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Violations of Dominance in Pricing Judgments

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Abstract

The dominance principle states that the judged price of gamble A should be equal to or greater than the judged price of gamble B whenever A's outcomes are equal to or better than the corresponding outcomes of B, holding everything else constant. Subjects often violate the dominance principle by assigning a higher price to a gamble with some probability of winning a positive amount, *Y*, otherwise zero, than to a superior gamble with the same chances of winning *Y*, otherwise winning *X*. Violations also occur with losses. Results are consistent with a configural-weight theory in which the decision weight for each outcome depends on the rank of the outcome with respect to the other outcomes in the lottery and the value of the outcome (zero vs. nonzero).

Key words: dominance violations, pricing judgments

The dominance principle in risky decision making states that when choosing among alternatives, one should select the *dominant* option—namely, that option for which the outcomes are as good or better than those of the other option, no matter what state of the world occurs. For example, if Car A has all the features of Car B and is also cheaper, Car A is said to dominate Car B. In the case of risky decision making, an option with a .5 chance of winning $100, otherwise $10, dominates an option with a .5 chance of winning $100, otherwise $0. Hereafter, gambles will be abbreviated with the notation, $(Y, p; X)$, which refers to an option with some probability, p, of obtaining Y, otherwise X. Thus, the gamble ($100, .5; $10) dominates gamble ($100, .5; $0). Another term for this form of dominance is monotonicity (Luce, 1992).

Dominance, or monotonicity, differs from stochastic dominance which is a more general property. For unidimensional risky options, option A stochastically dominates option B if the cumulative distribution of A is to the right of the cumulative distribution of B. Thus, the option ($100, .6; $0) stochastically dominates the option ($100, .5; $0).

One of the first reports of the dominance principle goes back to Arnobius, an African scholar from Sicca who was born sometime in the third century and died in the fourth

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(Grier, 1981). In his books, *Adversus Nationes*, Arnobius argued in favor of a belief in God using the dominance principle (Arnobius, translated in 1949). The alternatives confronting the decision maker are Christianity and Paganism, and the states of the world are the truth values for Christian promises about the future. If the promises are false, there is no danger in taking either position. But if they are true, the consequences are salvation vs. loss of salvation for Christians and Pagans, respectively. Arnobius argued that the position affording some hope, namely, a belief in God, is clearly the better of the two options. In his framework, Christianity dominates.[1]

1. Empirical violations of dominance

Empirical violations of dominance in the choice literature are rare, perhaps because investigators have assumed that the principle is so compelling that subjects would not violate it. Kahneman and Tversky (1984) and Tversky and Kahneman (1986) reported violations of dominance and stochastic dominance in choice under conditions in which the dominance relation is not clear without a formal analysis. In the present experiments, we investigate violations of dominance under conditions in which the dominance relation is clear, but the gambles are judged individually in pricing tasks, rather than compared in choice tasks.

The term dominance or monotonicity can be applied to *judgments* of risky options as follows: the price assigned to Gamble A should be equal to or greater than the price assigned to Gamble B, if the probabilities are the same and Gamble A's outcomes are equal to or better than those of Gamble B. For example, subjects should request at least as much or more to sell the gamble ($10, .5; $2) than the gamble ($10, .5; $0).

A recent paper by Birnbaum, Coffey, Mellers and Weiss (1992) found that subjects do not always obey the dominance principle when assigning prices to gambles. Some of their results are shown in figure 1. Judged prices for gambles of the form ($96, p; X) are plotted as a function of the probability of winning $96 with a separate symbol for each level of X (open points for $0 and solid points for $24) and a separate panel for each point of view. Lines are predictions of the configural-weight theory which will be discussed later.

Dominance requires that open points representing gambles of the form ($96, p; $0) should lie below the solid points representing gambles of the form ($96, p; $24). However, when the probability of winning $96 is about .8, open points lie above the solid points. Subjects, on the average, assign higher prices to inferior gambles, and they do so in all three points of view. Furthermore, 53%, 60%, and 36% of the individual subjects assigned a higher price to ($96, .95; $0) than to ($96, .95; $24) in the buyer's, neutral, and seller's point of view, respectively, compared to 34%, 25%, and 36%, who assigned lower prices.

2. Configural-weight theory

Birnbaum, Coffey, Mellers, and Weiss (1992) suggested an extension of a configural-weight theory (Birnbaum, 1974; Birnbaum and Stegner, 1979, 1981) to account for the

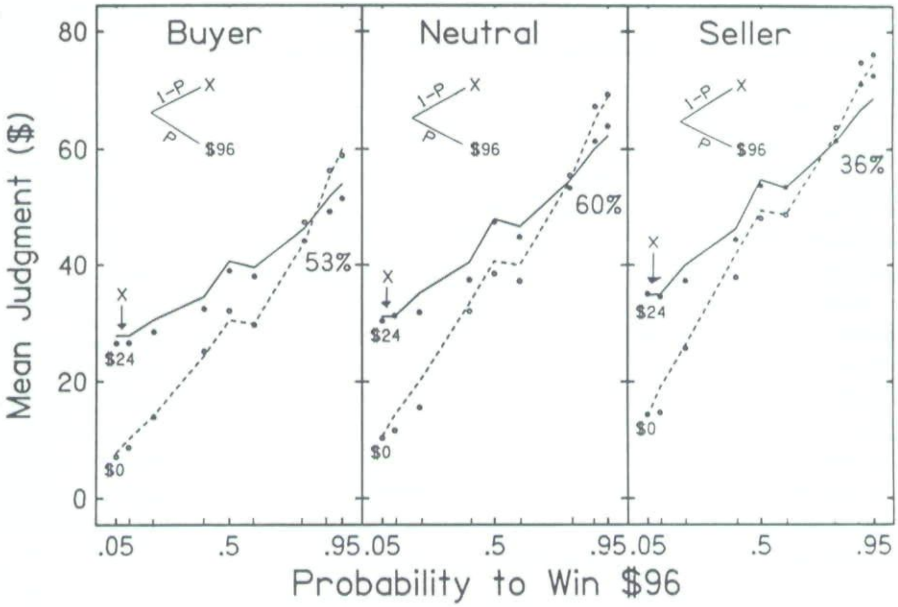

Figure 1. Dominance violations found by Birnbaum, Coffey, Mellers, and Weiss (1992). Average prices for gambles (in dollars) for the buyer's, neutral, and seller's point of view, plotted as a function of the probability to win $96, with a separate curve for each value of the other outcome, *X*. Open points show mean judgments of gambles for which *X* is $0; solid points show judgments when *X* is $24. Solid and dashed lines are the corresponding predictions of configural-weight theory.

