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DISAPPOINTMENT AVERSION IN INTERNET BIDDING-DECISIONS

ABSTRACT. The article presents an Internet experiment where subjects sequentially bid for basic gifts and binary-lotteries on these gifts in incentive compatible Vickrey auctions. Subjects exhibit uniformly pessimistic prize-weighting in spite of precautions to reduce suspicion and prohibit collusion. The bids for lotteries are close to the minimal payable value, even when the probability of obtaining a better prize is larger than 50%. Prize-weighting becomes even more conservative as the distance in value of payable prizes increases. The twofold aversive affect appears for three distinct groups of students; we demonstrate, however, that the same subjects overweight small win-probabilities in standard binary-choice.

KEY WORDS: bidding-decisions; disappointment aversion; Internet experiments; Vickrey auctions

JEL CLASSIFICATION: D8; C9

1. INTRODUCTION

The huge volume of trade in Web auctions has triggered diverse economic research into the factors that shape bidders and sellers behavior in such auctions. The current article studies the effect of uncertainty regarding the private-value that an auction may pay on individual bidding in incentive compatible auctions. We run an Internet Vickrey auctions experiment where subjects are asked to sequentially bid for several basic gift certificates and short sequences of binary lotteries over these gifts. The bids for the lotteries and underlying gifts

Electronic Supplementary Material The online version of this article (doi: 10.1007/s11238-007-9055-1) contains supplementary material, which is available to authorized users are contrasted to characterize the risk-weighting patterns of bidders in incentive-compatible Web-based auctions.

In the next few paragraphs we briefly describe the experiment, the main results, and discuss some methodological aspects. The Internet field-motivation is re-examined in more detail toward the end of the introduction.

The auctions run within the experiment were presented to the subjects in four distinct phases where each phase appeared on a separate Web page. Subjects were asked to bid for three basic gift certificates ranging in values from a luxurious weekend vacation to a fine-chocolate box at the first phase of the experiment. In each of the next three phases, subjects have bid sequentially for five binary lotteries over two of the three basic gifts. Lotteries that pay a better (in terms of market-value) prize X with probability p and a worse prize Y with complementary probability $1 - p$ were presented to the subjects in all three treatments, where each treatment involved a different pair of basic X/Y gifts. The gifts and lotteries were sold to the subjects in six-bidders second-price (Vickrey) auctions. Subjects were told that one of the auctions would be randomly selected to determine their actual payoff.

The results of the experiment demonstrate that value-uncertainty has a disproportional aversive effect on bids and prices in incentive compatible auctions. Participants in our auctions revealed consistent pessimism in the sense of submitting bids that are close to the lowest-possible prize that lotteries might pay, even when the probability of receiving the better prize was larger than 50%. Moreover, the level of pessimism increased as the distance between the lowest- and highest-prizes paid by the lottery got larger. Risk-weighting in cases where the difference in value of payable prizes was largest was significantly more conservative than weighting in treatments where the difference in value of prizes was lower. In this sense, the aversive effect of uncertainty on auction-bids is twofold. Firstly, the possibility that the auction would end-up with a lower prize triggers conservative prize-weighting and low bidding. Secondly, increase in variability of payoffs brings up an additional aversive affect in the sense that the bids for the lotteries get even closer to the lowest-possible prize.

The experiment was run on 107 students from three distinct groups: MBAs, business/law undergraduates and engineering/sciences students. The results appeared for each of the three groups, in two different academic institutes and in two distinct versions of the experiment. The pessimistic weighting schemes observed in the experiment are compatible with Gul's (1991) theory of disappointment aversion. Disappointment-averse decision makers overweight prizes that are lower than the Certainty Equivalent (CE) of a lottery while underweighting prizes that are higher than the CE. Disappointment aversion thus implies uniformly pessimistic weighting of the type revealed in the experiment. We briefly argue, however, that such pessimistic weighting is idiosyncratic to the auction-application and demonstrate that the same subjects may exhibit overweighting of small win-probabilities in standard binary-choice.

The Vickrey second-price auction method was selected for the experiment because of its simplicity and its (essential) strategic-equivalence to common auction-formats on the Web. Leading auction sites on the Internet like Ebay, Yahoo and Amazon, employ some variant of "English auction with proxy bidding." In such auctions, each bidder submits a secret (proxy) bid that represents one's maximal willingness to pay for the item. Upon the arrival of new proxy-bids, the auction program advances the winning-price up to the level, where only one winner remains active. It is well-known that when bidders hold private valuations that cannot be affected by the information revealed along the auction, the English auction with proxy bidding is strategically equivalent to the classic Vickrey (1961) second-price auction. In both cases, bidders should truthfully reveal their maximal willingness to pay for the item. We employ the simpler, static Vickrey auction format in the current experiment anticipating that the results would provide insights to the effect of value-uncertainty on proxy-bidding decisions in Web English auctions.[1]

In designing the experiment, we have attempted to foresee potential problems that may arise with the basic design:

(a) Subjects' suspicion. The auctioning of lotteries on the Internet might invoke subjects' suspicion or mistrust. Foreseeing this problem, we attempted to reduce hidden risk-factors. The invitations to participate in the experiment were distributed to students in person and emphasized that the fairness of the experimental procedure is guaranteed by the organizers. Subjects (or their representatives) were invited in advance to take active part in the lottery-drawing process. The instructions described the prize-drawing method in detail (see supplement) and underlined subjects' role in the process. The instructions also clarified that a list of prizes together with ids and affiliation of the winners would be distributed by e-mail among all participants at the end of the experiment.

(b) Collusion. The loss of control that characterizes Web-experimentation (see Birnbaum, 2000) raises the concern of collusive bidding. To minimize the risk of collusion, we have run the auctions on small 6 players' groups. The instructions explained that the experiment would be run in several academic institutes on more than 120 subjects that will be randomly matched into groups of six, so that "chances that you will play the auctions with a colleague or a friend are slim." We have in addition run 18 different versions of the auctions where each version employed a slightly different bundle of basic gift certificates (e.g., using different resorts for the weekend vacation). The differences among auctions were also meant to hinder collusive bidding attempts.

