different:
Risk behavior for gain, loss, and mixed prospects

\[ H_0 : p_{L_1} - p_{L_0} = 0 \quad \text{vs.} \quad H_A : p_{L_1} > p_{L_0} \]
\[ H_0 : p_{L_2} - p_{L_0} = 0 \quad \text{vs.} \quad H_A : p_{L_2} > p_{L_0} \]
\[ H_0 : p_{L_2} - p_{L_1} = 0 \quad \text{vs.} \quad H_A : p_{L_2} > p_{L_1}. \]

The corresponding values for the proportions test statistic are 2.51, 5.53, and 2.70 (to two decimal places). With the critical value for this proportions test being 2.33 at the 1% level, we can accept the alternative hypotheses in all cases. Thus, in contrast to PSD, probability weighting has a significant effect on choice behavior in accordance with PWSD and PT.

The GER-subcondition: The effects of the STR-subcondition are confirmed except for Tasks 93–95. In Task 93 optimism does not seem to dominate to a sufficient degree, while in Tasks 94 and 95 optimism together with diminishing sensitivity in losses appear to dominate the effect of pessimism. This suggests that probability weighting for losses may be less pronounced at the aggregate level than it is for gains.

5.3.2 Data for loss prospects at the level of individuals

Next we report the results from the loss tasks at the level of individuals. In analogy to the gain tasks, we classify individuals as PSD (MSD) if across all loss tasks they choose the riskier (safer) prospect significantly more often than the safer (riskier) prospect according to a binomial test at the 5% level. Similarly, we classify individuals as PWSD (MWSD) if across PWSD-gain tasks (MWSD-gain tasks) they choose the riskier (safer) prospect significantly more often than the safer (riskier) prospect according to a binomial test at the 5% level. Table 6 presents the results.

Table 6 confirms that the majority of individuals are unclassified, and that the number of individuals who chose significantly more often a riskier prospect is much higher than the number of individuals choosing significantly more often the safer prospect. We can reject MSD and MWSD behavior for the large majority of individuals.

5.4 Reflection of choice behavior

5.4.1 Aggregate data

Looking at Tables 1 and 2 it is apparent that the number of safe choices in a gain tasks is mirrored into a similar number of risky choices in the reflected loss task. To obtain statistical evidence for this observation we performed a difference of proportions test. Denoting \( p_G \) the proportion of safer choices in a gain task and by \( p_L \) the proportion of safer choices in a mirrored loss task, we conducted the following test:

| Tasks loss/choices | Majority risky | Majority safe | Unclassified |
|--------------------|----------------|---------------|--------------|
| All tasks          | 27             | 6             | 57           |
| PWSD tasks         | 22             | 6             | 62           |
| MWSD tasks         | 17             | 9             | 64           |
Table 7  PSD behavior for gain and loss tasks

| Tasks gain/loss | Majority safer (6) | Majority riskier (27) | Unclassified (57) |
|----------------|--------------------|------------------------|-------------------|
| Majority safer (32) | 2                  | 10                     | 20                |
| Majority riskier (6)  | 0                  | 5                      | 1                 |
| Unclassified (52)    | 4                  | 12                     | 36                |

Table 8  PWSD behavior for gain and loss tasks

| PWSD tasks gain/loss | Majority safer (6) | Majority riskier (22) | Unclassified (62) |
|----------------------|--------------------|------------------------|-------------------|
| Majority safer (31)  | 4                  | 10                     | 17                |
| Majority riskier (1)  | 0                  | 1                      | 0                 |
| Unclassified (58)    | 2                  | 11                     | 45                |

\[ H_0 : p_G - (1 - p_L) = 0 \text{ vs. } H_A : p_G - (1 - p_L) \neq 0. \]

Applying this test only results in two significant differences (53 and 75 and 54 and 76). This gives statistical support for the finding that behavior for gain prospects is reflected into the opposite behavior for loss prospects.

