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# INCONSISTENT PREFERENCES AMONG GAMBLES [1]

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The *S*s, when choosing among gambles, tend to prefer gambles with high probabilities of winning; the same *S*s, when naming selling prices, prefer gambles with small probabilities of winning larger amounts. The results, generally, support those found by Slovic and Lichtenstein in a previous study. A series of experiments are reported which tend to rule out contextual factors that might have contributed to this inconsistency. Changes in preferences over trials were also found; the changes fitted a hypothesis of learning through simple reinforcement.

In studies of decision making, three different methods have been used most frequently to determine *S*'s preferences among gambles. The first method involves direct comparisons among the gambles. The *S* is asked to rank order the gambles or a subset of them, to choose the one gamble (or the *n* gambles) he most prefers, etc. The other two methods involve indirect comparisons. One method consists of asking *S* how much he would be willing to pay to obtain each gamble; the resulting maximum buying prices are analyzed under the assumptions that if *S* is willing to pay more for Gamble A than for Gamble B, he prefers A to B. The final method consists of ascertaining how much *S* would be willing to sell each gamble for if he already owned it; the resulting minimum selling prices are analyzed under the assumption that if *S* sets a higher selling price on Gamble A then on Gamble B, he prefers A to B.

In comparisons among studies of choice, these three basically different methods of measuring preferences have been treated as behaviorally equivalent. Coombs and Pruitt's (1960) study of variance preferences, for example, was intended to be directly compared with Edwards' (1953, 1954a, 1954b, 1954c) studies of probability preferences, although Coombs and Pruitt's study used direct comparisons, while Edwards' used selling prices. Lichtenstein's (1965) later study, again using selling prices, was intended for direct comparison with Coombs and Pruitt's.

Such comparisons have often been made even when they were not theoretically justified. Although normative subjectively expected utility theory requires that relative selling prices agree with direct comparison choices, it does not require that these agree with relative buying prices. (See Raiffa, 1968, p. 89.) This report concerns a series of five experiments to determine whether, in fact, relative selling prices agree with direct choices.

## *General Procedure*

In all of the experiments, the stimuli were two-outcome gambles having a probability, $Pr(x)$, of winning amount $x$, and a probability, $Pr(y) = 1 - Pr(x)$, of winning amount $y$. The gambles are shown in Table 1.

The 24 gambles in Table 1 are divided into two sets, each of which is divided into four triples. Within a set, the bets in each triple are obtained from those in the preceding triple by subtracting \$1 from each outcome of each bet. All gambles within a triple have the same expected value (EV). In each experiment, the gambles were played by tossing an ordinary, six-sided die, and the gambling was for chips that represented imaginary money.

Selling prices were obtained by the method devised independently by Becker, DeGroot, and Marschak (1964) and Lindman (1965). The *S*s made a separate response to each gamble. Each time *S*

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was shown a gamble, he was required to name a "selling price" for the gamble. If it was a desirable gamble (in $S$'s opinion), his selling price was to be the smallest amount of money that $E$ would have to pay him before he would agree not to play the gamble. If it was an undesirable gamble, $S$'s selling price was the maximum amount of money that he would be willing to pay to be released from the obligation of playing the gamble. The $E$ then chose a "bid" randomly from a rectangular distribution whose limits were

$$\text{EV(gamble)} \pm Pr(x)\,Pr(y)\,(x - y), \quad [1]$$

where $Pr(x)$ and $Pr(y)$ are the probabilities of winning amounts $x$ and $y$. If the bid was positive, it was interpreted as the largest amount that $E$ would be willing to pay $S$ to induce him not to play the gamble; if it was negative, it was the least amount that $S$ would have to pay $E$ to avoid playing the gamble. In any case, if $E$'s bid was algebraically larger than $S$'s selling price, $S$ either received $E$'s bid, if positive, or paid the bid, if negative, in lieu of playing the gamble. If the bid was algebraically smaller than $S$'s selling price, $S$ played the gamble. It can be shown (Becker et al., 1964; Lindman, 1965), without reference to probabilities or expected values, that the optimal behavior for $S$ in this game is to name as his selling price an amount of money such that he would be indifferent between playing the gamble and receiving (or paying) his stated selling price. This point was explained to each $S$, and, in addition, $S$s were given 12 initial practice gambles to aquaint them with the procedure. None of the gambles in Table 1 were included among the practice gambles.

The $S$s in each experiment were male students in an introductory psychology course at Indiana University; participation in experiments was a course requirement.