(c) Casual Participation (noise). A traditional concern with laboratory experimentation is the risk of self-confirming "experimenter bias." Subjects that are nicely paid for their participation may (consciously or subconsciously) act to please the experimenter and confirm suspected hypotheses when taking part in the experiment.[2] An anonymous Internet experiment with valuable prizes, on the other hand, runs the contrary risk of hasty or mindless participation. The valuable prizes that we have paid might in particular attract casual participation of students aimed at quickly completing

the experiment with minimal deliberation. Such casual participation might increase the noise in the experimental-data and obstruct statistical inference. To decrease noise (within experimental strategy) we have taken several measures to facilitate participation and clarify tasks. Subjects, for instance, could re-examine their bids for the basic gift-certificates in each of the three subsequent lottery-bidding screens. The lotteries were presented to the subjects in a fixed order in each of the three treatments with the probability of winning the better-prize ascending or descending in each screen (see details in Section 2). The prize distribution of each lottery was illustrated in a two-color pie chart. In addition, we have asked subjects to bid twice (in different screens) for a randomly selected lottery to test reliability.

(d) Common-value considerations. The strategic equivalence of second-price and English auctions breaks down when the value of the item is common (and unknown) to the bidders. The common-value second-price auction model for example demands that bidders discount their private signals to avoid the "winner curse" (Kagel and Levin, 2002). To reduce the hazard of strategic bidding, we have restricted the gift certificates for personal use of the winners. The instructions to the experiment emphasized that the value of each gift to different participants depend on private tastes and may considerably vary across individuals. The second-price auction method was described in the instructions and the dominance of true-bid submission illustrated through an example. Subjects were explicitly advised to bid "their maximal willingness to pay" in each auction.

Empirical research on Web auctions suggests that increased uncertainty about qualities of auctioned items or reliability of sellers has a strong adverse effect on bids and selling prices. Kauffman and Wood (2006) show that "length of description" and "availability of a picture" significantly increases individual bids for coins traded in Ebay. The large literature on seller-reliability (for recent examples see Houser and Wooders, 2006; Lee and Lee, 2006; Resnik et al., 2006) demonstrates that a positive seller feedback-history may increase selling prices by up to 8%. Melnik and Alm (2005) show that seller-reputation interacts with other dimensions of uncertainty; the magnitude of seller-feedback effect, for instance, is strongest for "noncertified coins without a visual scan." Examination of actual complaint-rates regarding Internet auctions however reveals surprisingly low figures. The American Internet Crime Complaint center (IC3) received only 145,840 complaints on Internet auction fraud in 2005 while the number of listings on Ebay alone was about 1.9 billion auctions. The frequency of neutral/negative feedback comments on Ebay according to Cabral and Hortasço (2005) is lower than 1%; the median neutral/negative feedback proportion in their sample was lower than 0.2%. The empirical findings on the adverse affect of value-uncertainty on bidding and prices thus bring up the hypothesis that bidders overweight the risks of winning low-quality items or meeting a fraudulent seller in Web auctions. Controlled examination of the hypothesis in the field is hindered by the need to subjectively quantify perceived-risks in such auctions. This study alternatively adopts the experimental approach to examine the effect of private-value risk on individual bidding.

Another line of motivation to the experiment comes from the large empirical literature on probability weighting. In their seminal prospect theory paper, Kahneman and Tversky (1979) resolve the Allais paradox and other paradoxical choice behaviors by advancing the idea that probabilities are transformed into decision-weights in the evaluation of risky prospects. The notion of probability weighting has since become an accepted characteristic of human decision under risk and attracted a lot of empirical research aimed at determining the shape of probability weighting in various applications. Part of this research (e.g. Gonzales and Wu, 1999; Lattimore et al., 1992; Prelec, 1998; Tversky and Kahneman, 1992) followed a parametric approach by introducing and estimating formal probability weighting functions that capture the transformation of probabilities in empirical data. Another, more recent, stream in the literature deals with designing formal clever methods for the elicitation of probability-weights without any parametric assumptions (e.g. Abdellaoui, 2000; Bleichrodt and Pinto, 2000). Our Internet study complements this latter line of research by using experimental auction data to derive decision-weights from bids without making any *a priori* parametric assumptions on the shape of probability weighting. While some of the main results of our study contradict the typical weighting schemes observed in preceding elicitation experiments (e.g., uniformly pessimistic weighting contradicts the overweighting of small win-probabilities), we still find support for general principles of probability weighting that were documented in many preceding laboratory studies (upper subadditivity; linearity of weights for intermediate probabilities; diminishing sensitivity with respect to salient reference points).

The article proceeds as follows: Section 2 describes the experiment, Section 3 analyzes the results and Section 4 concludes.

2. THE EXPERIMENT

2.1. *Method*

Subjects were recruited by distributing ads to undergraduate and graduate students at the College of Management and Tel-Aviv University. The ads mentioned that the experiment is conducted for research by faculty at the College of Management that guarantees the fair experimental procedure. The ads also explained that the experiment involves participation in about 20 auctions, that winning-ratio is 1:6, and that prizes include a weekend vacation, gourmand dinner and other valuable gifts. Interested students were asked to send an e-mail to our address. In response, they received the URL of the experiment together with an individual username and password. No restrictions were imposed on the place or length of participation.

After logging-in to the experiment, subjects received detailed user-friendly instructions that introduced the second-price auction method and explained that all items included in the experiment will be sold in such six-bidders auctions (see supplement). Subjects were told that the experiment will be run on more than 120 subjects from several universities and colleges that will be randomly matched into six-players groups. The instructions emphasized that the large number of participants makes the possibility of playing the auctions with colleagues or otherwise familiar participants unlikely. The payoff rule of the second-price auction was demonstrated through arbitrary numeric examples and subjects were asked to answer three simple multiple-choice problems to show they have understood the method. The dominance of truthful bidding in Vickery auctions was illustrated through numeric examples and subjects were explicitly instructed to bid their maximal willingness to pay for each item. The instructions also emphasized that prizes are nontransferable and that the value of each prize for each subject depends on individual tastes and may considerably vary across participants. Subjects were told that at the end of the experiment one of the auctions would be randomly selected for each auction-group to determine actual payoffs.[3]