dominance violations in figure 1. Birnbaum and Stegner (1979) proposed a configural-weight theory to explain how point of view influences estimates of value. They asked subjects to estimate the value of a used car based on the opinions of sources who examined the car and the car's blue book value. Subjects made their judgments from three perspectives; a friend of the buyer, a friend of the seller, or a neutral observer who would presumably give a fair and unbiased price. Birnbaum and Stegner found that sellers' estimates of the cars were higher than buyers' estimates, and they proposed a configural-weight theory to account for the effect.

Several researchers have found that the amount people request to sell a possession is consistently higher than the amount people say they are willing to pay to purchase it (Coombs, Bezembinder, and Goode, 1967; Knetsch and Sinden, 1984; Marshall, Knetsch, and Sinden, 1986). In addition, survey respondents say they would require a larger sum to forgo their rights of use or access to a resource than they would pay to keep the same entitlement (Hammack and Brown, 1974; Rowe, d'Arge, and Brookshire, 1980).

Birnbaum and Stegner discovered another interesting fact: not only are there metric differences between buyers' and sellers' judgments, but ordinal differences as well. That is, sellers want a higher price to sell Car A than Car B, whereas buyers are willing to pay more to purchase Car B than Car A. Birnbaum and Stegner showed that configural-weight theory could describe these results. The weight or importance of a stimulus (the blue book value or the source's opinion) is assumed to depend on the judge's point of view in a configural (or rank-dependent) fashion. For two sources of specified bias and expertise, the theory can be written:

$$R = (w_0 s_0 + w_{v1} s_1 + w_{v2} s_2)/(w_0 + w_{v1} + w_{v2}) + \omega_v \left| s_1 - s_2 \right| \tag{1}$$

where R is the response; w_0, w_{v1}, and w_{v2} are the weights for the initial impression, the two sources' opinions that depend on expertise, bias and the judge's point of view, v; s_0, s_1, and s_2 are the scale values of the initial impression and the two sources' opinions; ω_v is a configural weight associated with the range of the stimulus information on any given trial. When ω_v is positive, weight is taken from the lower-valued stimulus and given to the higher-valued stimulus. When ω_v is negative, weight is taken from the higher-valued stimulus and given to the lower. Birnbaum and Stegner found that estimates of ω_v were positive for sellers and negative for buyers; sellers appeared to place greater weight on higher-valued information than lower-valued information, and buyers did the opposite. To account for differences between buyers' and sellers' prices for risky options, Birnbaum and Sutton (1992) and Birnbaum et al. (1992) applied an extension of configural-weight theory. When a risky option has two non-zero outcomes, X and Y, where $X < Y$, configural-weight theory can be written:

$$R = J[s_{v1}(p)\,u(X) + (1 - s_{v1}(p))\,u(Y)] \tag{2}$$

where R is the judged price; $s_{v1}(p)$ is the decision weight for probability level, p, which depends on the judge's point of view, v, and the rank order of X relative to Y, 1 (for lower-valued outcome); $u(X)$ and $u(Y)$ are utilities associated with the outcomes, X and Y. Utility functions are allowed to differ in the domain of gains and losses, but are assumed to be invariant across point of view. Finally, J is the strictly monotonic judgment function that maps subjective utilities into monetary judgments. In some situations, J can be theorized to represent the inverse of the utility function for money. However, in other applications, J can take on other functional forms. It is important to maintain the distinction between the psychophysical or input function and the judgment or output function. Birnbaum et al. (1992) and Birnbaum and Sutton (1992) approximated J as a power function. When the rank order of the outcomes is reversed, namely $X > Y$, the theory can be written:

$$R = J[s_{v1}(1 - p)\,u(Y) + (1 - s_{v1}(1 - p))\,u(X)] \tag{3}$$

The decision weight for the higher-valued outcome is assumed to be one minus the weight for the lower-valued outcome, so that only one set of weights is estimated for gambles with two nonzero outcomes.

To account for the dominance violations, Birnbaum et al. (1992) postulated that decision weights for lower-valued outcomes depend not only on the rank, but also on the value of the outcome (zero vs. nonzero). For a gamble with two outcomes, 0 and Y, the theory can be expressed:

$$R = J[s_{v0}(p)\,u(0) + (1 - s_{v0}(p))\,u(Y)] \tag{4}$$

where $s_{v0}(p)$ is the decision weight for the zero outcome. If weights for zero-valued outcomes are smaller than weights for nonzero outcomes with the same objective probabilities, dominance violations could occur. A two-outcome gamble with one zero and one nonzero outcome would have a smaller weight for the zero outcome and, therefore, a larger weight for the nonzero outcome, since weights are assumed to sum to one. Predictions of this configural-weight theory are shown as solid and dashed lines in figure 1. Lines intersect at approximately the same point as the data in all three panels and appear consistent with the dominance violations.

Estimated decision weights for the data from Birnbaum et al. (1992) are shown in figure 2 plotted as a function of objective probability with a separate panel for each point of view. Decision weights for the lower-valued, zero-valued, and higher-valued outcomes are shown as solid circles, open circles, and solid triangles, respectively. For all three points of view, decision weights for lower-valued outcomes are larger than those for higher-valued outcomes. However, the discrepancy between the decision weights decreases considerably for sellers relative to buyers. Furthermore, decision weights for outcomes of zero tend to be smaller than decision weights for lower-valued outcomes, especially for small objective probabilities. This discrepancy allows the theory to predict dominance violations.