5.4.2 Individual data

Similar to Tables 5 and 6 above we classify individuals according to PSD, MSD, and PWSD behavior\(^\text{15}\) if in both the gain and loss conditions behavior is in agreement with the corresponding prediction. We report the results in Tables 7 and 8 for PSD and PWSD, respectively.

These results show that the majority of subjects remain unclassified when both gain and loss tasks are combined. Of the remaining subjects many cannot be classified in at least one of the corresponding gain or loss conditions. This suggests that reflection of behavior observed at the aggregate level is a result of pooling the data rather than being widespread behavior of individuals.

5.5 Choice behavior in the mixed condition

In this subsection we focus on the mixed condition and report results at the aggregate and individual level.

5.5.1 Aggregate data for mixed prospects

First, we tested whether the observed choices in Table 3 are random (the null hypothesis, \(H_0 : \mu = 45\)) or not. The alternative hypothesis is that the safer prospect is

\(^{15}\text{Because very few subjects were MWSD for gains and for losses we skip the corresponding table.}\)
chosen in line with the prediction of LA (i.e., $H_A : \mu > 45$). The fourth to last column in Table 3 reports statistical significance for this test at 10, 5, and 1% indicated by *, **, and ***, respectively. For six tasks (11.76%) the alternative hypothesis is accepted at the 5% level. Similarly, the statistical test $H_0 : \mu = 45$ versus $H_0 : \mu < 45$ returns seven tasks where the alternative hypothesis is accepted at the 5% level.

We observe some variation in the number of safer prospects chosen across the mixed tasks. The third to last column in Table 3 reports significant deviations from the overall mean number of safe choices across all tasks according to a two-tailed binomial test (i.e., $H_0 : \mu - 45.02 = 0$ vs. $H_A : \mu - 45.02 \neq 0$). We observe significant deviations from the overall mean number of safer choices at the 5% level in just ten tasks. The aggregate data does not support for either LA or GS behavior.

In 28 out of 51 tasks we observe a majority of choices in agreement with the predictions of PT with a LA coefficient $L = 1.69$. The same holds if $L = 1.48$ is assumed. If effects resulting from probability weighting dominate the effect of the loss aversion index this should show in the STR tasks. We observe that in Tasks 28–30 and 34–36, where the decision weight of the largest gain significantly dominates that of the smallest loss under PT, there are fewer loss averse choices than in Tasks 31 and 32 (but not 33) and 37–39, where the decision weight of the smallest gain dominates that of the largest loss under PT. The choices in Tasks 33 and 39 are markedly opposite. This suggests that probability weighting may have some effect on choice behavior but less so on the LA coefficient. However, as the Tasks 31–33 (37–39) correspond to the Tasks 28–30 (34–36) when prospects are reflected through multiplication of their outcomes by $-1$, reflection of behavior may be a potential explanation for the observed choice behavior. We therefore test whether tasks being reflected has an effect. This is performed by separation of the tasks into two groups, labelled $M_1$ and $M_2$, respectively, and by comparing the proportion ($p_{M_2}$) of safer choices in each group $M_2$, against the alternative that the proportion ($p_1$) is lower in the first corresponding group $M_1$. The hypothesis is

$$H_0 : p_{M_2} - p_{M_1} = 0 \text{ vs. } H_A : p_{M_2} - p_{M_1} > 0$$

and the sub-groups are given in Table 9 together with the test statistic (where *, **, and *** refer to significance levels of 10, 5, and 1%: the respective critical values being 1.282, 1.645, and 2.326):

16 We observe that this test is equivalent to verifying if common outcomes being gains or being losses matters for choice behavior.
If one regards the choices in Task 33 as an outlier that should not be included, the corresponding test (Tasks 28 and 29 vs. Tasks 31 and 32) gives a statistic of 1.66**. This, together with the results in Table 9, suggests that reflection of choice behavior, i.e., reflecting common losses into common gains, increases the number of riskier choices. Such behavior is not compatible with PT, which demands that such rank-preserving common outcomes should not affect choice behavior. Only the LA parameter and the decision weights of the symmetric gains and losses should affect choice behavior. Here, however, it seems that the overall probability of losing matters for choice behavior.