## EXPERIMENT 1

### *Procedure*

Twenty-four $S$s took part in Exp. I. Three of these $S$s gave selling prices for one or more gambles that were either higher than the largest possible outcome or lower than the smallest possible outcome.

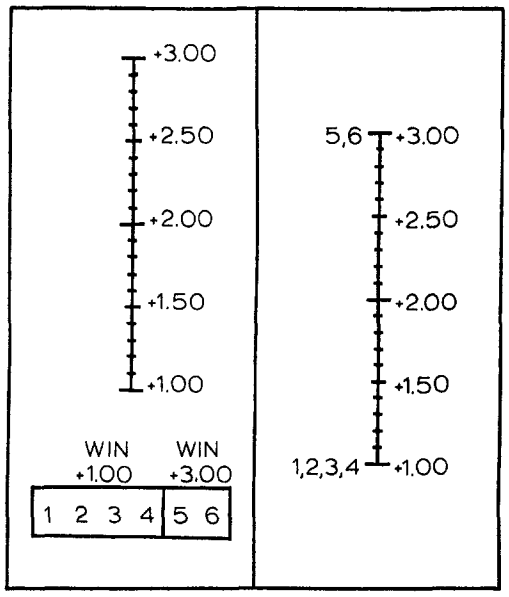


FIG. 1. Sample formats for presentation of gambles, Exp. I through V. Format shown is for Gamble A-2. (In Exp. I and II, $S$s were shown only the box and the winning amounts at lower left; selling prices were given verbally. In Exp. III and V, $S$s were shown the entire left side; $S$s responded by marking the scale and writing in the selling price next to the appropriate mark. In Exp. IV, they were shown only the right side; they responded as in Exp. III and V.)

Such prices violate the principle of dominance and they appeared to be due primarily to lapses of attention (e.g., $S$ responds "one-fifty" when he means "two-fifty"). The data from these 3 $S$s were omitted to avoid possible artifactual biasing of the results.

TABLE 1

LIST OF GAMBLES USED IN ALL SEVEN EXPERIMENTS

| Triple gamble | Set 1 | | | Set 2 | | |
|---|---|---|---|---|---|---|
| | $x$ | $Pr(x)$ | $y$ | $x$ | $Pr(x)$ | $y$ |
| A-1 | \$2.00 | 5/6 | \$0.00 | \$3.00 | 1/6 | \$1.00 |
| A-2 | 3.00 | 2/6 | 1.00 | 2.00 | 4/6 | .00 |
| A-3 | 2.50 | 1/6 | 1.50 | 1.50 | 5/6 | .50 |
| B-1 | 1.00 | 5/6 | −1.00 | 2.00 | 1/6 | .00 |
| B-2 | 2.00 | 2/6 | .00 | 1.00 | 4/6 | −1.00 |
| B-3 | 1.50 | 1/6 | .50 | .50 | 5/6 | − .50 |
| C-1 | .00 | 5/6 | −2.00 | 1.00 | 1/6 | −1.00 |
| C-2 | 1.00 | 2/6 | −1.00 | .00 | 4/6 | −2.00 |
| C-3 | .50 | 1/6 | − .50 | − .50 | 5/6 | −1.50 |
| D-1 | −1.00 | 5/6 | −3.00 | .00 | 1/6 | −2.00 |
| D-2 | .00 | 2/6 | −2.00 | −1.00 | 4/6 | −3.00 |
| D-3 | − .50 | 1/6 | −1.50 | −1.50 | 5/6 | −2.50 |

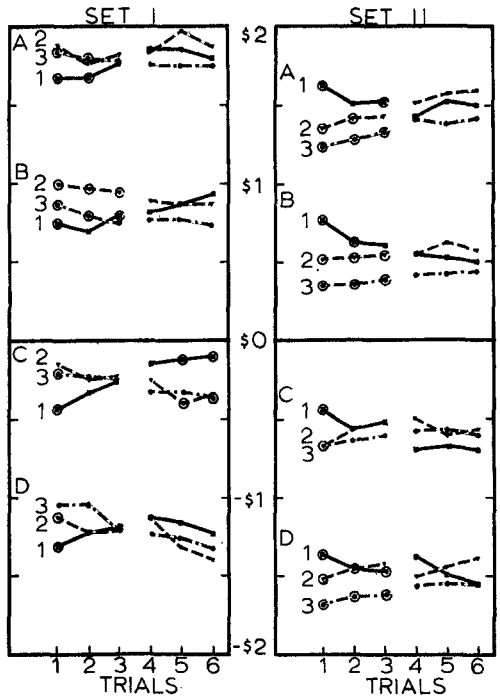


FIG. 2. Mean selling prices, Exp. I–V. (Trials 4–6 are from Exp. V only.)