The configural-weight theory has similarities to rank-dependent models of choice developed by Quiggin (1982), Luce and Narens (1985), Luce (1986; 1988, 1990, 1991,

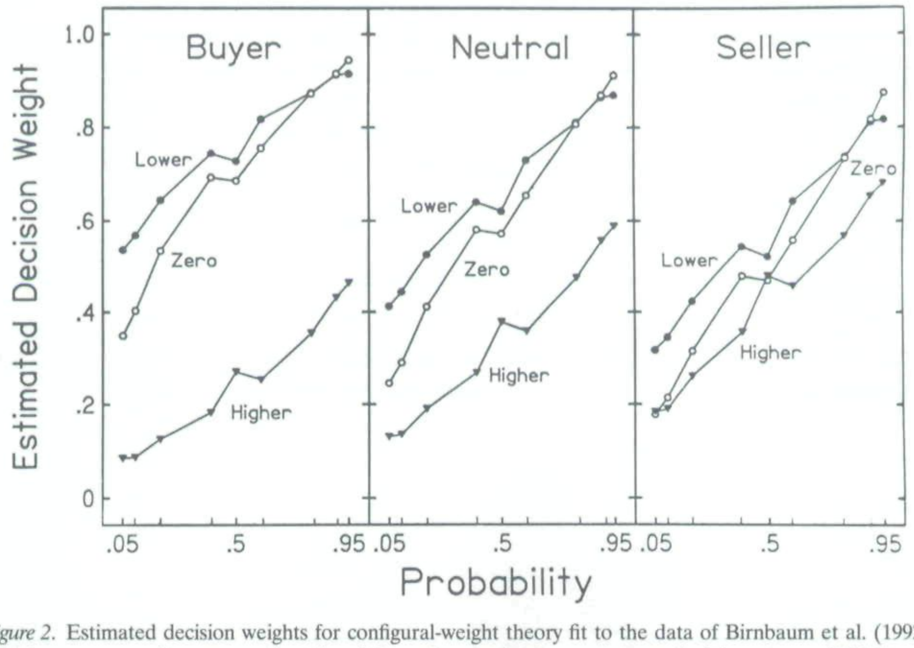

Figure 2. Estimated decision weights for configural-weight theory fit to the data of Birnbaum et al. (1992). Weights are assumed to vary as a function of the rank and value (zero vs. nonzero) of the outcome. Weights are plotted as a function of objective probability with a separate panel for each point of view. Solid circles, open circles, and solid triangles represent decision weights for lower-valued, zero-valued, and higher-valued outcomes, respectively.

1992), Luce and Fishburn (1991), Yaari (1987), and Lopes (1984). Luce and Narens (1985) discovered that if a measurement structure is to yield interval scales, it must follow a dual bilinear form, which is a rank-dependent weighted model that is equivalent to Birnbaum's (1974) range model for two stimuli. Luce (1990, 1991, 1992) and Luce and Fishburn (1991) generalized the rank-dependent theory in such a way that decision weights may also vary as a function of the sign of the outcome relative to the status quo. Neither the original rank-dependent theory nor the rank- and sign-dependent theory predict dominance violations in choice. By allowing different weights for zero-valued outcomes, however, the configural-weight theory can account for results that would violate these formulations.

The present experiments take a closer look at conditions under which dominance violations occur. It will be shown that dominance violations in pricing judgments occur with both small and large outcomes in the domain of gains and losses. Financially-motivated subjects also seem to violate dominance; their pricing judgments were not significantly different from judgments without financial incentives. Finally, subjects rarely violate dominance when the comparison of gambles is clear; violations are less frequent with choices and when the stimulus context includes only a small number of gambles. Under both of these conditions, dominance violations are presumably easier to detect, and subjects adjust their prices accordingly.

3. Experimental tests

Five experiments were conducted with different subjects serving in each. In all of the experiments, subjects were asked to state the value of two-outcome gambles. Gambles were displayed as in figure 3. The circle was said to represent a spinner device with a pointer. The amount to win or lose would depend on whether the pointer landed in the black or gray region. The size of the black region was varied in proportion to p, and amounts were indicated as shown in the figure.

3.1. *Instructions*

Subjects were asked to state the value of gambles from an ownership point of view. That is, they were told to assume they owned the gamble and would play it unless they either

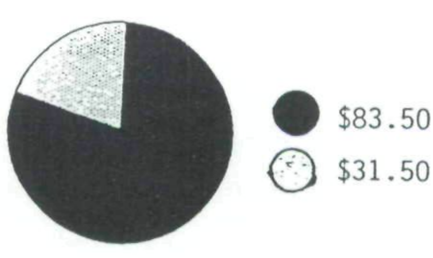

Figure 3. An example of the stimulus format. This gamble represents a .8 chance of winning $83.50, otherwise winning $31.50.

sold it or paid someone else to play it. If they liked the gamble, their task was to state the minimum amount they would be willing to accept to sell it. If they wanted to avoid playing the gamble, their task was to state the maximum amount they would be willing to pay to avoid it (analogous to buying insurance). All responses were made in dollars and cents. Positive numbers represent prices to sell the gambles, and negative numbers represent prices to avoid playing the gambles.

3.2. Design

In the first experiment, 112 gambles were constructed from an 8 × 2 × 7 factorial design of Amount *X* by Amount *Y* by Probability of *Y*. Levels of *X* were −\$31.50, −\$9.70, −\$5.40, \$0, \$5.40, \$9.70, \$31.50, and \$56.70. Positive numbers represented amounts to win, and negative numbers represented amounts to lose. Levels of *Y* were \$56.70 and \$83.50. Probabilities of receiving *Y* were .05, .20, .35, .50, .65, .80, and .95. The second experiment was identical to the first, except that subjects were paid to participate and had financial incentives.

In the third experiment, 112 gambles were constructed from another 8 × 2 × 7 factorial design. Levels of the factors were identical to those in the first experiment, except that the levels of *Y* were either −\$83.50 or \$83.50.

