Economic Theory of Choice and the Preference Reversal Phenomenon

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A body of data and theory has been developing within psychology which should be of interest to economists. Taken at face value the data are simply inconsistent with preference theory and have broad implications about research priorities within economics. The inconsistency is deeper than the mere lack of transitivity or even stochastic transitivity. It suggests that no optimization principles of any sort lie behind even the simplest of human choices and that the uniformities in human choice behavior which lie behind market behavior may result from principles which are of a completely different sort from those generally accepted. This paper reports the results of a series of experiments designed to discredit the psychologists' works as applied to economics.

The phenomenon is characterized by the following stylized example. Individuals under suitable laboratory conditions are asked if they prefer lottery A to lottery B as shown in Figure 1. In lottery A a random dart is thrown to the interior of the circle. If it hits the line, the subject is paid \$0 and if it hits anywhere else, the subject is paid \$4. Notice that there is a very high probability of winning so this lottery is called the P bet, standing for probability bet. If lottery B is chosen, a random dart is thrown to the interior of the circle and the subject receives either \$16 or \$0 depending upon where the dart hits. Lottery B is called the \$ bet since there is a very high maximum reward. After indicating a preference between the two lotteries, subjects are asked to place a monetary value on each of the lotteries.

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Psychologists have observed that a large proportion of people will indicate a preference for lottery A, the P bet, but place a higher value on the *other* lottery, the \$ bet. The following argument will help us see one way in which this behavior violates preference theory. Let w = initial wealth; $(z,1,0)$ = the state in which A is held and the wealth level is z; $(z,0,1)$ = the state in which B is held and the wealth level is z; $(z,0,0)$ = the state in which neither A nor B are held and the wealth level is z; $\$(A)$ and $\$(B)$ are the respective selling limit prices; $\sim$ and $\succ$ indicate indifference and preference, respectively.

(1) $(w+\$(A),0,0) \sim (w,1,0)$
by definition of $\$(A)$

(2) $(w+\$(B),0,0) \sim (w,0,1)$
by definition of $\$(B)$

(3) $(w,1,0) \succ (w\,0,1)$
by the statement of preference of A over B

(4) $(w+\$(A),0,0) \succ (w+\$(B),0,0)$
by transitivity

(5) $\$(A) > \$(B)$
by positive "utility value" of wealth

Though (5) follows from the theory, it is not observed.

Notice this behavior is not simply a violation of some type of expected utility hypothesis. The preference measured one way is the *reverse* of preference measured another and seemingly theoretically compatible way. If indeed preferences exist and if the principle of optimization is applicable, then an individual should place a higher reservation price on the object he prefers. The behavior as observed appears to be simply inconsistent with this basic theoretical proposition.

If the results are accepted uncritically and extended to economics, many questions are raised. If preference theory is subject to systematic exception in these simple cases, how many other cases exist? What type of theory of choice can serve as a basis for market theory and simultaneously account for

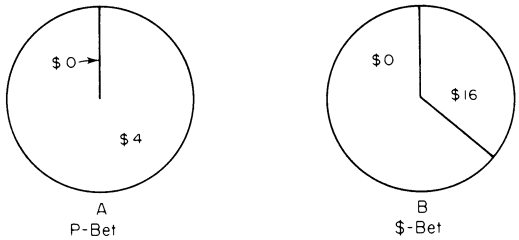

FIGURE 1

these data? Could such an alternative theory also serve as a basis for welfare economics? Should special extensions of the theory of market choice to other situations such as crime (Gary Becker, 1968), suicide (Daniel Hammermesh and Neal Soss), marriage (Becker, 1973, 1974), extramarital affairs (Ray Fair), politics, etc. be called into question? How are we to regard cost-benefit measures once we have accepted the fact that the sign of the benefit-minus-cost figure can be *reversed* by simply measuring preference in terms of "most preferred" options rather than in terms of a limit selling or purchase price?

There is little doubt that psychologists have uncovered a systematic and interesting aspect of human choice behavior. The key question is, of course, whether this behavior should be of interest to economists. Specifically it seems necessary to answer the following: 1) Does the phenomenon exist in situations where economic theory is generally applied? 2) Can the phenomenon be explained by applying standard economic theory or some immediate variant thereof?

This study was designed to answer these two questions. The experiments prior to those reported here were not designed with economics audiences in mind and thus do not answer either question though they are suggestive. In the first section we review the earlier experiments and their shortcomings from an economics point of view. Our experimental design is covered in the second section, and our results are reviewed in the third section. In the end we will conclude that the answer to the first question is "yes" and the answer to the second appears to be "no." As reflected in our concluding remarks, we remain as perplexed as the reader who has just been introduced to the problem.

I. Existing Experimental Work

Experimental results of direct relevance are reported in four papers (Sarah Lichtenstein and Paul Slovic, 1971, 1973; Harold Lindman; Slovic). The experiments are listed in Table 1 beside an array of theories, each of which would either render the experiment irrelevant from an economist's point of view or explain the results in terms of accepted theory. Along with the economic-theoretic explanations, we have listed some psychological-theoretic explanations and some theories which seek to explain the results as artifacts of experimental methods.

A. *Economic-Theoretic Hypotheses*

THEORY 1: *Misspecified Incentives.* Almost all economic theory is applied to situations where the agent choosing is seriously concerned or is at least choosing from among options that in some sense matter. No attempt is made to expand the theory to cover choices from options which yield consequences of no importance. Theories about decision-making costs do suggest that unmotivated choice behavior may be very different from highly motivated choice behavior, but the differences remain essentially unexplored. Thus the results of experiments where subjects may be bored, playing games, or otherwise not motivated, present no immediate challenges to theory.