In Exp. I, each *S* was run individually. The gambles were presented to *S*s on cards printed as shown at the bottom left of Fig. 1. Each *S* first gave selling prices for all 24 gambles, presented 1 at a time. After giving selling prices for each 4 consecutive gambles, 1 of the 4 gambles was chosen at random, and a bid was made for that gamble; the gamble was then either played or sold (for imaginary money). For this purpose, the gambles were first ordered according to decreasing EV and then divided into groups of 4 such that all 4 gambles in a group had nearly equal EVs. For actual presentation, both the groups and the gambles within the groups were randomly permuted. After giving selling prices for all 24 gambles, each *S* was presented with the eight triples, 1 at a time, and he was required to choose the gamble that he most preferred to play from each triple. In each case, *S* actually played the gamble he chose.

This entire procedure was repeated three times, giving three sets of choices for each *S*.

## *Results*

The choices did not differ significantly or consistently over trials ($p > .05$ in each of a set of chi-squared tests). The number of times each gamble was chosen—summed over all three trials—is shown in Table 2. In every triple in Set 1, Gamble 1 is chosen about two-thirds of the time, and Gamble 3 is chosen only about one-tenth of the time. In Set 2, Gamble 2 is clearly preferred to Gambles 1 and 3 in every triple.

Because the selling prices did not differ either consistently or significantly (by several $F$ tests, $p > .05$ in all of them) among the experiments, the selling-price data presented here are averaged over all five experiments. Figure 2 shows mean selling prices for each gamble as a function of trials. In Fig. 2, pairs of circled values, in the same triple on the same trial, are significantly different from each other at the .01 level; in addition, any larger differences for the same trial and the same triple are also significant. Thus, on Trial 1 for Triple 1-A, for example, Gambles 1 and 3 are circled to indicate that they are significantly different; Gambles 1 and 2, however, since they are further apart than 1 and 3 are also significantly different. For the same triple on Trial 2, the only significant difference is between Gambles 1 and

TABLE 2

NUMBER OF CHOICES OF EACH GAMBLE FROM ITS TRIPLE, AVERAGED OVER SUBJECTS AND TRIALS, EXPERIMENT I

| Gamble | Choices | | | |
|---|---|---|---|---|
| | Set 1 | | Set 2 | |
| | No. | % | No. | % |
| A-1 | 40 | 64 | 13 | 21 |
| A-2 | 19 | 30 | 41 | 65 |
| A-3 | 4 | 6 | 9 | 14 |
| B-1 | 45 | 72 | 13 | 21 |
| B-2 | 9 | 14 | 38 | 60 |
| B-3 | 9 | 14 | 12 | 19 |
| C-1 | 44 | 70 | 12 | 19 |
| C-2 | 15 | 24 | 31 | 49 |
| C-3 | 4 | 6 | 20 | 32 |
| D-1 | 45 | 72 | 10 | 16 |
| D-2 | 14 | 22 | 42 | 67 |
| D-3 | 4 | 6 | 11 | 17 |
| Total | | | | |
| 1 | 174 | 69 | 48 | 19 |
| 2 | 57 | 23 | 152 | 60 |
| 3 | 21 | 8 | 52 | 21 |

3. In Set 1-B, all three gambles are significantly different from each other on the first trial. The significance levels were obtained by multiple $t$ tests, modified to use a common error estimate; the high significance level required for rejection minimized the likelihood of spuriously significant results due to nonindependent tests. In addition, the general results were separately validated by $F$ tests that showed the same overall patterns of significance. The $t$ test results, therefore, are merely intended to indicate which differences are reliable.

In every set of gambles, the mean selling prices of Gamble 1 are of most interest. In Set 1, Gamble 1 was chosen most often, but Fig. 2 shows that in every triple it had the lowest mean selling prices. The difference is especially large on the first trial, and, although the selling prices of Gamble 1 tend to increase over trials, they still tend to be smaller than the selling prices of the other gambles, even on Trial 3. In Set 2, Gamble 1 was chosen significantly less often than Gamble 2, yet its mean selling prices tend to be larger. Again the difference is most striking on Trial 1, and it tends to decrease over trials; again, however, the difference is not completely erased even after three trials.