The fourth experiment had 152 trials, and it consisted of six designs. The first design was a 9 × 5 factorial design of Amount Combination by Probability of the Larger Amount. Amount combinations were \$0 vs. \$96, \$6 vs. \$96, \$24 vs. \$96, \$0 vs. \$480, \$30 vs. \$480, \$120 vs. \$480, \$0 vs. \$960, \$60 vs. \$960, and \$240 vs. \$960. Levels of probability to win the larger amount were .05, .20, .50, .80, and .95. The second design was a 5 × 5 factorial combination of Amount by Probability. Levels of amounts were \$6, \$24, \$30, \$60, and \$120. The smaller amount was always zero. Levels of probability to win the larger amount were .05, .20, .50, .80, and .95. The third design consisted of 6 two-outcome gambles with a .5 chance of either outcome. Amount pairs were \$6 vs. \$24, \$24 vs. \$30, \$30 vs. \$60, \$60 vs. \$96, \$96 vs. \$120, and \$480 vs. \$960. The remaining three designs used identical absolute values and probabilities as in the first three designs, but all of the positive amounts (to win) were converted to negative amounts (to lose).

The fifth experiment was conducted to examine whether dominance violations depended on the stimulus context. The hypothesis was that violations might be reduced if the dominance relation between two gambles was easier to detect because the two gambles were embedded among fewer trials. Two specific gambles were included to investigate the dominance violation: (\$96, .95; \$0) and (\$96, .95; \$24), which were embedded among only 18 other gambles with nonnegative outcomes.

3.3. Procedure

For all five experiments, materials were presented in booklets containing instructions, warm-up trials, and randomly-ordered test trials. In the first three experiments, there were 8 warm-up trials followed by the 112 test trials. In the fourth experiment, half of the subjects received 10 warm-up trials followed by the 76 test trials from the first three designs consisting of gambles with positive outcomes. After they completed their responses, subjects were given 10 additional warm-up trials followed by the 76 test trials for the gambles with negative outcomes. The gambles were separated to avoid possible confusion. In the section with positive outcomes, subjects always responded with amounts they would pay to play the gambles. In the section with negative outcomes, subjects always responded with amounts they would pay to avoid the gambles. The two sections were counterbalanced for order; the other half of the subjects received the other order. In the fourth experiment, there were two warm-up trials followed by 20 test trials on two pages. The two gambles that allowed the opportunity to check for dominance violations were on separate pages.

The second experiment used paid subjects who were told at the onset that they would receive $5. In addition, they were told that they would be given the opportunity to play one of two gambles at the end of the experiment for a bonus. Two gambles would be selected, and the one to which they had assigned the higher price during the experiment would be the one they would actually play. Although subjects thought that the selection would be random, the same two gambles, ($83.50, .95; $0) and ($83.50, .95; $31.50), were picked for all of the subjects. These gambles were chosen so that the experimenter could discuss the reasoning behind the possible dominance violations. Selling prices for these two gambles were compared, and subjects were asked: 1) which of these two gambles would you prefer to play? 2) if given the opportunity, would you like to change either of your selling prices? 3) if so, what would the new selling price(s) be?

The first three experiments took approximately 1 hour, the fourth experiment was about 1½ hours, and the fifth took about 15 minutes.

3.4. Participants

There were 58, 39, 71, 37, and 304 different subjects in the first through fifth experiments, respectively. Subjects in all but the second experiment were University of California, Berkeley, undergraduates who received course credit for their participation. A few additional subjects, who did not follow the instructions, were excluded from the analyses. Subjects in the second experiment were volunteers from the university community who were naive with respect to the issues under investigation.

4. Results

4.1. Replication and extension

Figure 4 shows results from Experiment 1 that replicate the original dominance violations found by Birnbaum et al. (1992) with different outcomes, different probability displays, and different subjects. Mean prices are plotted as a function of the probability

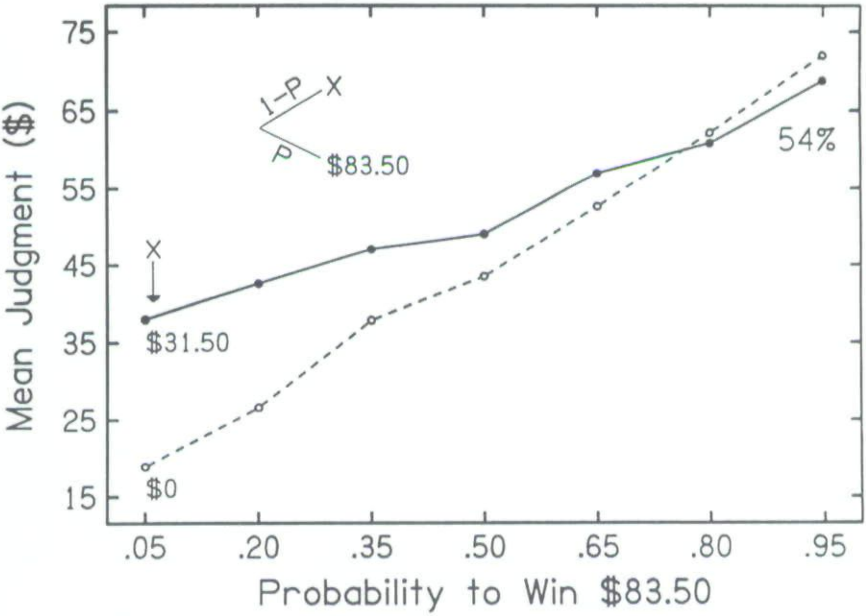

Figure 4. Mean prices for gambles of the form ($83.50, *p*; *X*) plotted as a function of the probability to win $83.50. The dashed line connects judgments when *X* is $0, and the solid line shows judgments when *X* is $31.50. The crossover of the curves indicates violations of dominance.

of winning $83.50, with a solid curve for gambles of the form ($83.50, *p*; $31.50) and a dashed curve for gambles of the form ($83.50, *p*; $0).