On this basis several experiments can be disregarded as applying to economics even though they may be very enlightening for psychology. In Lichtenstein and Slovic (1971) the first two experiments were made from gambles which involved imaginary money and in the third, the gambles were for points the value of which were not revealed until after the choices were made. All experiments in Lindman involved gambles for "imaginary money." Three of the experiments of Slovic dealt with the choices among fictitious commodity bundles. The only experiments which cannot be criticized on this ground are

TABLE 1—COEXISTING EXPERIMENTAL RESULTS: RELEVANCE AND POSSIBLE EXPLANATIONS

	Theoretical Criticism and/or Explanation	Lichtenstein & Slovic (1971) Experiment 1	2	3	Lichtenstein & Slovic (1973)	Lindman (1971)	Slovic (1975) Experiment 1	2	3	4	This Study Experiment 1	2
	Economic Theory											
1.	Misspecified Incentives	I	I	I	N	I	I	I	N	I	N	N
2.	Income Effects	N	N	E	?	N	N	N	E	N	N	N
3.	Indifference	N	I	I	I	I	I	I	I	I	N	N
	Psychological											
4.	Strategic Responses	E	E	E	E	E	N	N	N	N	E	N
5.	Probabilities	I	I	N	?	N	N	N	N	N	N	N
6.	Elimination by Aspect	N	N	N	N							N
7.	Lexicographic Semiorder	N	N	N	N							N
8.	Information Processing: Decision Costs	E	E	E	?	E	E	E	E	E	N	N
9.	Information Processing: Response Mode, Easy Justification	E	E	E	E	E	E	E	E	E	E	E
	Experimental Methods											
10.	Confusion and Misunderstanding	N	N	N	N	N	N	N	N	N	N	N
11.	Frequency Low	N	N	N	N	N	N	N	N	N	N	N
12.	Unsophisticated Subjects	?	?	?	N	?	?	?	?	N	N	N
13.	Experimenters Were Psychologists	I	I	I	I	I	I	I	I	I	N	N

I = The experiment is irrelevant to economics because of the reason or theory.

N = The experimental results cannot be explained by this reason or theory.

E = The experimental results are consistent with the reason or theory.

? = Data insufficient.

Lichtenstein and Slovic (1973), which was conducted on a Las Vegas casino floor for real and binding cash bets, and experiment 3 of Slovic in which gambles for values of up to $4 cash or nineteen packs of cigarettes were used.

THEORY 2: *Income Effects.* Three different modes of extracting subjects' attitudes have been used in existing experiments. Subjects were asked their preference between pairs[1] of lotteries, they were asked the maximum amount they would pay for the right to play various lotteries, and they were asked the minimum amount for which they would sell various lotteries. Clearly the income position of a subject can differ among these situations and this could account for apparent inconsistencies in preference. In three experiments income effects are of potential importance: Lichtenstein and Slovic (1971), experiment 3; Lichtenstein and Slovic (1973); and Slovic, experiment 3.

In Lichtenstein and Slovic (1971), experiment 3, subjects knew that all the gambles

[1]In Solvic subjects were asked to rank lotteries from sets of different sizes.

would be played at the end of the experiment. First, the subjects indicated their preferences from among a series of pairs of bets, the most preferred of which was to be played. After these choices the subjects were given a series of bets for which selling limit prices were extracted by standard techniques (see Gordon Becker, Morris DeGroot, and Jacob Marschak). After all choices were made, the relevant bets were played. Since all bets had a positive expected value, subjects had an increasing expected income throughout the experiment. Once one has agreed to play several *P* bets and expected income has accordingly increased, it is not so surprising that subsequently one is willing to go for riskier but potentially more rewarding gambles. Standard theories of risk taking suggest that risk aversion decreases with income, so as expected income increases, a tendency toward a higher limit selling price (the certainty equivalent for lotteries) would be expected. Thus the data which show preference reversals are consistent with an "income effect" hypothesis.

In Slovic, experiment 3, subjects first revealed indifference curves in a cigarette-money space. From this exercise they had an expectation of receiving some cigarettes (up to nineteen packs) from lotteries they knew would be played. A preference for a monetary dimension would thus be expected when two or three days later subjects were offered a choice between cigarette-money commodity bundles to which they had previously expressed indifference. Again the "income effect" hypothesis is consistent with the data.

The third case (Lichtenstein and Slovic, 1973) is an experiment conducted on a casino floor. Bets were played as soon as preferences were indicated. The wealth position of the subject at any time depended upon the sequence of wins and losses leading up to that time and these are not reported. Consequently, the relationship between the theory and this experiment cannot be determined.

THEORY 3: *Indifference.* In all experiments except those in Slovic, subjects were required to register a preference among bets. No indications of indifference were allowed. Thus the preference reversals exhibited in all other experiments could have been due to a systematic resolution of indifference on the part of subjects forced to record a preference. Slovic's results are also consistent with this hypothesis.

B. *Psychological-Theoretic Hypotheses*

THEORY 4: *Strategic Responses.* Everyone has engaged in trade and has some awareness of the various distributions of gains which accompany trade. Thus when asked to name a "selling price" an individual's natural strategic response may be to name a price above any true limit price modulated by what an opponent's preferences are conjectured to be. When asked to name a "buying price," one would tend to understate the values. This strategic reaction to the very words "selling price" may be very difficult to overcome even though the subject is selling to a passive lottery in which such strategic posturing may actually be harmful.

This theory predicts the reversals of all experiments except those reported in Slovic where the words buying and selling were not used. Notice that this theory would predict reversals when selling prices are elicited and fewer reversals, or reversals of the opposite sort, when buying prices are asked for. That is, one can argue that there is little ambiguity about the "value" of a *P* bet (for example, with probability of .99 win $4, and lose $1 with probability of .01). However, this is not true for the corresponding $ bets (for example, win $16 with probability one-third and lose $2 with probability two-thirds). Thus any tendency to state selling prices higher than the true reservation prices will primarily affect prices announced for $ bets. This behavior clearly can yield apparent preference reversals of the type reported. The same argument applied to buying prices suggests that there will be a tendency to understate the value of $ bets more than *P* bets.