2.2. *The auctions*

The auctions composing the experiment were presented to the subjects in 4 separate phases that appeared on four distinct screens. At the first phase, subjects were asked to sequentially bid for three basic gift-certificates: A, B, and C. Gift certificate A paid a weekend vacation (bed and breakfast for two nights) in a four-stars hotel to the winner and her spouse or friend. Certificate B offered a choice among three gourmand restaurants where the winner and his friend could enjoy a three course dinner from the restaurant's menu. Gift certificate C finally offered a choice between a fine bottle of wine or a box of gourmand chocolate. Additional details on each gift were provided to the subjects on screen (see supplement). The market values of the three gift certificates were extensively different; the average weekend-vacation value was about 1000 NIS, while the gourmand dinner was worth approximately 350 NIS and the wine/chocolate choice about 100 NIS.[4]

To decrease the risk of collusion among subjects we have used three different versions of certificates A and B and two distinct versions of C. The three versions of the weekend-vacation certificate referred to three different resorts across the country. Certificate B similarly appeared in three different forms with three different gourmand restaurants in the choice-menu of each version. The two versions of certificate C varied in the specific type of wine offered to the winner. The mixing of different versions created 18 different combinations of the A, B, and C certificates. The market-values of the different versions of each item were similar. The use of different combinations was intended to differentiate auctions in order to decrease the possibility of meaningless collusive bidding.

After filling-in their three bids, subjects were asked to click a "submit bids" button to transmit their decisions. The experiment program then presented the three bids in a smaller window and asked subjects to reconfirm their bids or return to the auctions page to revise their offers. Subjects did not receive any feedback on the results of the auctions along the experiment; the instructions explained that detailed feedback on the composition of each auction-group, the randomly selected lottery and the results of the selected auction would be e-mailed at the end of the experiment.

In the next three phases of the experiment subjects were asked to bid for binary lotteries over the basic certificates. Each phase/treatment referred to a different combination of gift certificates: AB, AC, and BC. Subjects were reminded of their bids for the three basic certificates at the beginning of each phase and then asked to sequentially bid for five binary lotteries over two of the gifts. Lotteries that pay a better prize X with probability p and a worst prize Y with probability $(1 - p)$ were presented to the subjects in all three treatments, where each treatment involved a different combination of X/Y prizes. In particular, we have run two different versions of the experiment. In *Version I*, the probability *p* of winning the prize with higher market-value took the odd values 0.1, 0.3, 0.5, 0.7, and 0.9. In *Version II*, *p* similarly varied between 0.2, 0.4, 0.5, 0.6, and 0.8.[5] The order in which the three treatments were presented was randomly selected for each auction. The payoff-distribution of each lottery was tabulated and illustrated in a two-color pie chart. The five lotteries were presented to each subject at the same order (with *p* either ascending or descending) in all three treatments. Each treatment appeared on a separate page; subjects were asked to fill-in their five bids and click a "submit your bids" button. The five bids were then represented in a smaller window for subjects' reconfirmation.[6]

At the end of the four bidding phases, subjects were asked, on a separate page, to bid for an additional lottery that "might seem familiar from the preceding phases of the experiment." The additional lottery was in fact randomly selected, for each auction group, from the 15 lotteries included in the preceding phases. The additional lottery was included to measure the reliability of subjects' price proposals. The screen for the additional-auction was similar to the ones for the original lotteries. The individual bids for the three basic certificates were represented on screen but subjects could not page-back and examine their original bid for the same lottery. Returning to preceding pages was also impossible in other phases of the experiment.

2.3. *Sample*

Subjects were recruited from three groups: (1) MBA students at the College of Management, (2) Business/law undergraduate students at the College of Management, and (3) Engineering and exact sciences students at Tel-Aviv University. We have run the experiment on 120 subjects. The bids of 13 subjects were classified as unreasonable and removed from the sample.[7] The sample size for the analysis thus consists of 107 subjects: 38 MBAs, 34 business/law undergraduates, and 35 engineering/science students.[8] The sample size for version I of the experiment was $N = 55$ and the sample size for Version II was $N = 52$. The proportion of Version I (and Version II) in each group was approximately 50%. The average age of the MBA subjects was 31 while the average age in the other groups was about 24.

3. RESULTS

3.1. *Preliminaries*

The average participation time in the experiment was about 21 min. A total of 16 subjects (15%) spent more than 30 min on site; four subjects spent less than 10 min on the experiment. The coefficient of correlation between the first and second bids for the repeated lottery was 0.9167. About 40% of the subjects reproduced the same bid in the two repetitions. To examine the magnitude of deviation across the two repetitions we divide the absolute value of difference in bids to the original bid. The median (average) deviation ratio was 10.56% (21.56%).

The bids for the three gift-certificates varied considerably across subjects. The bids for the weekend-vacation, for instance, ranged from 0 to 2,299 NIS with a median of 550 and standard deviation of 425.[9] Most subjects (101 out of 107) have bid highest for the vacation certificate A and lowest for the wine/chocolate choice C. Six subjects however did not follow the anticipated ordering. For subsequent analysis we therefore renamed the three certificates using H to denote the most-valuable certificate, M to denote the second-best certificate, and L to denote the least-valuable certificate in the eyes of the subject. We accordingly use V_H, V_M, V_L to denote the highest, medium, lowest bids for the three basic gifts. The median values and standard deviations of the 3 ordered-bids are disclosed in Table I.

3.2. *Deriving decision-weights from bids*

To concisely analyze the risk-weighting patterns of subjects in the experiment we extract from the bids of each subject "decision-weights" (Kahneman and Tversky, 1979) that represent the weighting of prizes in the evaluation of each lottery.

To illustrate the calculation of these weights consider the case where a subject has bid 500 for certificate X, 200 for certificate Y, and 320 for a lottery L that pays X with probability 70% and Y with probability 30%. Note that the bid of 320 for the lottery reflects a (0.4, 0.6) weighting of prizes X and Y in the sense that $320 = 0.4^{*}500 + 0.6^{*}200$. We therefore conclude that the "decision-weight" of prize X in the evaluation of lottery L is 0.4. Since X is the more valuable prize paid by the lottery and L pays X with probability 0.7, we say that the 0.7 winning-probability received weight 0.4 and write $w(0.7) = 0.4$ to summarize the weighting patterns for lottery L.