5.5.2 Data for mixed prospects at the level of individuals

In the preceding subsection the aggregate data suggests no evidence for our LA condition. It could be that the reflection of behavior eliminates the effect of LA at the aggregate level. We, therefore, classify individuals as LA or GS if their choices over all mixed tasks deviates significantly from 50 % in the corresponding direction according to a one-tailed binomial test at the 5 %-level to find out if reflection of behavior neutralizes LA for all subjects. We find that 30 individuals (33 %) are LA, 27 (30 %) are GS, and 33 individuals (37 %) are unclassified. This suggests that the similar proportions of LA and GS individuals is the actual cause for the low level of LA choice behavior at the aggregate level.

6 Discussion

The results presented in the previous section confirm that PT with the specification of Tversky and Kahneman (Abdellaoui 2000; Tversky and Kahneman 1992) provides comparable parameter estimates to previous studies for utility, with somewhat higher parameter estimates for the probability weighting functions. This suggests that probability weighting is less pronounced for multiple outcome prospects. Yet, for gain and loss prospects, probability weighting still plays a significant role for choice behavior in the tasks of this experiment. Hence, we find that PSD is not a good predictor for choices among multiple outcome prospects, whereas PWSD and PT are compatible and predict the choice behavior that we observe. Based on the evidence in the gain and loss conditions, we can reject the MWSD and MSD principles on descriptive grounds.

Our findings are in contrast to recent results of Harbaugh et al. (2009). They find that the fourfold pattern of risk attitude of PT is confirmed in valuation tasks, while in binary choice tasks it is not supported. Their binary choice tasks involve choices between a binary prospects and its expected value. For such choices the expected value may act as a reference point such that choice behavior among prospects may be influenced by it. In our WR tasks we used similar choices and find that choices in the gain and loss tasks are compatible with the fourfold pattern of risk attitude under PT, as are the choices among the non-binary prospects.

While a concave/linear utility for gains and a linear/convex utility for losses seems to be the pattern at the aggregate level, a somewhat surprising finding is that we do
not find strong evidence for LA both captured as parameter or revealed through our LA-principle. There is an equal split of subjects into loss averse, GS and unclassified. In an earlier experiment by Brooks and Zank (2005) twice as many subjects were loss averse as compared to GS. A difference to Brooks and Zank is that here the likelihood associated with a reduction in losses through an MPS is smaller (0.2 compared to 0.25 and 0.33). The lower likelihood may have made increases in losses less prominent and thereby inducing more neutral or GS behavior.\textsuperscript{17}

The reflection of behavior from gain tasks into that for loss tasks, as predicted by PWSD and PT, is supported by our aggregate data but seems a less prominent feature of behavior at the individual level. Further, we find that reflection of behavior also plays a role for mixed prospects. This finding violates PT. Such behavior cannot be observed with mixed binary prospects, where there are no common outcomes and the LA parameter dominates choice behavior. For mixed multiple outcome prospects as used here it seems that the number and sign of common outcomes matter. Both reduce the prominence of the symmetric gains and losses that are traded off within a task. Additionally, the overall likelihood of winning can influence choice behavior. These findings are compatible with those of Payne (2005) and Brooks and Zank (2005) and suggest that PT may not perform well in the domain of (non-binary) multiple mixed outcome prospects.

\textbf{7 Conclusion}

In this paper we took a different approach to testing SSD principles. Instead of selecting a single or just a few choice problems to obtain evidence in favor or against SSD, P/MSD, or P/MWSD and LA/GS, we designed several tasks that took account of key aspects of PT. We were able to provide a detailed analysis of behavior at the level of individuals in addition to the aggregate data analysis. We observe that few subjects reveal behavior in agreement with M(W)SD and that some individuals choose in agreement with PSD. Most notably, PT can accommodate a larger number of individual behavior than any of the SSD variants, a finding that is also supported by the estimated PT parameters. This conclusion, however, follows from observed choice behavior for gain prospects combined with the separate choice behavior for loss prospects. For