Experiment 2 of Lichtenstein and Slovic (1971) used buying prices rather than selling prices. Compared with experiment 1 (which involved selling prices), Lichtenstein and Slovic report that for experiment 2 the rate of reversals was significantly lower (significance

level at least .01) and the rate of opposite reversals significantly higher (also at least .01). Further, they report that bids for the P bets average \$.07 below expected value in experiment 1, but \$.44 below expected value in experiment 2. Bids for the \$ bets were \$3.56 higher than expected value in experiment 1, and \$.04 below expected value in experiment 2. Thus, the data in these two experiments are quite consistent with this theory.

THEORY 5: *Probabilities.* With the exception of Slovic, experiments 1, 2, and 4, all experiments involved lotteries at some stage. Naturally if subjective probabilities are not well formed, or change during the experiment, consistency among choices is not to be expected. In fact, probabilities in all experiments except Lichtenstein and Slovic (1971), experiments 1 and 2, were operationally defined, and with the exception of Lichtenstein and Slovic (1973), there was no reason to suspect that they may have changed during the experiment.

THEORY 6: *Elimination by Aspect.* (See Amos Tversky, 1972.) Let A be a set of "aspects" and let the objects be subsets of A. This theory holds that individuals order the elements of A and then choose from among objects by a lexicographic application of this underlying order. Specifically, the stochastic version holds that an element x of A is chosen at random (perhaps with a probability proportional to its importance), and all objects B, such that $x \notin B$, are then eliminated. The process continued until only one object remains.

This theory runs counter to traditional economic reasoning on two counts. First the lexicographic application runs directly counter to the principle of substitution (quasi concavity of utility functions). Secondly, the random elimination choice process does not sit well with the idea of maximization or "rational" choice.

One implication of the model is a type of moderate stochastic transitivity.[2] The heart of the preference reversal phenomenon is shown above to be a type of cyclic choice. Such an intransitivity is in violation of the moderate stochastic transitivity property of the model. Thus the preference reversal phenomenon must be added to Tversky's own work (1969) as situations in which the elimination-by-aspects model does not seem to work.

THEORY 7: *Lexicographic Semiorder.* In a classic paper Tversky (1969) demonstrated that binary choices could cycle in a predictable fashion. The argument used was that choices are made on the basic dimensions of objects, but when for two objects the magnitudes along a dimension becomes "close," their magnitudes are treated as being equal. Thus a series of objects x, y, z, and w may be ordered as listed when compared in that order because each is close to those adjacent on a given dimension. Yet w may be chosen over x because the magnitudes on this dimension are far enough apart to be discernible.

It is difficult to see how this argument can be applied to account for the cycles in the reversal phenomenon. No long chains of binary comparisons were involved. No small magnitude differences, such as those used by Tversky, were present. We suspect that whatever ultimately accounts for the preference reversals will also account for the Tversky intransitivities, but we doubt that it will be the lexicographic semiorder model.

THEORY 8: *Information Processing—Decision Costs.* Individuals have preferences over an attribute space, but the location of an object in this attribute space may not be readily discernible. Resolution of choice problems, which involves locating an object in the attribute space, is a costly, disagreeable activity, so in their attempt to avoid decision costs people tend to adopt the following simple rule. An individual first looks at the "most prominent" dimension or aspect of the object. The magnitude of this aspect, called an "anchor," is used as the value of the object and is adjusted upward or downward to account for other features. As an empirical generalization the psychologists note that the adjustments are usually inadequate so the ultimate choice is heavily influenced by the starting point or

[2]If $P(x, y) \geq \frac{1}{2}$ and $P(y, z) \geq \frac{1}{2}$, then $P(x, z) \geq \min [P(x, y), P(y, z)]$.

anchor. Individuals who originally choose the *P* bet have tended to focus upon the probability of winning and inadequately adjust for the low monetary amounts. When asked about selling price or buying price, they naturally focus on dollars first and adjust for the probabilities. Since the adjustments for probabilities are inadequate, the dollar bets tend to be given the higher value. Thus, the "preference reversal" phenomenon is explained.

This theory is consistent with all experiments where no incentives were used. It is also consistent with the choices from among indifferent objects such as those in the Slovic 1975 study. When incentives are used, however, more effort in decision making is warranted and the frequency of reversals should go down. Thus on this theory one might have expected fewer reversals than occurred in the Lichtenstein and Slovic (1973) study, but since no control group (i.e., a group playing the gambles without monetary incentives) existed for this subject pool, the results are inconclusive.

THEORY 9: *Information Processing—Response Mode and Easy Justification.* The anchoring and adjustment mechanism described above may exist but it may be entirely unrelated to the underlying idea of decision-making costs. Indeed Lichtenstein and Slovic argue only that "variations in response mode cause fundamental changes in the way people process information, and thus alter the resulting decisions" (1971, p.16). The view is that of the decision maker "as one who is continually searching for systematic procedures that will produce quick and reasonably satisfactory decisions" (Slovic, p. 280). On occasion, it is argued that the mechanism is "easy to explain and justify to oneself and to others" (Slovic, p. 280). The anchoring process described above is offered as the mechanism that people adopt. The particular dimension used as an anchor is postulated to be a function of the context in which a decision is being made. Such thinking may not necessarily be contrary to preference theory. Rather, it is as though people have "true preferences" but what they *report* as a preference is dependent upon the terms in which the reporting takes place. Certain words or contexts naturally induce some dimensions as anchors while others induce other dimensions. The theory is consistent with all observations to date. Details can be found in Slovic.