In general, let L represent a lottery that pays X with probability p and Y with complementary probability $(1 - p)$ where X is the more-valuable prize paid by the lottery (so that $V_X > V_Y$). Using $V(\mathrm{L})$ to denote the value of the lottery we extract the decision-weight of prize X from the bids for the lottery and underlying prizes through the next equation:

$$(*) \qquad w(p) = \frac{V(\mathrm{L}) - V_Y}{V_X - V_Y}$$

Note that since $w(p) \cdot V_X + (1 - w(p)) \cdot V_Y = V(\mathrm{L})$, $w(p)$ indeed represents the decision-weight of prize X in the evaluation of

TABLE I
Median bids and standard deviations

$N = 107$	V_H	V_M	V_L
Median bid	550	160	35
Standard deviation	420	88	27

prospect L. The distinction between probabilities and decision-weights is a major ingredient of Prospect Theory (Kahneman and Tversky, 1979), Rank-dependent Utility (Quiggin, 1982) and other generalizations of expected utility theory. In the current application, the decision-weight $w(p)$ is used to summarize the risk-weighting patterns of the subjects when bidding for binary lotteries with winning probability p.

An alternative interpretation to equation (*) would be that $w(p)$ represents the normalized bid for lottery L where the normalization transforms V_Y to 0 and V_X to 1. The normalization clears away the effect of differences in individual bidding for underlying prize-certificates from the lottery-bids. Subjects that follow the expected utility model for example would have $w(p) = p$ independently of their bids for the underlying certificates. Decision-makers that employ a fixed probability weighting scheme $f(\cdot)$ will accordingly reveal similar weights $w(p) = f(p)$ in each of the three treatments employed in the experiment. In the next sections we therefore focus on comparison of $w(p)$ across lotteries and treatments.

3.3. *Pessimistic weighting*

Table II provides the median decision weights revealed in the experiment. The three rows of the table refer to the three treatments HL, HM, and ML. The columns denote the probability p of winning the best-prize paid by the lottery. The 0.5636 in the upper-right cell of the table for example denotes the median value of $w(0.9)$ as derived from the bids for lotteries that pay the best-certificate H with probability 0.9 and the lowest prize L with probability 0.1.

The data on Table II reflects very conservative prize-weighting. The median decision-weights are lower than corresponding (objective) probabilities in all 27 cells of the table. The $p = 0.9$ probability for example is cut-down to median decision-weights of 0.56 in treatment HL, 0.6 in treatment HM and 0.66 in treatment ML (differences across treatments

TABLE II
Median decision weights[10]

$p =$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	($N = 55$)	($N = 52$)	($N = 55$)	($N = 52$)	($N = 107$)	($N = 52$)	($N = 55$)	($N = 52$)	($N = 55$)
HL	0.0000	0.0082	0.0217	0.0416	0.1000	0.1637	0.2708	0.3133	0.5636
HM	0.0000	0.0000	0.0000	0.0568	0.1176	0.1980	0.3053	0.5000	0.6000
ML	0.0000	0.0000	0.0500	0.1437	0.1875	0.4157	0.3750	0.7141	0.6667

are discussed in the next section). Our subjects thus weight the best and worst prizes in approximately (0.6, 0.4) ratios where the probabilities of actually winning the two prizes are (0.9, 0.1). Similar conservative weighting appears in the other columns of the table. The $p=0.5$ winning-probability is transformed into decision-weights of 0.1–0.18. The median decision-weights in the $p=0.1$–0.3 columns are about 0, indicating that more than 50% of the subjects were not willing to pay any premium for the possibility to obtain a better gift-certificate with probability p, when $p \leq 0.3$.

Quiggin (1982) terms the condition $w(p) < p$, where p is the probability of obtaining the more favorable outcome of a binary lottery, "*pessimism*." When probability weighting is pessimistic, the probability of the better outcome is discounted while the probability of the worse outcome is accordingly increased. The overall proportion of pessimistic weighting in the experiment was 86.73% (1392 of 1604 weights).[11] The frequency of pessimistic weighting was similar across the three groups of subjects (88.4% for the MBA; 88.4% for the business undergraduates and 83.2% for the engineering) and the two versions of the experiment (88.1% for version I; 85.3% for version II). Pessimism was more frequent in the high $p=0.6$–0.9 range (91%) compared to the low $p=0.1$–0.4 range (82%); it was also more frequent in the HL treatment (90.09%) compared to the HM (85.6%) and ML treatments (81.12%).

Pessimistic weighting may be intuitively explained by subjects' reluctance to pay for a lottery more than the worst value that the lottery may pay. Subjects may "fear the regret" (Bell, 1982; Loomes and Sugden, 1982) of paying a weekend-vacation fee for a box of fine chocolate or they may anticipate the disappointment (Bell, 1985) from collecting a wine bottle where they could win a luxurious vacation. Fear of regret or disappointment may reflect in conservative uniformly pessimistic prize weighting. A 10% chance for collecting a cheaper prize thus drastically decreases subjects' willingness to pay for more expensive certificates.

An interesting aspect of the results is that an addition of 10%, 20%, or even 30% probability for obtaining a better outcome from an auction did not increase the price that subjects were willing to pay for a lower-valued item. Probability weighting in Vickery auctions is thus strongly asymmetric; small loss probabilities are significantly overweighed while corresponding small win probabilities are completely ignored. The classic literature on probability weighting on the contrary refers to overweighting of small win and loss probabilities. Kahneman and Tversky (1979) suggest that overweighting of small win and loss probabilities may provide an explanation to simultaneous gambling and insurance. Overweighting of small win probabilities has been documented in the nonparametric studies of Gonzales and Wu (1999), Abdellaoui (2000), Bleichrodt and Pinto (2000) and others. The observed risk weighting patterns in our lottery-auctions are in this sense qualitatively different from typical weighting patterns in the choice under uncertainty literature.

Underweighting of small win-probabilities and uniform pessimism, however, are compatible with Gul's (1991) theory of disappointment aversion. According to Gul's theory, disappointment-averse decision makers overweight the probabilities of prizes that are lower than the certainty equivalent of the lottery while underweighting the probabilities of prizes that are higher than the CE. The value of binary lottery L that pays a better prize X with probability p and a worse prize Y with probability $(1-p)$ according to the theory is $V(\mathrm{L}) = \gamma(p) \cdot V_{\mathrm{X}} + (1-\gamma(p)) \cdot V_{\mathrm{Y}}$ where $\gamma(p) = p/(1+(1-p)\cdot\beta)$ for every $p \in [0, 1]$. When preferences are disappointment-averse, $\beta > 0$ and $\gamma(p) < p$ for all p. The decision-maker exhibits uniform pessimism.