The crossover interaction shows the dominance violation, as in figure 1. On the average, subjects assigned a higher selling price to inferior gambles, ($83.50, *p*; $0), when the probability of winning $83.50 was .8 or larger. Fifty-four percent of the subjects assigned higher prices to ($83.50, .95; $0) than to ($83.50, .95; $31.50), as compared to 28% who gave lower prices.

4.2. Is zero a necessary component?

The dominance violations in figures 1 and 4 suggest that subjects either assigned unusually low prices to gambles with two nonzero outcomes or unusually high prices to gambles with a zero and a nonzero outcome. Figure 5 helps identify which prices might be out of line. Mean prices are shown for gambles of the form ($83.50, *p*; *X*), plotted as a function of *X*. Each curve represents a constant probability of winning $83.50, otherwise, *X*. The curves converge to the right and would apparently intersect at $83.50; that is, subjects would presumably accept about $83.50 to sell "sure thing" gambles of the form ($83.50, *p*; $83.50) for any value of *p*.

Although each curve tends to increase as values of *X* increase, there is a systematic deviation from monotonicity when *X* has the value of zero. Subjects, on the average,

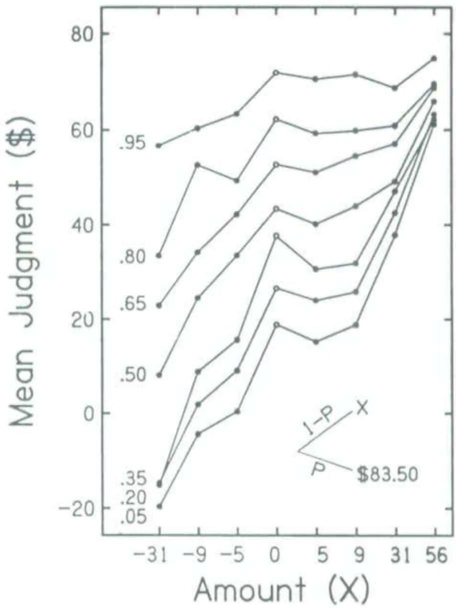

Figure 5. Mean prices for gambles of the form ($83.50, *p*; *X*) plotted as a function of *X* with a separate curve for each level of *p*. All seven curves show a systematic nonmonotonicity when *X* is $0. Judgments assigned to gambles with zero outcomes are overpriced relative to other gambles.

assigned higher prices to gambles of the form ($83.50, *p*; $0) than to gambles of the form ($83.50, *p*; $5.40) for all seven values of *p*. Furthermore, they assigned higher prices to gambles of the form ($83.50, *p*; $0) than to gambles of the form ($83.50, *p*; $9.70) for five of the seven values of *p*. In sum, judgments for gambles with a zero-valued and a nonzero-valued outcome are "too large" relative to the overall pattern of responses; they appear to be overpriced and produce violations of dominance.

To further investigate whether an outcome of $0 is associated with violations of dominance, the proportion of dominance violations and nonviolations was counted for the gamble pair ($83.50, .95; $31.50) vs. ($83.50, .95; $0) and for the gamble pair ($83.50, .95; $31.50) vs. ($83.50, .95; $5.40). A binomial test for correlated proportions was performed to test whether the percentage of dominance violations was significantly different for the two pairs. Although the gap between $0 and $31.50 is actually larger than the gap between $5.40 and $31.50, there were significantly more violations for the former than the latter comparison.

4.3. *Financial incentives*

To investigate whether dominance violations would be reduced when subjects were financially motivated, we computed the percentage of paid subjects who assigned a higher price to ($83.50, .95; $0) than to ($83.50, .95; $31.50). Thirty-six percent of the individual subjects violated dominance. Although this percentage is less than the 45%

found without financial incentives for the same gamble pair (combining subjects in Experiments 1 and 3), the difference is not statistically significant. In addition, an analysis of variance was run to examine possible effects of payment for all gambles of the form ($83.50, p; X). No main effects or interactions for the payment factor were statistically significant.

To examine whether gambles with outcomes of $0 had higher prices than gambles with outcomes of $5.40 for financially-motivated subjects, a figure similar to figure 5 was drawn. On the average, paid subjects assigned higher prices to gambles of the form ($83.50, p; $0) than to gambles of the form ($83.50, p; $5.40) for five of the seven values of p. Thus, even with financial incentives, subjects assigned relatively high prices to gambles with zero-valued outcomes.

When financially-motivated subjects were confronted with their violations of dominance, only one subject persisted in defending the violation. Most of the others tried to explain their judgments by saying that they had simply "made a mistake."

4.4. The domain of losses

If subjects assign higher prices to ($83.50, .95; $0) than to ($83.50, .95; $31.50), are they also willing to pay more to avoid playing (−$83.50, .95; $0) than (−$83.50, .95; −$31.50)? Figure 6 presents mean prices to avoid gambles, with larger prices to avoid at the top of the ordinate to facilitate comparison with figures 1 and 4. The crossover interaction showing the dominance violation appears in the mean prices with negative outcomes. Forty-two percent of the subjects violated dominance by paying more to avoid (−$83.50, .95; $0) than (−$83.50, .95; −$31.50); only 32% assigned less.

4.5. Same sign vs. opposite sign outcomes

Table 1 shows the percentage of dominance violations for gamble pairs of the form ($83.50, .95; $0) vs. ($83.50, .95; X). When X was smaller than $31.50 but still positive, dominance violations occurred at approximately the same rate as when X was $31.50. When X was negative, dominance violations occurred less often. For example, only 17% of the subjects assigned a higher price to ($83.50, .95; −$9.70) than to ($83.50, .95; $0). Thus, although subjects, on the average, assigned a higher price to ($83.50, .95; $0) than to ($83.50, .95; $31.50), they rarely assigned a higher price to ($83.50, .95; −$5.40) than to ($83.50, .95; $0). Table 2 shows the percentage of violations for gamble pairs of the form (−$83.50, .95; $0) vs. (−$83.50, .95; X). In this case, dominance violations were less frequent when X was positive. Both tables 1 and 2 show that dominance violations are most frequent when the two outcomes have the same sign.