C. *Experimental Methods*

The psychologists whose work we are reporting are careful scientists. Yet a bit of suspicion always accompanies a trip across a disciplinary boundary. In particular, we consider four possible sources of experimental bias.

THEORY 10: *Confusion and Misunderstanding.* In all experiments subjects were trained, rehearsed, and/or tested over procedures and options. In all instances repeated choices were made. In general there is reason to believe there was little confusion or misunderstanding, and in all cases the results hold up even when the responses of potentially confused subjects are removed from the data. However, there is some evidence reported in Lindman that suggests some type of "learning" takes place with experience. All experimenters reported some very "erratic" choices whereby, for example, a subject offered to pay more for a gamble than the maximum that a favorable outcome would yield.

THEORY 11: *Frequency Low.* If the phenomenon only occurs infrequently or with a very few subjects, there may not be a great need for concern or special attention. In fact, however, the behavior is systematic and the rate of reversals is high. Consider, for example, the following results, recalling that a *P* bet is a lottery with a high probability of winning a modest amount while the $ bet has a low probability of winning a relatively large amount of money. The Lichtenstein and Slovic (1971) study found that of 173 subjects indicating a preference for the *P* bet, 127 (73 percent) always placed a higher monetary valuation on the $ bet (they called these predicted reversals). On the other hand, the reverse almost never happens. That is, individuals who state that they prefer the $ bet will announce prices which are consistent with their choices. In this same study, for

example, 144 subjects *never* made the other reversal (termed unpredicted reversals).

THEORY 12: *Unsophisticated Subjects.* Psychologists tend to use psychology undergraduates who are required to participate in experiments for a grade. With the exception of Lichtenstein and Slovic (1973) the sources of subjects were not made explicit in the studies. If indeed psychology undergraduates were used, one would be hesitant to generalize from such very special populations.

THEORY 13: *The Experimenters were Psychologists.* In a very real sense this can be a problem. Subjects nearly always speculate about the purposes of experiments and psychologists have the reputation for deceiving subjects. It is also well known that subjects' choices are often influenced by what they perceive to be the purpose of the experiment. In order to give the results additional credibility, we felt that the experimental setting should be removed from psychology.

II. Experimental Design

Our format was designed to facilitate the maximum comparisons of results between experiments. The gambles used for our experiments (see Table 2) were the same ones used in Lichtenstein and Slovic (1971), experiment 3, where actual cash payoffs were made. They used a roulette wheel to play the gambles and, therefore, all probabilities were stated in thirty-sixths. The random device for our experiments was a bingo cage containing balls numbered 1–36. This eliminates the problem of nonoperational probabilities that was raised by Theory 5. All the gambles were of the form: if the number drawn is less than or equal to n, you lose \$$x$, and if the number drawn is greater than n, you win \$$y$.

The procedures for both of our experiments were so nearly identical that we shall describe only the first experiment in detail. Only those features of the second experiment that differ from the first will be discussed.

A. *Procedures: Experiment 1*

Student volunteers were recruited from economics and political science classes. They were told that it was an economics experiment, that they would receive a minimum of \$5, and that the experiment would take no longer than one hour. As the subjects arrived, they were randomly divided into two groups. The groups were in separate rooms, and there was no communication between them until after the experiment. Once the experiment was started, subjects were not allowed to communicate with each other though they were allowed to ask the experimenters questions.

Table 3 gives the organization of the experiment. At the start of the experiment the subjects received a set of general instructions that described the nature of the gambles they were to consider and explained how they were

TABLE 2—EXPERIMENT 1: PAIRS OF GAMBLES USED IN THE EXPERIMENTS

Pairs	Type	Probability of Winning	Amount if Win	Amount if Lose	Expected Value
1	*P*	35/36	\$ 4.00	−\$1.00	3.86
	\$	11/36	\$16.00	−\$1.50	3.85
2	*P*	29/36	\$ 2.00	−\$1.00	1.42
	\$	7/36	\$ 9.00	−\$ .50	1.35
3	*P*	34/36	\$ 3.00	−\$2.00	2.72
	\$	18/36	\$ 6.50	−\$1.00	2.75
4	*P*	32/36	\$ 4.00	−\$ .50	3.50
	\$	4/36	\$40.00	−\$1.00	3.56
5	*P*	34/36	\$ 2.50	−\$ .50	2.33
	\$	14/36	\$ 8.50	−\$1.50	2.39
6	*P*	33/36	\$ 2.00	−\$2.00	1.67
	\$	18/36	\$ 5.00	−\$1.50	1.75

TABLE 3—EXPERIMENT 1

Parts	Group 1 No Monetary Incentives	Group 2 Monetary Incentives
1	Preferences for Pairs (1), (2), (3)	
2	Selling Prices, All Twelve Gambles	
3	Preferences for Pairs (4), (5), (6)	

to be paid. These are included in the Appendix. Throughout the experiments all instructions and other materials handed out were read aloud. The instructions included a sample gamble (not used in the actual experiment): lose $1 if the number on the ball drawn is less than or equal to 12 and win $8 if the number is greater than 12. The way the gambles worked was demonstrated.

Two different monetary incentive systems were used which together control for Theory 1 and allow Theory 8 to be assessed. In one room (group 1) subjects were told that they would be asked to make a series of decisions concerning various gambles, and that when they were finished they would be paid $7. In the other room (group 2) subjects were told that at the end of the experiments one of their decisions would be chosen at random (using a bingo cage to determine which one) and their payment would depend upon which gamble they chose and upon the outcome of that particular gamble. It was explained that they had a credit of $7 and whatever they won or lost would be added to or substracted from that amount. Finally, it was stated that the most they could lose on any of the gambles was $2 so that $5 was the minimum possible payment.[3]

The use of a randomizing device to pick which decision "counted" was intended to reduce the problem of income effects discussed as Theory 2. Strictly speaking, even this procedure does not completely eliminate the possibility of some income effects, but it should reduce their magnitude substantially. Here there is little opportunity to have a growing expectation of rewards over the course of the experiment.