We however, suspected, that the uniformly conservative weighting observed in the auctions is idiosyncratic to the specific application. To check this intuition we have distributed among the subjects by e-mail an additional binary-choice problem that was individually tailored for each subject. Subjects were asked to choose between (I) a lottery that pays certificate A with probability 90% and certificate B with probability 10% and (II) a certain payoff of $0.9 \cdot V_{\mathrm{A}} + 0.1 \cdot V_{\mathrm{B}}$, where we used the individual bids for gifts A and B to calculate the certain payoff for each subject. Subjects were told that the lottery would be drawn using the same procedures that were introduced in the auction experiment and that subjects will be invited to actively participate in the prize-drawing process. Of the 48 subjects that sent us their choices, 25 subjects (52%) chose the lottery thereby revealing $w(0.1) > 0.1$ in the choice-task.[12]

3.4. *Lottery-dependent weighting*

The median data in Table II also suggests that decision-weights consistently vary with the level of prizes paid by the lottery. The lowest median weights appeared in the HL treatment while the highest weights showed with the ML prize-combination. The median decision-weights strictly increase from top to bottom in 6 of 9 columns of Table II ($p = 0.4$ to $p = 0.9$). The median weights are approximately zero in all cells of the remaining columns ($p = 0.1$–0.3). Multivariate repeated measures ANOVA tests confirm that treatment has a significant effect on decision weights.[13] Significance is confirmed in separate tests for each of the three groups of subjects and each version of the experiment.

A possible explanation to the change in weights across treatments is that prize-weighting becomes more conservative as the difference between best and worst values paid by the lottery gets larger. The difference in prize-values was largest (by definition) in the HL treatment where the lowest-median decision-weights appeared. The prize-value distance was lowest in the ML treatment for 94 out of 107 subjects (88%); this is the case where the maximal median decision-weights showed.[14] Larger difference in payable prize-values may strengthen the disappointment from winning the less-valuable prize instead of collecting the high-valued certificate. It may also enhance the regret from paying a premium for the possibility to collect a valuable prize but ending up with the low-valued certificate.[15] Prize-weighting thus appears more conservative in those auctions where the difference in values is larger.

To formally test the hypothesis that decision-weights increase as distance-in-values decreases we reorder the three treatments for each subject by the distance in values of underlying prizes. Max(d) is used to denote the treatment where the distance in values was maximal; Med(d) is similarly applied to the case where the distance was second-largest while Min(d) is reserved for the treatment where the distance in values was minimal.[16]

We first use Page tests for ordered alternatives (Siegel and Castellan, 1988) to test the hypothesis that weights are equal across treatments versus the alternative that weights increase as the distance in payable values gets smaller.[17] The results of the test for each problem p are presented on Table III. We disclose the results for the complete sample ($N = 107$) and for the restricted sample of subjects that did not violate Gneezy et al. (2006) "internality condition" ($N = 78$). Subjects were classified as violating internality when they submitted some lottery-bid that was lower than their bid for the least-valuable prize paid by the lottery (see discussion in the next section). Some of the subjects that violated internality posted similar low-bids in treatments HL and HM thereby revealing lower weights for the Med(d) treatment compared to the Max(d) case (see Section 3.5).[18] The significance-levels of the Page

TABLE III

Page tests for ordered alternatives*

	Complete sample	Restricted sample[19]
$p = 0.9$	$z = 2.00$ ($\alpha = 0.02$)	$z = 3.09$ ($\alpha < 0.001$)
$p = 0.8$	$z = 4.36$ ($\alpha < 0.001$)	$z = 4.3$ ($\alpha < 0.001$)
$p = 0.7$	$z = 1.43$ ($\alpha = 0.07$)	$z = 2.75$ ($\alpha = 0.003$)
$p = 0.6$	$z = 4.26$ ($\alpha < 0.001$)	$z = 4.3$ ($\alpha < 0.001$)
$p = 0.5$	$z = 2.39$ ($\alpha = 0.01$)	$z = 3.53$ ($\alpha < 0.001$)
$p = 0.4$	$z = 1.52$ ($\alpha = 0.06$)	$z = 2.4$ ($\alpha < 0.01$)
$p = 0.3$	$z = 1.24$ (N.S.)	$z = 2.92$ ($\alpha < 0.005$)
$p = 0.2$	$z = -0.73$ (N.S)	$z = 0.39$ (N.S)
$p = 0.1$	$z = -0.38$ (N.S)	$z = 1.31$ ($\alpha = 0.1$)

*N.S is used for cases where the null hypothesis could not be rejected at significance-level lower than 0.1.

tests thus improve when subjects that violated internality are removed from the sample.

To examine the impact of distance on weighting at the individual level, we compare the weights in treatment Max(d) to the corresponding weights in treatment Med(d) and the weights in treatment Med(d) to parallel weights in treatment Min(d) for each subject. Let INC denote the proportion of (strict) increase in weights and DEC denotes the proportion of (strict) decrease in weights in these 10 comparisons.[20] The proportion of weight-increase (INC) was larger than the proportion of weight-decrease (DEC) for 48% of the subjects; DEC was larger than INC for only 26% of the subjects. The hypothesis INC = DEC is strongly rejected in a Wilcoxon signed-rank test ($z = 2.78$; $p < 0.01$; $N = 107$). Significance improves when subjects that violated the internality axiom are removed from the sample ($z = 3.97$; $\alpha < 0.001$; $N = 78$).[21]

3.5. *Uncertainty effect*

Standard models of choice like expected utility, prospect theory, and rank-dependent utility assume that the value of a risky prospect should lie between the prospect's highest- and lowest-payable values. Gneezy et al. (2006) recently term this requirement: "*the internality axiom.*" In our framework, internality implies that the value of binary lottery L should be positioned between the values of the lowest-prize Y and best-prize X payable by the lottery so that $V_Y \leq V(L) \leq V_X$.[22]

Almost 12% of the lottery-bids submitted along our experiment (191 out of 1,605 bids), however, were lower than the bids for the lowest-prize paid by the lottery.[23] A total of 29 subjects (27%) violated the $V(L) \geq V_Y$ condition at least once; 21 subjects violated the lower-bound condition in more than three (of 15) cases. The violation-rate for the engineering students (16%) was larger than the violation-rates for the other two groups (about 10%) but the hypothesis of equality across groups could not be rejected (Chi-square test for the equality of three independent proportions; $\chi^2 = 1.7$; N.S). The violation-rates, for version I (10%) and II (13%) of the experiment were also similar ($\chi^2 = 0.83$; N.S.). The rate of violation decreased with the probability of winning the best-prize p: The highest violation-rates (around 20%) were observed for the $p = 0.1$–0.3 problems while the lowest frequency of violation (about 4%) appeared for $p = 0.8$–0.9. The proportion of violations in the HM treatment (15.3%) was significantly larger than the corresponding proportion for the HL case (8.7%).[24] A closer look into the data explains that violating subjects frequently posted similar lottery-bids in the HL and HM conditions, thereby violating internality in the HM treatment where the value of lower-prize M was higher than their bid without violating the condition in treatment HL where the value of the lowest prize L was smaller than their bid (see footnote 18).