Although mean selling prices are shown in Fig. 2, these are not the best indicators of preferences. Selling prices for all gambles were somewhat skewed in the direction of skewness of the gamble itself. (A gamble is skewed in the direction of its least likely outcome.) Since different gambles are skewed in different directions, the effects of skewness on the mean selling prices are different for different gambles. In particular, the gambles with lowest mean selling prices in Table 2 tend to be those that are negatively skewed, so that the differences among mean selling prices could be due almost entirely to the rather arbitrary choice of the mean as the measure of central tendency.

To eliminate this problem, the three selling prices for the gambles in each triple were compared for each $S$ on each trial. The gamble with the highest selling price

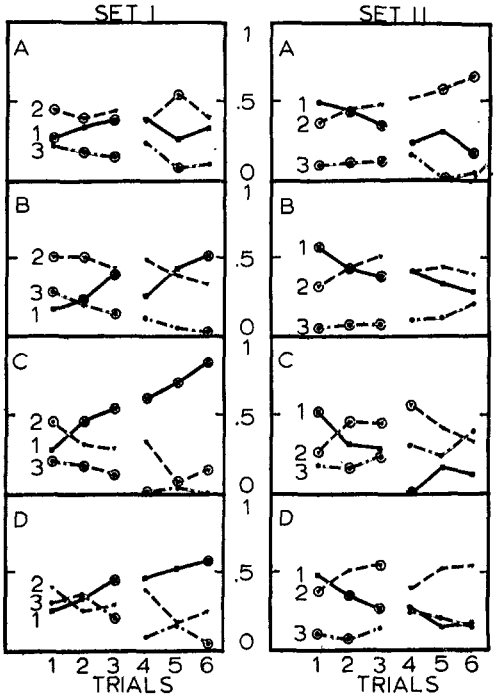


FIG. 3. Choices among triples inferred from selling prices, Exp. I–V. (Trials 4–6 are from Exp. V only.

was then given a value of one, and the other two were given values of zero. If two gambles were tied for highest selling price, each received a value of one-half. If all three were tied, they all received values of zero. The sum of these values for each gamble, taken over all $S$s and all replications, gives an index analogous to the choice index for each gamble.

Figure 3 shows the selling prices analyzed as inferred proportions of choices among triples. Expressed in this way, the results are slightly more similar to those obtained from the choice data. In Set 1, Gamble 1 appears to be slightly more preferred when the data are expressed as inferred choices than when mean selling prices are plotted; however, it is still generally not the most preferred gamble. In Set 2, the same thing holds; Gamble 1 appears slightly less preferred in Fig. 3 than in Fig. 2, but it is still not consistently less preferred than Gamble 2. On the first trial especially, and to some extent on later trials as well,

TABLE 3

PAIR COMPARISON CHOICES AMONG GAMBLES, EXPERIMENT II

| Gamble | Set 1 | | | | Set 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Times chosen over | | | Total choices | Times chosen over | | | Total choices |
| | 1 | 2 | 3 | | 1 | 2 | 3 | |
| A-1 | | 24 | 29 | 53 | | 15 | 16 | 31 |
| A-2 | 16 | | 23 | 39 | 25 | | 31 | 56 |
| A-3 | 11 | 17 | | 28 | 24 | 9 | | 33 |
| B-1 | | 20 | 33 | 53 | | 14 | 13 | 27 |
| B-2 | 20 | | 21 | 41 | 26 | | 26 | 52 |
| B-3 | 7 | 19 | | 26 | 27 | 14 | | 41 |
| C-1 | | 28 | 32 | 60 | | 12 | 8 | 20 |
| C-2 | 12 | | 15 | 27 | 28 | | 34 | 62 |
| C-3 | 8 | 25 | | 33 | 32 | 6 | | 38 |
| D-1 | | 25 | 38 | 63 | | 15 | 9 | 24 |
| D-2 | 15 | | 22 | 37 | 25 | | 30 | 55 |
| D-3 | 2 | 18 | | 20 | 31 | 10 | | 41 |
| Total | | | | | | | | |
| 1 | | 97 | 132 | 229 | | 56 | 46 | 102 |
| 2 | 63 | | 81 | 144 | 104 | | 121 | 225 |
| 3 | 28 | 79 | | 107 | 114 | 39 | | 153 |

*S*s may give selling prices that are inconsistent with their choices among gambles.