\textsuperscript{17} Another explanation could be that the high number tasks involving mixed prospects and loss prospects may have generated pessimism about gaining any amount of money out of this experiment. This would explain why most subjects were not willing to pay a large proportion of their earnings from the experiment to participate again in the same study (a finding which can be interpreted as a form of loss aversion). 82 subjects provided us with such information: on average, those who lost from their fixed payment (31 subjects earned £6.64 on average) were willing to pay 44.66\% of their earnings; those who gained (27 subjects earned £24.22 on average) were willing to pay 23.85\% of their earnings, and those who neither gained nor lost (24 subjects received £17) were willing to pay 24.5\% of their earnings to repeat the experiment. Recall that the expected pay from the experiment was £17, while the minimum one can ensure is £2. Thus, it may well be, that the frequent reoccurrence of tasks with potential losses has induced many subjects to exhibit more risk neutral behavior in the SSD-sense. However, this result is obtained using a valuation task (i.e., assessing the value of an experiment where losing is likely) which may trigger additional LA.
mixed prospects, we find evidence against PT, and the loss averse individuals were matched by a similar number of gain seeking individuals.

PT has emerged as a reasonable compromise between empirical validity and mathematical tractability, and this accounts for much of the popularity of the model (Starmer 2000; Wakker 2010). We have, once more, confirmed PT’s superiority over gain prospects and over loss prospects and shown that this superiority extends to the domain of common sign multiple outcome prospects. Our study reinforces a distinction of behavior over gain and loss prospects, and in particular behavior over mixed prospects. As most real decisions that we face involve gains and losses within one alternative, the critical test for PT concerns PT’s predictive power for choices among mixed prospects. In this domain we have identified shortcomings of the theory, for the range of real stakes that we used and possibly because of the more complex non binary prospects used in this study. Additional studies seem warranted to evaluate PT’s predictive power for complex multi-outcome prospects and for drawing comparisons with PT estimates using choice over binary prospects.

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Appendix 1:“Experiments on Individual Choice” instructions

(This experiment has been approved by the Senate Committee on the Ethics of Research on Human Beings of the University of Manchester)

Welcome to this session. The aim of this experiment is to investigate how people make decisions. We will ask you to make several decisions, and will record your choice. The records will be used for scientific purposes only. Our published results will not identify any individuals. Our general interest is to observe and analyse how people make decisions. We expect that 100 or more people will participate in this experiment.

This experiment is not a test. There is no way for us to tell whether your decisions are good or bad. That is for you to judge. People are different, and faced with the same situation they will prefer to take different courses of action. What you need to consider is the fact that the amount of money that you receive by participating in this experiment depends partly on your decisions, and partly on luck.

We will ask you to perform 105 tasks. Each task consists of choosing one of two gambles. An example of a task is described below:

Choose the gamble that you would like to play:

☐ left
☐ right

Submit
After deciding which gamble to play by marking “left” or “right” and pressing the “Submit” button the next task appears.

Now we explain what a gamble is and how it is played. A complete gamble is visualised on the screen as 15 balls numbered consecutively from 1 to 15 with amounts of money underneath balls of the same colour. An example is the following gamble:

This is how a gamble is played: A bag contains all 15 balls. One ball is drawn at random. Each ball in the bag is equally likely to be drawn. The outcome of a gamble is the sum of money indicated underneath the drawn ball.

In the example above, the red balls indicate that £15.00 will be gained for a ball with the number 1, 2, 3, 4, 5 or 6 on it. The green balls indicate that £3.00 will be lost for a ball with the number 7, 8, or 9 on it. The blue balls indicate that £5.00 will be lost for a ball with the number 10, 11, or 12 on it. Finally, the orange balls indicate that £3.00 will be gained for a ball with the number 13, 14, or 15 on it.

In this experiment there will be several types of gambles. Three examples of gambles are explained below.