Gneezy et al. (2006) term the case where lotteries are priced lower than their worst possible prize "*the uncertainty effect*." They document the effect in pricing tasks, choice tasks and in field experiments involving substantial incentives. Their study, however, deals with between-subject comparisons where different groups of subjects evaluate the no-risk items and the lotteries. The violations of internality in the current Internet study were documented in a within-subject design where the same subjects bid for the gift certificates and for the lotteries within a short interval of time. Moreover, the violations occurred although the bids for underlying gift certificates were presented on screen when subjects submitted the lottery-bids.

Comparison of the participation time of subjects that exhibited the uncertainty effect to the participation time of all other subjects reveals a significantly lower input time for the violating subjects. The average participation time was about 16 min for the 29 subjects that violated lower-bound internality compared to an average of 24 min to all other subjects (Mann–Whitney test for comparison of independent samples; $z = 2.88$; $\alpha < 0.002$).

To collect indication on the motives for violations of internality we have distributed a post-experimental survey among the participants. Subjects were presented with an example to the type of internality violations observed in the experiment

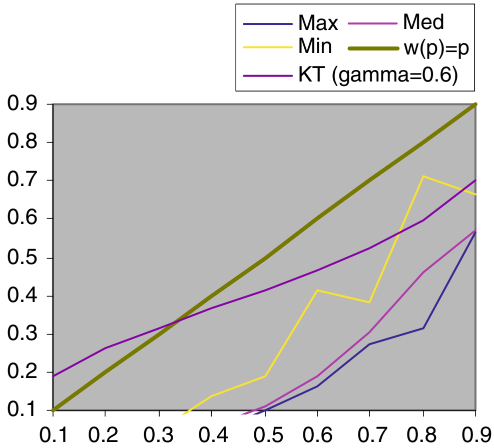

Figure 1. Median decision-weights* *KT denotes the Tversky and Kahneman (1992) weighting function $w(p) = p^{\gamma}/(p^{\gamma} + (1-p)^{1-\gamma})^{1/\gamma}$ where the parameter $\gamma = 0.6$.

and asked to try recall if they exhibited such behavior. Subjects were then asked to mark their favorite explanation to this behavior: (I) noise or distraction, (II) aversion to lotteries ("subjects dislike lotteries and prefer gift-certificates"), and (III) other explanations.[25] The survey was filled-in by 63 subjects; 34 subjects (54%) admitted that they could exhibit the type of behavior demonstrated in the example. Twenty two of these 34 subjects (64.7%) chose "aversion to lotteries" as their preferred explanation to such violations; only 6 of these subjects marked the "noise or distraction" explanation. The survey thus demonstrates that decision-makers may deliberately choose to price lotteries lower than their worst payable prize. The uncertainty effect may accordingly be relevant in contexts that extend beyond the between-subjects studies of Gneezy et al. (2006). The motives for internality violations in within-subject designs and the robustness of such violations seems an interesting topic for further exploration.

3.6. *Convexity*

The median $w(p)$ weights for the Max(d), Med(d) and Min(d) treatments are graphed in Figure 1. To outline the trends we

TABLE IV
Median Proportions of Convex, Concave and Linear Weighting

	All treatments	Max(d)	Med(d)	Min(d)
Convex	71.42%	69.4%	68.4%	58.1%
Linear	14.29%	14.5%	13.3%	20.6%
Concave	14.29%	16.1%	18.3%	21.3%

connect adjacent points by straight lines. The figure clearly reveals a convex pattern of weighting in all three treatments.[26]

To test the hypothesis of convex-weighting at the individual level, we calculate for each subject the proportion of compliance with convex, linear, and concave weighting. For this, we compare the differences $w(p+q)-w(p)$ and $w(p'+q)-w(p')$ for all possible p, q and $p'>p$ for each subject.[27] Say that the subject exhibits *convex weighting* at p, q, p' when $w(p+q)-w(p)<w(p'+q)-w(p')$. Weighting is similarly classified *concave* at p, q, p' when $w(p+q)-w(p)>w(p'+q)-w(p')$ and *linear* at p, q, p' when $w(p+q)-w(p)=w(p'+q)-w(p')$. For each subject, we calculate the proportion of convex, concave and linear weighting (out of all possible p, q, p'). The median proportions are disclosed in Table IV.

The median proportion of convex weighting was 71.42% compared to median proportions of 14.29% for concave and linear weighting. Comparisons across the three treatments suggest that compliance with convex weighting was less frequent in the Min(d) treatment compared to the Max(d) and Med(d) cases. The proportion of linear weighting varied between 13.3% and 20.6% and was significantly larger than 0 in all 3 treatments. Cases of linear weighting were most frequent around 0.5. The highest proportions of linear weighting were calculated for $p=0.4$, $q=0.2$, $p'=0.6$ (36.54%), $p=0.4$, $q=0.1$, $p'=0.5$, (28.21%), and $p=0.3$, $q=0.2$, $p'=0.5$, (26.67%). (Mixed) evidence for linearity of the probability weighting function for intermediate probabilities was obtained in the nonparametric studies of Abdellaoui (2000), Bleichrodt and Pinto (2000) and others.