## EXPERIMENT II

It is quite possible that choices among triples may reveal a different preference pattern than would choices among pairs. The purpose of Exp. II was to determine whether pair comparisons would reveal the same pattern of preferences as had triplet comparisons. The *S*s were 23 introductory psychology students serving as *S*s on the same basis as those in Exp. 1. Three of the *S*s violated dominance in one or more of their selling prices, so the data presented here are only for the remaining 20. The general procedure was the same as in Exp. I with sessions of selling prices followed by choice sessions. The selling-price sessions were identical to those in Exp. I, but in the choice sessions, *S*s made pair comparisons instead of triplet comparisons. The three gambles in each triple were paired in all possible ways, and the 3 pairs thus created from each triple were shown to *S* with the requirement that he choose which gamble of the pair he most preferred to play. During each choice session, the 24 pairs that could be formed from the eight triples were presented in a random order. Because of the extra number of choices that had to be made, the experiment was replicated only twice with each *S*; that is, each *S* gave a selling price for each gamble, then chose among all pairs, after which the entire procedure was repeated once more.

### *Results*

The results for the selling price data were essentially the same as those shown for the first two trials in Fig. 2 and Fig. 3. They did not differ either significantly or consistently from those in Exp. I. The choice data, summed over trials, are shown in Table 3. The choices on Trial 2 were neither consistently nor significantly different from those on Trial 1 ($p > .10$ for chi-squared tests on all 24 pairs of gambles tested).

The pair-comparison choice data in Table 3 are almost exactly identical to the triplet choices in Table 2. It seems clear from these data that the inconsistencies of choice found in Exp. I cannot be erased by changing the number of gambles among which *S*s choose. The remaining studies sought the solution in a closer examination of the selling-price procedure. In every one, the results were substantially the same as in the first two experiments.

## EXPERIMENT III

One basic difference between the selling-price procedure and choice procedure is that when giving selling prices, *S* sees only one gamble at a time; when making choices, he sees two or more gambles at a time. Thus the choice procedure allows him to make direct comparisons among gambles, while the selling price procedure requires him to evaluate each gamble independently. Experiment III was designed to determine whether *S*s' selling prices would be more similar to their choices if they could com-

pare gambles directly while giving selling prices.

The gambles were reproduced by mimeograph on legal-size sheets, with the three gambles in a given triple all on the same sheet. The order of placement of the gambles on the sheets was random, and the sheets were presented to *S*s in random order. The *S*s indicated each selling price by a mark on a vertical scale running from the smallest to the largest possible outcome of the gamble (see Fig. 1). The *S*s were allowed to consider the gambles on a single sheet in any order, and they could change their minds on any gamble at any time before the gambles were played. This procedure allows group administration, and *S*s were run in groups of two to four. When all of the *S*s had finished responding to the three gambles on a sheet, one of the three gambles was randomly chosen to be either played or sold. The *S*s whose selling prices were smaller than *E*'s bid for that gamble received the bid; *S*s whose selling prices were larger had their winnings determined by a play of the gamble. In this and subsequent experiments, no choices were made.

Initially, a total of 20 *S*s went through the entire set of gambles three times each. With only 20 *S*s, however, it was not clear whether changes over trials, similar to those found in Exp. I and II, had occurred. Accordingly, another 20 *S*s were run under the same conditions. The results for the second 20 were not significantly different from those for the first, but the combined data did show the characteristic changes over trials.

## Experiment IV

In general, the choice data in Table 2 and 3 tend to reveal preferences for large probabilities of winning the large amount. The selling-price data, on the other hand, tend to show preferences for the larger outcomes associated with the smaller probabilities. The data on selling prices suggested that *S*s, when naming selling prices, partially ignored probabilities of winning.

In Exp. IV, the probabilities of winning were presented in a manner intended to make it more difficult for *S*s to perceive and use them. A sample stimulus from Exp. IV is shown in Fig. 1. The gambles were not presented in the form of a box neatly divided into two parts whose areas represented the probabilities of the two outcomes.

It was hoped that *S*s in this experiment would differ from those in previous experiments in either of two ways. The *S*s might tend to ignore the probabilities completely, leading to an even greater inconsistency effect than was found in the first five experiments, either because the probabilities are not so obvious as in previous studies or because the increased attention required to determine the probabilities might lead *S*s to pay more attention to the probabilities in setting their selling prices.