**Gamble type 1** A bag contains 15 balls numbered from 1 to 15. One ball is drawn at random. Each ball in the bag is equally likely to be drawn. If the ball is numbered 1, 2, 3, 4, 5, or 6 the outcome is the amount of money indicated underneath those balls (therefore, there is a 40 % chance of getting that amount). If the ball is numbered 7, 8, 9, 10, 11, or 12, the outcome is the amount of money indicated underneath those balls (therefore, there is a 40 % chance of getting that amount). If the ball is numbered 13, 14, or 15, the outcome is the amount of money indicated underneath those balls (therefore, there is a 20 % chance of getting that amount). We represent this gamble with balls in the respective colours, as follows:

**Gamble type 2** A bag contains 15 balls numbered from 1 to 15. One ball is drawn at random. Each ball in the bag is equally likely to be drawn. If the ball is numbered 1, 2, or 3, the outcome is the amount of money indicated underneath those balls (therefore, there is a 20 % chance of getting that amount). If the ball is numbered 4, 5, or 6, the outcome is the amount of money indicated underneath those balls (therefore, there is a 20 % chance of getting that amount). If the ball is numbered 7, 8, or 9, the outcome is the amount of money indicated underneath those balls (therefore, there is a 20 % chance of getting that amount). If the ball is numbered 10, 11, or 12, the outcome is the amount of money indicated underneath those balls (therefore, there is a 20 % chance of getting that amount). If the ball is numbered 13, 14, or 15, the outcome is the amount of money indicated underneath those balls (therefore, there is a 20 % chance of getting that amount). We represent this gamble with balls in the respective colours, as follows:
Gamble type 3  A bag contains 15 balls numbered from 1 to 15. One ball is drawn at random. Each ball in the bag is equally likely to be drawn. If the ball is numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or 15 the outcome is the amount of money indicated underneath those balls (therefore, there is a 100 % chance of getting that amount). We represent this gamble with balls in the respective colour, as follows:

Most gambles involve negative and positive amounts of money. In such a gamble one may lose some amount of money from the fixed payment (£17.00) that you receive if you complete all tasks. For example the gamble below indicates that you can either lose £15.00 with 20 % chance, or gain £2.00 with 20 % chance, or gain £10.00 with 40 % chance, or gain 15 with a 20 % chance.

If you complete all tasks, then you receive a participation fee of £17.00 plus an additional amount of money determined by your decision in one randomly selected task. The computer will select this gamble after all tasks have been completed, and we will play that gamble for real. The additional amount of money ranges from £ − 15.00 to £15.00. Therefore the final sum of money that you receive will be a positive amount in the range of £2.00 and £32.00; it will never be negative.

There is enough time allocated for completing all tasks. You may withdraw from the experiment at any time. If you withdraw from the experiment, we will not be able to compensate you for your effort.

Take your time to make sure that you have understood everything. The window with these instructions will be accessible at all times. You may also ask the experimenters for help. Please do not use the “Back” button of your internet browser unless you are asked on the computer screen. Also, please do not distract (or talk to) other people taking part in the experiment. If you completed all tasks please remain seated and indicate to the experimenter that you have finished.

When you are ready to start with the tasks, press the “Proceed with the Experiment” link below, and then follow the instructions set by the computer.

Proceed with the experiment.
Appendix 2: “Experiments on Individual Choice” payment form

Experiments on Individual Choice

| Project: | British Academy Small Research Grant SG-36804 |
|----------|-----------------------------------------------|
| Choice under Risk: An Experimental Investigation |

| Name/Surname: |
|---------------|

| Student Registration No. |
|--------------------------|

| Address where Cheque should be sent: |
|--------------------------------------|

| Date: | 19 March 2004 |
|-------|--------------|

| Scope: | Prize for Participation in Experiment |
|--------|---------------------------------------|

| Winning Ball: | No. |
|---------------|-----|

| Payment: |
|----------|

| Please indicate if you would like to participate again in similar experiments |
|-----------------------------------------------------------------------------|

| £ | Yes / No |
|---|---------|

| Please indicate how much of your payment you are willing to give up in order to participate again in this experiment |
|------------------------------------------------------------------------------------------------------------------|

| £ |

| Your Signature: |
|------------------|

| Verified / Signed: | H. Zank: |
|--------------------|---------|

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