Tversky and Kahneman (1992) apply the general notion of *diminishing sensitivity* to provide psychological foundations to the typical inverse S-shaped probability weighting function (see Figure 1). According to the principle of diminishing sensitivity decision-makers become less sensitive to given changes as they move away from reference-points. In standard probability weighting, the two endpoints 0 and 1 of the unit probability-interval serve as relevant reference points as both represent salient cases of certainty. The principle of diminishing sensitivity then explains the overweighting of small probabilities of extreme outcomes: gains and losses. The results documented in the current study however suggest that in incentive compatible auctions only the certainty point $p = 1$ applies as a references point in determining the weights of probabilities $p < 1$. An initial decrease in winning-probability from 1 to $(1 - q)$ thus has stronger negative impact on the value of a lottery then any subsequent decrease from winning-probability $p < 1$ to $(p - q) \geq 0$. The principle of diminishing sensitivity thus explains the convex pattern of weighting observed in the experiment.

4. DISCUSSION

Sensitivity of probability-weighting to the range of outcomes has been demonstrated in several preceding studies. Lattimore et al. (1992) find more curvature of the probability weighting function (pwf) in the domain of losses compared to the domain of gains. Abdellaoui (2000) confirms that the pwf for losses is higher than the pwf for gains. In checking the reliability of his weight-elicitation method (by eliciting the weights of given probabilities repeatedly using different level of prizes) Abdellaoui finds that weighting in the domain of gains is unaffected by the level of prizes. In the domain of losses, however, elicited weights are higher when more extreme losses are employed. Etchart-Vincent (2004) also finds that weighting of loss probabilities is affected by the magnitude of loss; larger losses induce more conservative weighting. Rottenstreich and Hsee (2001) demonstrate that affect-rich outcomes invoke stronger weighting than outcomes that are affect-poor. While subjects for instance prefer a $500 coupon for tuition on $500 coupon towards a "romantic vacation in Europe", preferences are reversed when the probability of winning the coupon is decreased to 0.01. Similar results are obtained in checking the willingness to pay to avoid a short electric shock. In the current application, the disappointment affect triggered by missing a valuable weekend-vacation for an alternative wine/chocolate certificate may be stronger than the affect from losing the weekend vacation for a gourmand dinner alternative. The stronger affect translates into more conservative prize-weighting when distance in prizes is larger.

The experiment reported in this article could be run in a standard computerized laboratory or even by distributing a pen and pencil questionnaire to the subjects. The Internet was selected for efficiency and in order to approximate the motivating field-application. We conjecture that uniform pessimism that increases with payoff variability would similarly appear in lab/class versions of the experiment but speculate that the smaller distance between subjects (and between subjects and the experimenter) might increase competition and reduce the level of pessimism in such alternative designs.[28]

A major problem with Internet experimentation is the inherent loss of control. In our experiment, for example, subjects could log in from distinct computers at the same laboratory and strategically collude in attempt to win the gifts in low prices. To decrease the risk of such collusion we have run 18 different versions of the experiment using slightly modified versions of the basic gifts. We have also used small six-bidders auctions to determine actual payoffs while the instructions emphasized that the experiment would be run on more than 120 subjects. Prizes were restricted for personal use of winners and the instructions illustrated the dominance of true willingness-to-pay bidding in second-price auctions. In addition, we took measures to reduce subjects' suspicion and convince subjects in the fairness of the experimental protocol. Subjects, in particular, were invited to take active part in the prize-drawing process that was described in detail in the instructions.

The main results of the experiment appeared for three different groups of subjects (from two geographically separated academic institutes) and in two different versions of the experiment. Moreover, the results appear when subjects that exhibit the uncertainty effect are removed from the pool. The experiment thus suggests that the aversive effect of private-value risk on auction-bids and prices is twofold. Firstly, the possibility that the auction would end-up with a lower prize triggers disproportional conservative risk-weighting and bidding. Secondly, an increase in the distance between best and worst payable prizes brings up an additional aversive affect in the sense that the bids for the lotteries get even closer to the lowest possible prize.

Recent empirical research on Internet-auctions demonstrates that increased uncertainty about the quality of auctioned items or the reliability of sellers may have a strong negative effect on bids and selling prices. Examination of formal-complaint records, however, reveals that actual complaint-rates regarding Web-auctions are low relatively to the huge volume of trade in these auctions. The adverse effect of uncertainty on bidding thus suggests that Internet auction-participants may overweight perceived risks when contemplating their bids. The results of the experiment confirm that fears of disappointment or regret strongly affect bidders' price-proposals in experimental Web auctions. Bidders on the field, accordingly, may strongly react to any cues that make the auction or seller look suspicious. Clear and complete product-descriptions, detailed information on the seller and other measures that decrease perceived uncertainty may thus strongly affect the prices that auctioneers would collect on the Internet.

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NOTES

1. The equivalence of English auctions with proxy bidding and Vickrey auctions may also be disrupted by strategic collusive bidding (see Roth and Ockenfels, 2006 for a recent example). The effect of value-uncertainty on strategic bidding (either in common value auctions or in collusive bidding) has to be analyzed within the assumptions of the model describing the game.
2. For classic discussion of experimenter bias issues see Hoffman et al. (1994); for a recent interesting example see Innocneti and Pazienza (2004).
3. Subjects that won the weekend vacation were requested to pay their winning price to our travel agency; subjects that won the gourmand dinner received a partial refund (at the amount of their meal minus their winning price) after presenting a receipt from the restaurant. The gourmand chocolate boxes/wine bottles were distributed to winners in person, after collecting their checks.
4. The New Israeli Shekel was traded at a rate of about 4.5 NIS to 1 US dollar at the time of the experiment.
5. Note that the design is symmetric in the sense that subjects simultaneously bid for lotteries that pay X with probability p and for lotteries that pay X with probability $(1-p)$ in each phase. The symmetry is essential for comparison of bids across treatments since the subjective valuations of certificates sometimes contradicted the market value ordering (see Section 3).
6. An alternative design would involve the auctioning of one-prize lotteries that pay a basic gift (A, B, or C) with fixed probability p and pay nothing with complementary probability $(1-p)$. The two-prize design is richer since it allows for joint comparisons of risk-weighting in treatments HL vs. HM (where the high prize is fixed and the low prize changes) and in treatments HL vs. ML (where the low

prize is fixed and the high prize is changed). The 3 prize design thus provides a more stringent test for the distance hypothesis discussed in 3.4.