A total of 19 *S*s were run in groups of 2 to 4 *S*s each. Only selling prices were obtained. The results did not differ consistently or significantly from those of the preceding studies.

## Experiment V

### *Procedure*

Finally, it became more and more clear as the data from these experiments were pooled that the changes in selling prices over trials—shown in Fig. 2 and 3—were large and systematic. In Exp. V, the total number of trials per *S* was doubled to determine whether the observed changes would continue in later trials or whether the selling prices would reach asymptote. It was reasoned that if the changes in selling prices were due to a learning effect, it would have to be a generalized learning rather than learning about the specific properties of each gamble. This was because large changes occurred even after each gamble had been presented only once. On the other hand, if the changes were due to a kind of generalized learning, they might approach asymptote within six trials. After six trials, each *S* had given selling prices for 144 gambles.

This experiment involved 19 *S*s. The stimuli and procedure were the same as those for Exp. III.

### *Results*

The results for the first three trials of Exp. V are pooled with those of the previous experiments in Fig. 2 and 3. The values for the last three trials in Fig. 2 and 3 are those for Exp. V alone. These values are less reliable than those for Trials 1 through 3 because they are based on data from only

19 *S*s. Certain facts seem clear, however. First, in at least some triples, Gamble 1 of Set 1 is still not clearly the most preferred, even after six trials. Conversely, Gamble 1 in Set 2 is not always clearly the least preferred, even after six trials. Finally, selling prices do not appear to approach asymptote, even after six trials. Whether selling prices and choices would eventually agree after even more trials is not ascertainable from these data.

## Discussion and Conclusions

In general, choices—whether among pairs or triples of gambles—tend to reveal preferences for gambles in which the more favorable outcome is most likely. Conversely, selling prices tend to reveal a preference for the gamble for which the more favorable outcome has the largest value.

The selling price data agree generally with the theory, proposed by Lichtenstein and Slovic (Lichtenstein & Slovic, 1968; Slovic, 1967; Slovic & Lichtenstein, 1968), that *S*s choose selling prices for favorable gambles by first noting the largest possible win and then subtracting from that an amount only very roughly related to the probabilities; conversely, *S*s choose selling prices for undesirable gambles by noting the largest possible loss and adding some relatively arbitrary amount to that. Selling prices for desirable gambles should then have the same rank order as the more desirable outcomes, while selling prices for undesirable gambles should have the same rank order as the less desirable outcomes. These predictions are largely borne out by the data; one conspicuous violation, however, is in Set 2-D where Gamble 3 should be preferred to Gamble 2.

One weakness of the Slovic and Lichtenstein theory is that it is stated only in rather vague terms. Clearly, the amounts added and subtracted, when choosing selling prices, are not completely unrelated to the probabilities, since selling prices are at least approximately related to the expected values of the gambles. On the other hand, Exp. IV seems to indicate that the extent to which they use them is independent of the ease with which they are perceived. Such would be the case if *S*s were in fact determined to evaluate the probabilities and use them fully no matter how they were displayed. Experiment IV is not conclusive, however, as *S*s may carefully evaluate the probabilities but still use them ineffectively when setting selling prices.

The selling prices show a gradual trend over trials toward greater agreement with choices. One plausible explanation for this might be that *S*s learn, over trials, from cues provided by *E* or experimental situation (e.g., they might learn from the distribution of *E*'s bids). Selling prices then, however, would be expected to change in the direction of greater agreement with the expected values of the gambles; yet, some of the most dramatic changes in mean selling price are away from the expected values (e.g., Gamble 1 in every triple of Set 1).

A more plausible explanation for the changes over trials might be simple reinforcement: *S*s tend to increase their selling prices for gambles on which they have won in the past and to decrease their selling prices for gambles on which they have lost. Gambles with high probabilities of winning (e.g., Gamble 1 of Set 1 and Gambles 2 and 3 of Set 2) would then be likely to show a trend of increasing selling prices over trials, while gambles with low probabilities of winning (Gambles 2 and 3 of Set 1 and Gamble 1 of Set 2) would tend to show decreasing selling prices. The obtained selling prices show exactly these trends.

Why, then, do the selling prices show such trends while the choices do not? Gambles with high probabilities of winning show high probabilities of choice from the very first trial. Since choice probabilities are already very high, any increases over trials would probably be small. It is possible that with more *S*s or a larger number of trials, a very small learning effect could be found.

Another possibility is that *S*s have had more experience with choices than with selling prices before entering the experiment. Their learning on choices might then be near asymptote.

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