Part 1 of the experiment was distributed (the subjects were allowed to keep the instructions). This part consisted of three pairs of gambles.[4] For each pair subjects were told to indicate which bet they preferred or if they were indifferent. Subjects were told that if one of these three pairs was chosen at the end of the experiment, the two gambles would be played and that individual payments would be made according to which gamble was listed as preferred. Indifference was allowed and the subjects were told, "If you check 'Don't care,' the bet you play will be determined by a coin toss." Indifference was thus allowed and operationally defined in conformance with Theory 3.

After all subjects had completed part 1, the instructions and part 1 were collected and the instructions for part 2 were distributed. For part 2 of the experiments the subjects were asked to give their reservation prices for each of the twelve bets (the order of presentation was randomized). Specifically, subjects were asked "What is the *smallest* price for which you would sell a ticket to the following bet?"[5]

In order to ensure that actual reservation prices were revealed, the method suggested by Becker, DeGroot, and Marschak was employed. If one of the twelve items were chosen to be played at the end of the experiment, an offer price between $0.00 and $9.99 would be randomly generated and the subjects would play the gamble if their announced reservation price exceeded the offer price. Otherwise they would be paid the offer price (in addition to the $7 credit).[6] Thus our procedures

[3]This was the only difference in the instructions between the two rooms. In the other room also, a decision was to be chosen randomly at the end of the experiment. However, it was stated that this was just for fun as people often wish to know how much they would have won.

[4]In each pair the bets were referred to as *A* and *B*. Assignment of *P* bets and $ bets to *A* or *B* was done randomly. On all materials passed out students were told to write their name, Social Security number, and in the room where payoffs were uncertain, their address.

[5]Announced preferences and those inferred from reservation prices should agree, but as this need not be the case with buying prices, no experiments involving buying prices were considered.

[6]The offer prices were generated by making three draws (with replacement) from a bingo cage containing balls numbered 0–9, these three draws giving the digits of the offer price.

conformed to those used in many other experiments and the problems raised by Theory 1 were avoided.

In order to be sure that all subjects fully understood how payments were to be determined, the instructions to part 2 were rather elaborate. The details, which can be found in the Appendix, include the following: an explanation about why it was in the subjects' best interest to reveal their true reservation prices; a practice gamble; a demonstration of the procedures; and a written test. The correct answers to the test were discussed and subjects' questions were answered. These procedures were designed to anticipate the problems raised by Theory 10. Subjects were allowed to work at part 2 at their own pace and were allowed to determine selling prices in whatever order they pleased.

Part 3 was identical to part 1 except that the remaining three pairs of bets were presented as shown on Table 3. Again, for each pair, subjects were asked to indicate a preference for bet *A*, bet *B*, or indifference. This procedure controls for a possible order effect implicit in the "cost of decision making" arguments of Theory 8. Once the subject has "invested" in a rule which yields a precise dollar value, then he/she would tend to use it repeatedly when the opportunity arises. Thus, we might expect greater consistency between decisions of parts 2 and 3 than between those of parts 1 and 2. After completing this part of the experiment, the subjects were paid as described.

B. *Procedures: Experiment 2*

The purpose of this experiment was to test the strategic behavior theory described as Theory 4. The structure of the experiment was identical to that of experiment 1 with two major exceptions. First, section 2 of the experiment was replaced at points by a section in which "limit prices" were extracted without references to market-type behavior. Second, subjects were not partitioned according to the method of payment. All subjects were paid with the same procedure as group 2 in experiment 1.

The organization of experiment 2 is shown in Table 4. Subjects were randomly divided into two rooms (the same two as used before) and designated as group 1 and group 2. Each group received identical instructions except the order in which the parts were administered was different as shown in Table 4.

TABLE 4—EXPERIMENT 2

Parts	Group 1	Group 2
	Monetary Incentives	
1	Preferences for Pairs (1), (2), (3)	
2	Selling Prices, All Twelve Gambles	Dollar Equivalents, All Twelve Gambles
3	Preferences for Pairs (4), (5), (6)	
4	Dollar Equivalents, All Twelve Gambles	Selling Prices, All Twelve Gambles

Part 2 for group 1 and part 4 for group 2 were identical to part 2 of experiment 1. Part 4 for group 1 and part 2 for group 2 consisted of a new section. In this new section no words suggestive of market-type activity (for example, selling prices and offer prices) were used. Instead students were asked to give "the exact dollar amount such that you are indifferent between the bet and the amount of money." For the operational details of how this was accomplished the Appendix should be consulted.

III. Results

A. *Experiment 1*

Table 5 summarizes the results for the room in which the subjects' payment was independent of their choices. It is clear that the reversal phenomenon has been replicated: of the 127 choices of *P* bets, 71 (56 percent) were inconsistent with the announced reservation prices. By comparison only 14 (11 percent) of the 130 choices of $ bets were contradicted by the quoted reservation prices. Allowing the subjects to express indifference appears to have had little impact as in only 7 (3 percent) of the 264 choices made, was indifference indicated.

The propensity to reverse was the same for preferences obtained before and after selling prices for both types of bets. Thus, if asking

TABLE 5—FREQUENCIES OF REVERSALS, EXPERIMENT 1 (NO INCENTIVES)

			Reservation Prices		
	Bet	Choices	Consistent	Inconsistent	Equal
Total	*P*	127	49	71	7
	$	130	111	14	5
Indifferent		7			
Before Giving	*P*	73	30	39	4
Prices	$	56	48	5	3
After Giving	*P*	54	19	32	3
Prices	$	74	63	9	2
$n = 44$					

for selling prices focuses attention on the dollar dimension, it does not stay focused on it. The proportions in which *P* bets and $ bets were chosen before pricing differed significantly from those obtained after the prices (significant at .025 but not at .01). No other statistically significant effects were found.