7. The formal criterion for removing subjects was the following: Say that bidding is monotone if bids do not decrease as the probability of winning the certificate with higher (subjective) valuation increases. Bidding was classified as unreasonable when subjects violated monotonicity by more than 20% in more than one occasion.
8. 32 (91.4%) of the engineering and sciences students were undergraduates.
9. One subject bid 0 for the weekend vacation explaining in the remarks that she does not value this gift; the second lowest bid for the weekend vacation was 80. The subject that bid 0 for the weekend vacation submitted positive bids for gifts B (300) and C (50).
10. Recall we had 55 subjects in Version I of the experiment and 52 subjects in Version II. Since $p = 0.5$ appeared in both versions, the sample size for this problem was 107. Mann–Whitney tests for comparison of $w(0.5)$ across the two groups of subjects could not reject the hypothesis that weights are equal across the two groups ($z = -0.099$ for treatment HL; $z = 0.5342$ for treatment HM and $z = 0.6211$ for treatment ML).
11. The proportion of optimistic weighting where $w(p) > p$ was only 9.1%; only three subjects had $w(p) = p$ for all problems in all three conditions; one subject had $w(p) = 0$ for all problems in all three conditions.
12. One of the participants in the choice task was randomly selected to receive the prize of his/her choice. In using the bids for the basic gifts to calculate the value of the lottery for the choice-task we implicitly assume that subjects willingness to pay for the basic certificates did not change in the period between the two tests. Subjects that won prizes in the auction experiment were excluded from the sample for the choice-task since winning might have affected their willingness to pay for the different gifts.
13. The tests were run on SAS Qlim procedure (which allows for multivariate repeated measures Anova tests with different sample size for different problems). Wilks' lambda for testing the (Problem*Treatment) effect equals 0.8183 ($\alpha < 0.001$).
14. The remaining 13 subjects had $V_H - V_M < V_M - V_L$. Comparison of the decision-weights of these subjects in the HM and ML treatments indeed reveals higher median decision-weights in the HM-case for $p = 0.9$ to $p = 0.5$, but the sample is too small for statistical testing.
15. Note that $V(L) = V_Y + w(p) * (V_X - V_Y)$ where V_X / V_Y represent the best/worst values paid by the lottery. The decision-weight $w(p)$ thus also represents a proportional premium that subjects are willing to

pay for the possibility to collect the best prize paid by the lottery. Our results demonstrate that this premium-rate decreases as the distance in values $V_X - V_Y$ increases.

16. Since the largest distance in values always appeared in treatment HL (by definition) and the second-largest difference appeared in treatment HM for 88% of the subjects, the median decision-weights for treatments Max(d), Med(d) and Min(d) are very similar to those reported in Table II; we therefore omit this data.
17. Formally, page test is used to test the hypothesis $w(p)_{\max(d)} = w(p)_{\text{med}(d)} = \text{w(p)}_{\min(d)}$ versus the alternative $w(p)_{\max(d)} < w(p)_{\text{med}(d)} < w(p)_{\min(d)}$ where $w(p)_x$ denotes the decision weight of win-probability p in treatment x. Since the test is "directional" the significance level is one-tail.
18. A concrete example: subject number 13 has bid 444 for certificate A, 170 for certificate B, and 80 for certificate C while submitting similar bids of 350 for the lottery AB9 that pays A with probability 0.9 and B with probability 0.1 and for lottery AC9 that pays A with probability 0.9 and C with probability 0.1.
19. The sample size for the restricted sample is $N = 40$ for the odd problems ($p = 0.9, 0.7, 0.3, 0.1$), $N = 38$ for the even problems ($p = 0.8, 0.6, 0, 4, 0.2$) and $N = 78$ for $p = 0.5$.
20. Statistical-testing at the individual-level (e.g., using sign-tests to examine the hypothesis that subjects are as likely to increase or decrease weights across treatments) in hindered by the small sample size: only 5 observations for each subject and treatment. We thus calculate the statistics at the individual-level but apply statistical testing on the complete sample.
21. The hypothesis that weights in treatment Max(d) are equal to the weights in Med(d) could not be rejected on the complete sample ($z = 0.3647$; N.S.). As explained above, subjects that violated internality sometimes posted similar low-bids in treatments HM and HL thereby revealing lower weights for the Med(d) treatment compared to the Max(d) case. When these 29 subjects are removed from the sample the difference between weights in treatments Max(d) and Med(d) becomes significant ($z = 2.8$; $\alpha < 0.001$).
22. In the framework of equation (∗), internality implies that $0 \leq w(p) \leq 1$. When the bid for a lottery is lower than the bid for its worst payable prize, (∗) reveals a negative weight $w(p) < 0$.
23. Violation of the $V(\text{L}) \leq V_X$ condition occurred in only 12 observations (0.75%).
24. Violations in the HM treatment with no parallel violations in the HL treatment occurred in 43 cases; violations "in HL but not in the HM" occurred in only 8 cases. The hypothesis that violations are as

likely in both treatments is rejected in a sign-test at $\alpha < 0.001$. The violation rate in the ML treatment was 11.58%.

25. The post experimental questionnaire was distributed at the end of the experiment (about 2 months after the experiment began). To encourage subjects to fill-in the survey we have drawn two wine/chocolate prizes among the participants. About 27% the survey-participants submitted answers that contradicted their actual behavior: 5 of 19 subjects that violated the internality condition marked the "no-violations" option in the survey while 12 of the 44 subjects that did not violate the condition marked "yes" for the possibility that they exhibited such behavior.
26. The kinks in the graph for the Min(d) treatment (see Figure 1) follows from weaker pessimism of the subjects in version II of the experiment compared to version I of the experiment in treatment ML (see the data on the bottom line of Table II).
27. In Version I of the experiment the possible (p, q, p') combinations are: (0,0.1,0.9), (0.5,0.2,0.7), (0.3,0.2,0.7), (0.1,0.2,0.7), (0.3,0.2,0.5), (0.1,0.2,0,5), (0.1,0.2,0.3). The possible combinations in Version II are: (0.6,0.2,0.8), (0.4,0.2,0.8), (0.2,0.2,0.8), (0,0.2,0.8), (0.4,0.2,0.6), (0.2,0.2,0.6), (0,0.2,0.6), (0.2,0.2,0.4), (0,0.2,0.4), (0,0.2,0.2), (0.4,0.1,0.5).
28. Charness et al. (2007) show that trust on the Internet is lower than trust in classroom experiments although subjects exhibit qualitatively similar behaviors in the alternative designs.

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