4.6. Bigger stakes

Figure 7 allows one to examine whether dominance violations depend on the size of the outcomes. Mean prices are plotted for gambles with a common outcome of $96, $480, or

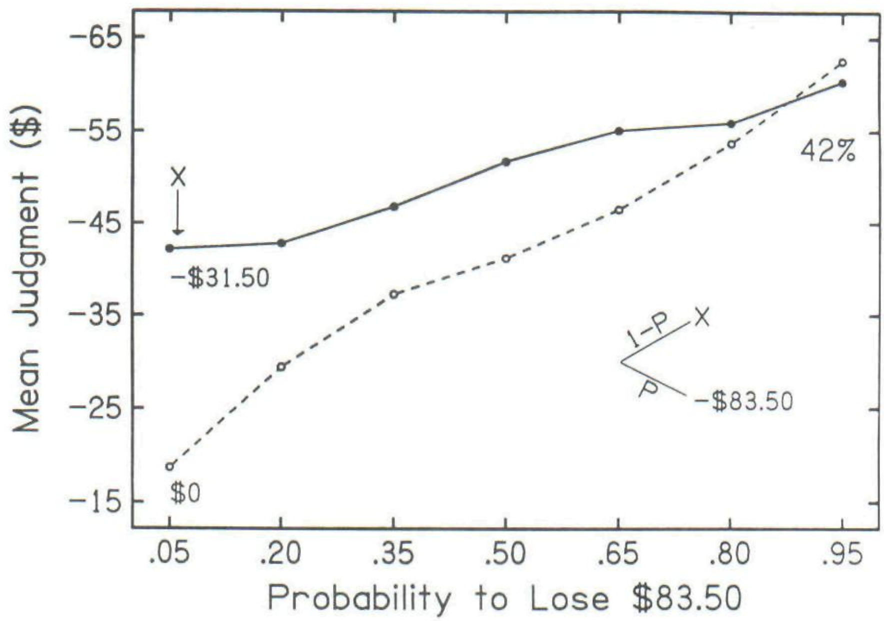

Figure 6. Mean judgment of price to avoid playing each of the gambles. Ordinate is labelled to facilitate comparison with figure 4. Higher values on the ordinate indicate larger prices to avoid. The crossover of the solid and dashed curve for losses is comparable to the dominance violations found for gains.

Table 1. Tests of dominance comparing ($83.50, .95; *X*) vs. ($83.50, .95; $0)

X	Violations	Dominant Higher	Ties
$31.50	45%	33%	22%
$ 9.70	45%	31%	24%
$ 5.40	47%	26%	27%
−$ 5.40	20%	61%	19%
−$ 9.70	17%	63%	20%
−$31.50	13%	73%	14%

Note: When the value of *X* is positive, violations are said to occur when the price assigned to ($83.50, .95; $0) is greater than the price assigned to ($83.50, .95; *X*). When the value of *X* is negative, violations are said to occur when the price assigned to ($83.50, .95; *X*) is greater than the price assigned to ($83.50, .95; $0). Data are from 129 subjects in Experiments 1 and 3.

$960. Solid lines represent judged prices when the value of the other outcome, *X*, is $24, $120, or $240; dashed lines represent prices when *X* is $0. Average prices in all three panels show the crossover interaction. Fifty-four percent of the subjects assign a higher value to the dominated gamble, ($960, .95; $0) than to the gamble, ($960, .95; $240), compared to 32% who assign a lower value to ($960, .95; $0). The average difference in judged prices is $44.20, with the higher price associated with the inferior gamble.

Figure 8 presents average prices to *avoid* gambles with larger amounts to avoid (negative values) at the top of the ordinate. Once again, the curves cross for all three levels of the common outcome, −$96, −$480, and −$960. Forty-nine percent of the subjects pay

Table 2. Tests of dominance comparing (− \$83.50, .95; *X*) vs. (− \$83.50, .95; \$0)

X	Violations	Dominant Higher	Ties
− \$31.50	42%	31%	27%
− \$ 9.70	44%	39%	17%
− \$ 5.40	42%	33%	25%
\$ 5.40	27%	50%	23%
\$ 9.70	27%	63%	10%
\$31.50	20%	69%	11%

Note: When the value of *X* is negative, dominance is violated when subjects pay more to avoid (− \$83.50, .95; \$0) than (− \$83.50, .95; *X*). When the value of *X* is positive, violations are said to occur when subjects pay more to avoid (− \$83.50, .95; *X*) than (− \$83.50, .95; \$0). Data are from 71 subjects in Experiment 3.

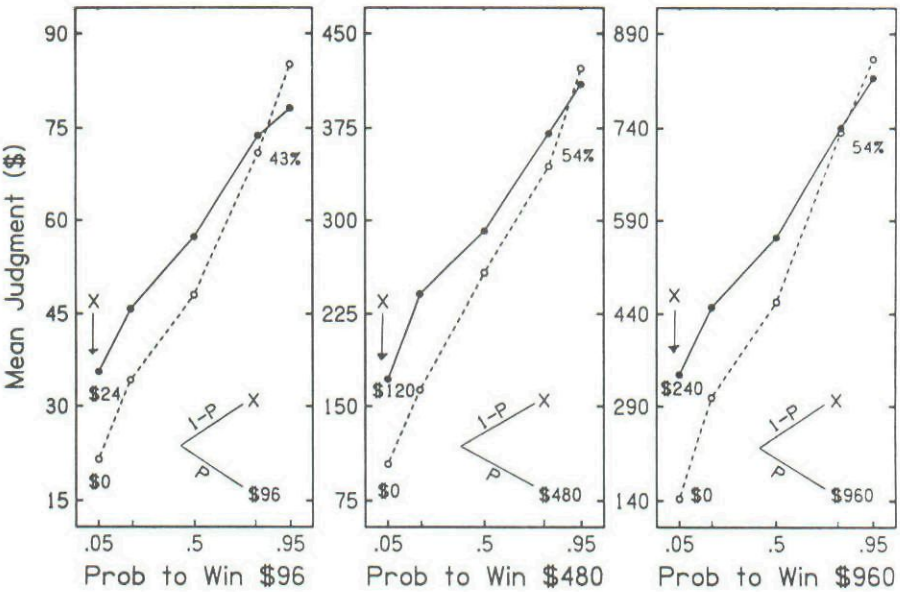

Figure 7. Open and solid points show mean selling prices for gambles, plotted as a function of the probability of winning the larger outcome, *Y*, with a separate panel for each value of *Y* (\$96, \$480, and \$960) and a separate curve for each level of the other outcome, *X*. Dashed lines represent gambles for which *X* is \$0; solid lines represent gambles for which *X* is either \$24, \$120, or \$240, respectively.

more to avoid (− \$960, .95; \$0) than (− \$960, .95; − \$240), compared to 27% who pay less, in accord with the dominance principle.