Table 6 shows the corresponding data for the room in which the decisions were made for real money. Clearly (and unexpectedly) the preference reversal phenomenon is not only replicated, but is even stronger. Seventy percent of the choices of *P* bets were inconsistent with announced selling prices while reversals occurred for just 13 percent of the $ bet choices. Choice patterns and reversal rates appear to be the same for choices made before and after obtaining selling prices. The only significant differences between the performance in the two rooms are a higher proportion of selections of the $ bet in the incentive room (easily significant at .01 levels) and also a greater proportion of reversals on *P* bets (just clears the bar at .05).

We calculated a variety of summary statistics on the prices. The prices for $ bets tend to be higher than the prices for the corresponding *P* bets and were above their expected values. The distributions are apparently different for the two types of bets. In all twelve cases the mean, median, and estimated standard deviations were greater for the $ bet than for the corresponding *P* bet. There does not seem to be any systematic difference between the prices quoted in the two rooms. For each of the twelve bets the hypothesis of equal means was rejected only once (the *P* bet in pair number 2), and the t-statistic was just significant at a .05 level. From Table 7 one can see that not only were the preference reversals frequent, but also large. The magnitude of the reversals is generally greater for the predicted reversals than for the unpredicted reversals and also tends to be some-

TABLE 6—FREQUENCIES OF REVERSALS, EXPERIMENT 1 (WITH INCENTIVES)

			Reservation Prices		
	Bet	Choices	Consistent	Inconsistent	Equal
Total	*P*	99	26	69	4
	$	174	145	22	7
Indifferent		3			
Before Giving	*P*	49	15	31	3
Prices	$	87	70	12	5
After Giving	*P*	50	11	38	1
Prices	$	87	75	10	2
$n = 46$					

TABLE 7—EXPERIMENT 1: MEAN VALUES OF REVERSALS
(In Dollars)

	Predicted		Unpredicted	
Bet	Incentives	No Incentives	Incentives	No Incentives
1	1.71	2.49	.40	.79
2	1.45	2.64	.51	.90
3	1.48	1.29	1.00	.25
4	3.31	5.59	3.00	1.83
5	1.52	1.79	.38	1.29
6	.92	1.18	.33	.31

what smaller for the group with incentives "on." Thirty-four individuals (20 in the incentives room and 14 in the other) reversed every time they chose a *P* bet and of the 24 individuals who never reversed, 14 of them always chose the $ bet.

B. *Experiment 2*

Tables 8 and 9 summarize the results of experiment 2. Clearly the preference reversal phenomenon has again been replicated, and the strategic or bargaining behavior explanation shot down. If this explanation had been correct, reversals should have been obtained when using selling prices and not when dollar equivalents were asked for. It is apparent from the tables that this simply is not the case. Further, this theory would have predicted that selling prices should be higher than the monetary equivalents, but this is not true either. The mean selling price exceeded the mean equivalent in only ten of the twenty-four cases. Again, in every instance the mean price and dollar amount for a $ bet exceeds the respective means for the corresponding *P* bet. For each bet six *t*-tests(testing equality of means within and between rooms) were calculated. Of the seventy-two tests calculated the null hypothesis was rejected four times at a significance level of .05 and never at the .01 level. The overall conclusion is that the results obtained using prices and dollar equivalents are essentially the same. In both rooms and by both prices and equivalents approximately one-half the subjects reversed whenever they

TABLE 8—EXPERIMENT 2: SELLING PRICES
GROUP ONE

	Bet	Choices	Consistent	Inconsistent	Equal
				Selling Prices	
Total	*P*	44	8	30	6
	$	72	54	15	3
Indifferent		4			
Preferences	*P*	20	5	12	3
before Prices	$	39	24	12	3
Indifferent		1			
Preferences	*P*	24	3	18	3
after Prices	$	33	30	3	0
Indifferent		3			
				Equivalents	
Total	*P*	44	4	34	6
	$	72	59	11	2
Indifferent		4			
$n = 20$					

TABLE 9—EXPERIMENT 2: EQUIVALENTS
GROUP TWO

	Bet	Choices	Consistent	Inconsistent	Equal
				Equivalents	
Total	*P*	44	16	27	1
	$	64	54	9	1
Indifferent		0			
Preferences	*P*	22	8	14	0
before	$	32	27	4	1
Equivalents					
Preferences	*P*	22	8	13	1
after	$	32	27	5	0
Equivalents					
				Selling Prices	
Total	*P*	44	19	22	3
	$	64	51	10	3
$n = 18$					

chose a *P* bet. The number of individuals who chose a *P* bet at least once and never reversed varied between two and four.

IV. Conclusion

Needless to say the results we obtained were not those expected when we initiated this study. Our design controlled for all the economic-theoretic explanations of the phenomenon which we could find. The preference reversal phenomenon which is inconsistent with the traditional statement of preference theory remains. It is rather curious that this inconsistency between the theory and certain human choices should be discovered at a time when the theory is being successfully extended to explain choices of nonhumans (see John H. Kagel and Raymond C. Battalio, 1975, 1976).

As is clear from Table 1 our design not only controlled for the several possible economic explanations of the phenomena, but also for all but one of the psychological theories considered. Note that all the theories for which we exercised control can be rejected as explanations of the phenomena. Thus several psychological theories of human choice are also inconsistent with the observed preference reversals. Theory 8 is rejected since reversals do not go down as rewards go up. Theories 6 and 7 are rejected since the original results of Lichtenstein and Slovic (1971) have been replicated.

The one theory which we cannot reject, 9, is in many ways the least satisfactory of those considered since it allows individual choice to depend upon the context in which the choices are made. For example, if the mode of response or the wording of the question is a primary determinant of choice, then the way to modify accepted theory is not apparent. Even here, however, we have additional insight. If the questions give "cues" which trigger a mode of thinking, such cues do not linger. The reversals occur regardless of the order in which the questions are asked.

The fact that preference theory and related theories of optimization are subject to exception does not mean that they should be discarded. No alternative theory currently available appears to be capable of covering the same extremely broad range of phenomena. In a sense the exception is an important discovery, as it stands as an answer to those who would charge that preference theory is circular and/or without empirical content. It also stands as a challenge to theorists who may attempt to modify the theory to account for this exception without simultaneously making the theory vacuous.

APPENDIX

These instructions are those given to group 1 in experiment 2. From these, with the help of Tables 3 and 4 and the test, the instructions for all experiments can be reproduced. In

order to save space only those portions containing detailed instructions and examples used are shown. For example, part 1 consists of three similar items only one of which is shown.

Instructions

The experimenters are trying to determine how people make decisions. We have designed a simple choice experiment and we shall ask you to make one decision in each of several items. Each decision you shall make will involve one or more *bets*. If a bet is played, then one ball will be drawn from a bingo cage that contains 36 balls numbered 1, 2, . . . , 36. Depending upon the nature of the bet, the number drawn will determine whether you lose an amount of money or win an amount of money. Bets will be indicated by Figure 2. For example, if you play the following bet, then you will lose $1 if the number drawn is less than *or equal to* 12, and you will win $8 if the number drawn is greater than 12.

You will be paid in the following fashion. We first give you $7. After you have made a decision on each item, one item will be chosen at random by drawing a ball from a bingo cage. The bet(s) in the chosen item will then be played. You will be paid an amount depending upon your decisions and upon the outcomes of the bets in the chosen item—any amount you win will be added to the $7, and

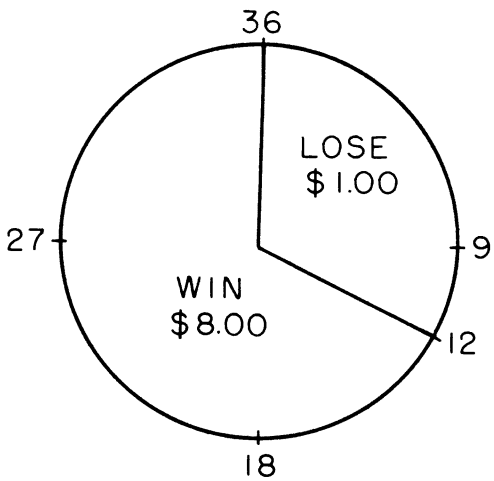

FIGURE 2

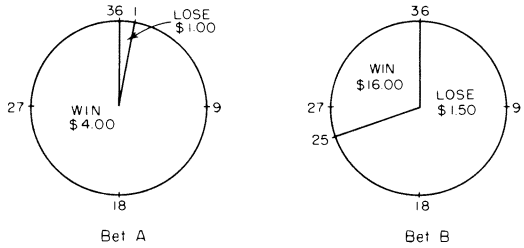

FIGURE 3

any amount you lose will be subtracted from the $7. However, the most you can lose on a bet is $2, so you will certainly receive at least $5. All actual payments will occur after the experiment.

PART 1: If an item from this part is chosen at the end of the experiment, you will play the bet you select. If you check "Don't care," the bet you play will be determined by a coin toss.

Item 1: Consider carefully the following two bets shown in Figure 3.

Suppose you have the opportunity to play one of these bets. Make *one* check below to indicate which bet you would prefer to play:

Bet *A*:_____

Bet *B*:_____

Don't care:____

. . . the instructions continue to items 2 and 3 from Table 2 . . .

PART 2: *Instructions*: In each of the items below, you have been presented a ticket that allows you to play a bet. You will then be asked for the *smallest* price at which you would sell the ticket to the bet.

If an item from this part is chosen at the end of the experiment, we will do the following. First, a bingo cage will be filled with 10 balls numbered 0, 1, 2, . . . , 9. Then 3 balls will be drawn from this cage, with each ball being replaced before the next is drawn. The numbers on these 3 balls will determine the digits of an offer price between $0.00 and $9.99, with the first number being the penny (right) digit, the second number the dime (middle) digit, and the third number the dollar (left) digit. If this offer price is greater than or equal to the price you state is your

minimum selling price for the item's bet, you would receive the offer price. If the offer price is less than your selling price, you would play the bet and be paid according to its outcome.

It is in your best interest to be accurate; that is, the best thing you can do is to be honest. If the price you state is too high or too low, then you are passing up opportunities that you prefer. For example, suppose you would be willing to sell the bet for $4 but instead you say that the lowest price you will sell it for is $6. If the offer price drawn at random is between the two (for example $5) you would be forced to play the bet even though you would rather have sold it for $5. Suppose that you would sell it for $4 but not for less and that you state that you would sell it for $2. If the offer price drawn at random is between the two (for example $3) you would be forced to sell the bet even though at that price you would prefer to play it.

Practice Item: What is the *smallest* price for which you would sell a ticket to the following bet? _____. (The group is then shown the same bet as Figure 2.)

Item 0:[7] What is the *smallest* price for which you would sell the following bet shown in Figure 4?_____

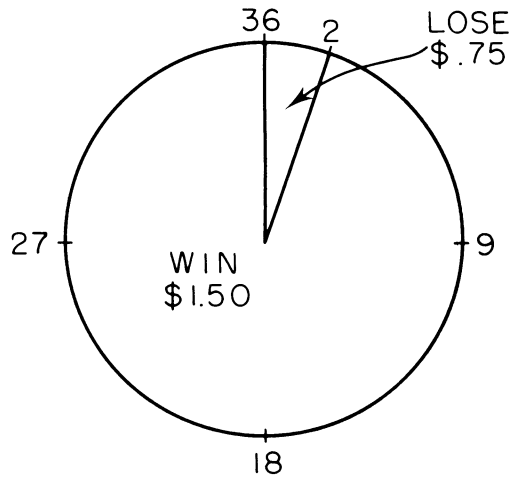

FIGURE 4

[7]Item 0, listed here, and item 00, with $7 with 15/36, lose $1.25 with 21/36, were given as a "test" prior to undertaking part 2.