4.7. *Stimulus context*

Dominance violations between two gambles may also depend on the surrounding stimulus context provided by the other gambles for judgment. In the first four studies, there were from 112 to 152 trials, and subjects may have been unaware of the violations in their judgments. With a smaller number of trials, subjects might notice the dominance

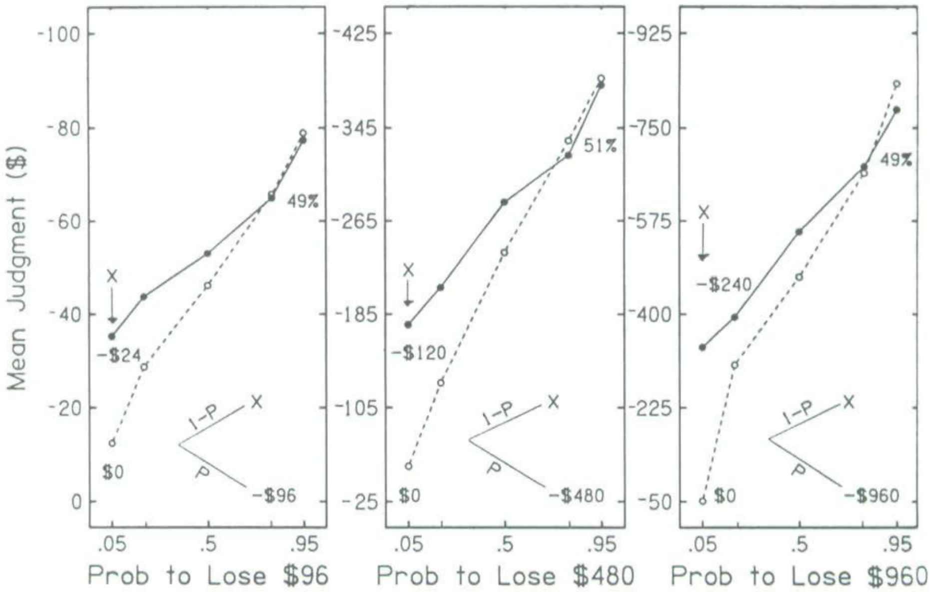

Figure 8. Mean judged price (to avoid) plotted as a function of the probability to lose the common outcome, *Y*, with a separate panel for each value of *Y* (−$96, −$480, and −$960) and a separate curve for each level of the other outcome, *X*, as in figure 7.

relationships among pairs of gambles and adjust their prices accordingly. Experiment 5 used only 20 trials to investigate this hypothesis. Dominance violations were reduced; only 31% of the subjects assigned a higher selling price to ($96, .95; $0) than to ($96, .95; $24), compared with 45% who assigned a smaller value. These percentages of dominance violations in the short version were significantly less than the percentages obtained for the same pair of gambles in Experiment 4, which used 152 trials ($X^2(2) = 5.78$).

5. Discussion

Results from the present experiments demonstrate that subjects do not always assign higher prices to better options, even when "better" is defined by the compelling concept of dominance. Subjects consistently assigned higher prices to a gamble with a high probability of winning the same large amount, otherwise nothing, such as ($83.50, .95; $0), than to a gamble with the same probability of winning a large amount, otherwise a small amount, such as ($83.50, .95; $31.50). Financially-motivated subjects also violated the dominance principle; the observed frequency of violations was lower, but not significantly lower than without financial motivation. Dominance violations also occurred for gambles with losses. Larger outcomes do not appear to reduce the dominance violations; they persisted for outcomes as high as $960 and as low as −$960. On the average, subjects judged the inferior gamble, ($960, .95; $0), as worth $44.20 more than the superior gamble, ($960, .95; $240).

In sum, these results corroborate and extend the findings of Birnbaum et al. (1992) using new stimulus displays, new stimulus levels, and new subjects. Dominance violations are found with positive, negative, small, and large outcomes, and even when subjects are financially motivated. Dominance violations depend on the stimulus context. When subjects received only 20 gambles (rather than 152 gambles), the rate of dominance violations was significantly reduced. Perhaps with fewer trials, subjects were better able to compare their previous responses with previous stimuli, and the task more closely resembled choice.

A procedure that can reduce the number of trials to a minimum is the between-subject design. In these designs, subjects may make only a single judgment or a small set of judgments, and the experimentor compares responses between groups. Stimuli compared by the experimenter are never directly compared by the subjects. Mellers et al. (1992) manipulated the context in a between-subject design and obtained judged prices of gambles. The comparisons of judgments between groups could be viewed as dominance violations. For example, consider the two gambles ($31.50, .6; −$9.70) and ($31.50, .6; −$5.40). The second gamble dominates the first since the amount to lose is smaller. *Within* each group of subjects, the average price assigned to the first gamble is consistently lower than the average price of the second gamble, as expected from monotonicity. However, *between* groups, the average price of the first gamble can be higher than the average price of the second, violating dominance. In one group (where most of the gambles had low expected values), subjects offer to pay $5.24 to play the inferior gamble ($31.50, .6; −$9.70); in another group (where most of the gambles had higher expected values), subjects pay only $3.92 to play the superior gamble, ($31.50, .6; −$5.40).