The offer price is $___. ___.

The number drawn for the bet was _____.

If this item had actually been played, the amount I would (circle the correct word) gain lose is _____.

. . . (see fn. 7) . . .

Item 4: What is the *smallest* price for which you would sell a ticket to the following bet shown in Figure 5? _____

. . . continue with all items in Table 2 . . .

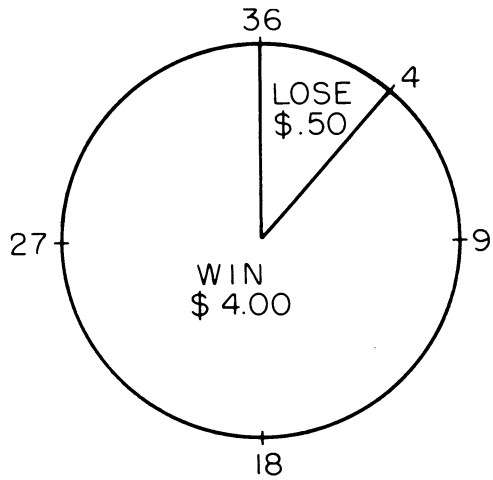

FIGURE 5

PART 3: The items below are like the items of part 1. If one of them is chosen at the end of the experiment, you will play the bet you select. If you check "Don't care," then the bet you play will be determined by a coin toss.

Item 16: Consider carefully the following two bets shown in Figure 6:

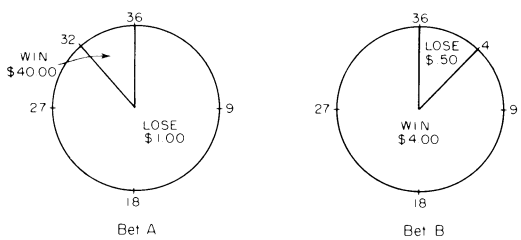

FIGURE 6

Suppose you have the opportunity to play one of these bets. Make *one* check below to indicate which bet you would prefer to play:

Bet *A*:_____

Bet *B*:_____

Don't care:____

. . . continue with items 4, 5, and 6, Table 2 . . .

PART 4: *Instructions*: Each of the items in this part shows a bet and a monetary scale. As in the example below the dollar amounts increase as you go from the bottom to the top of the scale. (The group is then shown the same bet in Figure 2 plus the scale shown in Figure 7.)

For each item in this part we ask you to do the following. Put your finger at the bottom of the scale and ask yourself which you would prefer to have—the bet shown or the dollar amount. In this case the bet offers 24 chances out of 36 of winning $8 and 12 chances of losing $1. We assume you prefer the bet to giving up $2. Now move your finger up the scale towards the top continuing to ask the same question. At the very top of the scale is an amount of money greater than that which could be won on the bet. We assume you would prefer the $10 to the bet. All scales in this part will be constructed so that for some of the numbers at the bottom you will prefer to have the bets and for some at the top you will prefer to have the money. What we would like to know is this: what is the exact dollar amount such that you are indifferent between the bet and the amount of money. Mark this amount (with an X) on the scale. Since X's are not always easy to read, and as the scale may not be fine enough for you, we also ask that you write the amount checked in the space provided.

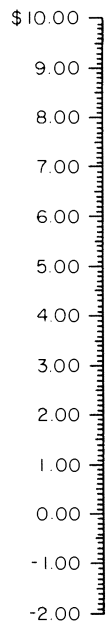

FIGURE 7

In order to provide you with an incentive to be as accurate as possible, we will do the following. If an item from this part is chosen, we will randomly choose one of the numbers shown on the scale. For example, for this scale a bingo cage would be filled with 10 balls numbered 0, 1, 2, . . . , 9. Then 3 balls would be drawn with replacement. The numbers on these 3 balls will determine an amount of money with the first ball drawn being the penny (right) digit, the second number the dime (middle) digit, and the third number the dollar (left) digit. If this number is greater than the amount you check, you will receive the number *drawn*. If the number is less than the amount checked, we will play the bet and you will be paid according to its outcome. If the number drawn is the same as the amount checked, the toss of a fair coin will determine whether you play the bet or get the money. As in this example, we will never generate any negative numbers, but all positive numbers shown on the scale will be equally likely.

Notice that your best interest is served by accurately representing your preference. The best thing you can do is be honest. If the number you mark is too high or too low, then you are passing up opportunities that you prefer. For example, suppose $4 is your point of indifference but you marked $6. If the amount of money drawn at random is anything between the two (for example, $5), you would be forced to play the bet even though you would rather have the drawn amount. Suppose your point of indifference was $4 and you marked $2. If the amount of money drawn at random is between the two

(for example, $3) then you would be forced to take the money even though you prefer to play the bet.

Item 0: (The group is shown the bet in Figure 4 and the monetary scale in Figure 7.)

The dollar amount drawn was $__.__
The number drawn for the bet was _____.

If this item had actually been played, the amount I would (circle the correct word) gain lose is _____.

. . . see fn 7 . . .

PART 5:

Item 19: On the scale mark the exact dollar amount such that you are indifferent between the bet and the amount of money. (The group is shown the same bet as Figure 5, and the monetary scale in Figure 7.) . . . continue with Items 1 through 6, Table 2 . . . .

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