Between-subject results should be interpreted with caution because the between-subject designs confound the context with the stimuli (Birnbaum, 1982). Subjects in different groups presumably have different J functions, and comparisons between groups should be interpreted with respect to a theory of the context. This type of dominance violation seems far less compelling than those obtained within-subjects, as in the present study, where the same subject produces the two prices that reveal the violation.

It would be even more noteworthy if the same subject violated dominance in a direct comparison between the two gambles. In choice tasks, there are fewer demands on memory than in judgment tasks, and choices might be less likely to show dominance violations. Birnbaum and Sutton (1992) investigated dominance violations in both judgment and choice paradigms, using the same stimuli as in Birnbaum et al. (1992). Subjects were presented with pairs of gambles, including ($96, .95; $0) vs. ($96, .95; $24), and were asked to choose the gamble they would prefer to play. Only 5 of the 72 subjects violated dominance in choice, but the violations in pricing judgments were similar to those in figure 1. Therefore, the present recipe for violations of dominance appears to produce them in judgment tasks but not in direct choice.

As Birnbaum and Sutton (1992) noted, this type of preference reversal in choice and pricing tasks produced by dominance violations is a new type of preference reversal that is not predicted by theories proposed to explain the "classic" preference reversal, such as contingent weighting theory (Tversky, Sattah, and Slovic, 1988) or change-of-process theory (Mellers, Ordóñez, and Birnbaum, 1992). Those theories would need revision to accommodate violations of dominance. For more discussion, see Mellers et al. (1992).

Results that may be analogous to these dominance violations have been found in other judgment domains. Birnbaum and Mellers (1983) obtained similar findings in a probabilistic inference task. Subjects were asked to judge the probability of a hypothesis given base rate information and the report of a source with known hit and false alarm rates (conditional probabilities for the report given the hypothesis and its complement). Birnbaum and Mellers found that judgments of probability based only on a high base rate were more extreme than judgments based on the same base rate and the opinion of a low-expertise (but diagnostic) individual who gave a confirming report. According to Bayes Theorem, the latter probability should be more extreme than the former, since confirmation from a source, even of weak credibility, should enhance the belief in the hypothesis. However, a favorable report from a weakly credible source, like faint praise, actually seems to reduce the probability judgment. This result and others (Birnbaum, 1976; Troutman and Shanteau, 1977) seem consistent with the present findings, in which addition of mildly favorable information can actually lower the overall impression.

5.1. Theories

Configural-weight theory provides a good account of the differences between buyers', neutrals', and sellers' prices (Birnbaum et al., 1992; Birnbaum and Sutton, 1992) and can also predict the dominance violations found in all three points of view. According to this theory, decision weights associated with the outcomes vary as a function of the rank and the value of the outcomes (zero vs. nonzero). Decision weights for zero-valued outcomes of low probability tend to be smaller than those for nonzero outcomes of the same probability (figure 2). If a gamble has two outcomes, one of which is zero, a smaller decision weight for the zero-valued outcome results in a larger decision weight for the nonzero outcome, since the relative weights sum to one in Equation 4.

Why might zero-valued outcomes receive less weight? One possibility is that decision weights depend on the operations a subject uses when making judgments. Consider an analogy with the computation of expected value. In computing the expected value of $(Y, p; 0)$, zero can be ignored; however, the expected value of $(Y, p; X)$ is a weighted average of Y and X. Subjects may use this analogy with expected value and give less weight to \$0. For example, when evaluating the gamble $(Y, p; \$0)$, subjects might multiply the utility of Y and the decision weight for p and ignore zero. When evaluating the gamble $(Y, p; X)$, subjects might perform additional operations by multiplying each utility by its decision weight, summing over outcomes, and dividing by the sum of the weights (see Birnbaum, Wong, and Wong, 1976).

Another interpretation of the configural weighting is that it is a consequence of a cognitive simplification by the subjects in which they represent complex gambles in terms of two variables. When estimating prices for gambles of the form $(Y, p; X)$, subjects first consider the gamble, $(X, .5; Y)$, which is presumably easier to judge since it has only two free variables. Subjects might then average the expected utility for this gamble with the expected utility for the gamble $(Y, p; \$0)$. In other words, the simpler gamble, $(Y, .5; X)$, is taken into consideration in the pricing judgment. This idea is a variation of prospective reference theory (Viscusi, 1989). If one assumed that the simple gambles (e.g., $(Y, p; 0)$) did not evoke this step, then this idea could imply decision weights that yield violations of dominance.

An alternative hypothesis to the theory that weights differ for zero and nonzero outcomes is that theory that utilities change, depending on the other outcome with which a given outcome is presented. The utility of the higher-valued outcome might increase as the lower-valued outcome decreases. For example, the utility obtained from \$83.50 might seem greater when it is paired with \$0 than when it is paired with \$31.50. This theory suggests that dominance violations should occur even when the lower-valued outcome is negative, since a negative outcome ought to make \$83.50 seem even better by comparison. However, table 1 shows that when X is a loss, dominance violations are much less frequent. For this reason and others (e.g., the pattern of results in figure 5), changing utility theory seems less plausible than the changing weight theory.

5.2. Conclusions

The present studies demonstrate that subjects assign selling prices to gambles that can violate the dominance principle. Our recipe compares gambles of the form $(Y, p; X)$ with gambles of the form $(Y, p; \$0)$; violations are likely to occur when p is close to 1 and X is about ⅓ of Y. Dominance violations continue to occur when X and Y are multiplied by a constant. In addition, when X and Y are of the same sign, violations are more frequent than when X and Y are of different signs. Configural-weight theory provides a descriptive account of the phenomenon. According to this account, zero-valued outcomes associated with low probability receive less weight than equally probable outcomes with either negative or positive values.

Notes

1. Approximately 1300 years later, Pascal developed a more sophisticated version of the same argument using an expected value formulation (Horwich, 1982). By assigning probabilities to the existence of God and attaching values to the outcomes, Pascal argued that a belief in God had the higher expected value, even for very small probabilities of God's existence, because the costs of erroneous faith were far less than the costs of failing to believe in a God who really exists.

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