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Financial Engineering and Rationality: Experimental Evidence Based on the Monty Hall Problem

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Abstract - Financial engineering often involves redefining existing financial assets to create new financial products. This paper investigates whether financial engineering can alter the environment so that irrational agents can quickly learn to be rational. The specific environment we investigate is based on the Monty Hall problem, a well-studied choice anomaly. Our results show that, by the end of the experiment, the majority of subjects understand the Monty Hall anomaly. Average valuation of the experimental asset is very close to the expected value based on the true probabilities.

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Psychologists and experimental economists have collected convincing evidence that many agents regularly violate the rationality assumptions usually made by financial economists. Most recent research in behavioral finance investigates the theoretical and empirical consequences. The present paper, however, explores a rather different behavioral question: can financial engineering ever reduce or eliminate irrationality?

Financial engineering can be defined as "combining or carving up existing financial assets to create new financial products" (Harvey, 2005). Such products allow agents to trade positions that are otherwise more costly or even unavailable. But perhaps financial engineering has additional impact, altering the environment so that agents can learn to behave more or perhaps less rationally. For instance, some investigators believe that "portfolio insurance," engineered in the mid 1980s, encouraged irrationality associated with the 1987 stock market crash.[1]

To investigate such questions, we conduct a controlled laboratory experiment based on the Monty Hall problem, one of the most persistent and best documented examples of irrational behavior. Using methods adapted from earlier studies, we first verify the presence of erroneous beliefs and choices. Next we engineer a specific financial asset that embeds the Monty Hall problem, and require individual subjects to value this asset. Finally, we repeat the initial test for the existence of the Monty Hall

[1] After the 1987 stock market crash, the government commissioned a presidential task force (the Brady Commission) to investigate causes of the crash, and to recommend measures to reduce the likelihood of future crashes. Although portfolio insurance was not the only cause of the crash, it was identified as a contributing factor (Fabozzi and Modigliani (2003), p. 269-270).

error. We do not conduct an actual market, so subjects can't learn from competitive prices or from observation of others' trading behavior. Nevertheless, by the end of the experiment, most subjects have learned to avoid the error. Indeed, to our knowledge, our final Monty Hall error rate is lower than in any other previous individual learning environment. We conclude that the mere act of valuing an appropriately engineered asset can be a powerful learning experience.

The rest of the paper is organized as follows. Section 2 discusses relevant previous research, and Section 3 presents the experimental design. The experimental results are reported in Section 4. Section 5 summarizes. Appendix A includes the instructions to subjects.

2. Background

Financial engineering and behavioral finance are two of the most currently popular topics in Finance, but there is not much prior research linking the two. The most relevant previous studies are concerned separately with framing effects in market experiments, and with the Monty Hall problem. We begin with the former topic.

2.1 Framing in markets

Framing effects refer to the possibility that alternative ways of posing an identical problem may affect agents' choices. Several sorts of framing effects are well-documented in individual choice experiments (See Camerer (1995) for a review). Financial engineering involves the creation of new financial assets from existing assets. As such, it can present investors with a re-framed version of the underlying decision problem, and may lead to different valuations.

Two prior studies examine framing in experimental asset markets. Kirchler, Maciejovsky and Weber (2004) study an asset market where the end of period payoff on the traded asset has a normal distribution with announced mean and variance. Positively framed subjects are also given the redundant information that there is a five percent chance that the next payoff will be higher than the corresponding .95 value, while negatively framed subjects are told that there is a five percent chance the next payoff will be lower than the corresponding .05 value. The authors report that positively framed subjects are more likely to be buyers and negatively framed subjects are more often sellers. Prices, however, are unaffected.

Weber, Keppe and Meyer-Delius (2000) study framing in an experimental asset market with a risky asset whose payoff depends on a drawing from an urn containing yellow and white balls. In positive frame treatments, some subjects are endowed with cash and shares of a white asset (W), which pays 100 if a white ball is drawn from the urn at the end of the period (and zero otherwise). In negative frame treatments, these subjects begin with a short position in yellow assets (Y), which pay 100 only if a yellow ball is drawn. Since a portfolio of one white share and one yellow share pays 100 for sure (W + Y = 100), a share of one asset is equivalent to cash and a short position in the other asset (W = 100 – Y). Negatively framed endowments substitute 100 - Y for each white share in the corresponding positively framed endowment. Although Weber, Keppe and Meyer-Delius use the term "endowment frame," they are clearly practicing financial engineering when changing from the positive frame (endowments with only long positions) to the negative frame (endowment containing a short position). The authors report higher asset prices in the negative endowment frame; subjects with short positions were willing to pay a higher price to buy assets to cover their short positions. Evidently subjects are not always maximizing expected utility, but the design can not tell us whether the divergence from rationality is occurring in the positive frame, the negative frame, or both.

2.2. The Monty Hall problem

The Monty Hall problem is a stylized version of a game from the classic TV show "Let's Make A Deal." Game show host Monty Hall asks a contestant to choose one of three doors. One of these doors conceals a valuable prize such as a new car while the other two doors conceal worthless prizes. After the contestant picks a door, Monty always opens one of the remaining doors and reveals one of the worthless prizes. Then Monty gives the contestant a chance to switch doors, that is, to choose the remaining door. The probability that the valuable prize is behind the original door is one-third, so switching to the remaining door has a two-thirds probability of winning. Thus the rational strategy is to switch. The contestant, however, refuses to switch in the belief that his strategy will win with probability (at least) one-half. [2]

The Monty Hall problem has been extensively studied in the laboratory, and the error is very common and very persistent. Indeed, even after having the error explained, many people cling to the belief that winning is equally likely whether or not the contestant switches. Such people include several professors, including a mathematician (e.g., Haddon, 2003, p. 61-65). Friedman (1998) finds an initial error rate of almost 90%, and even in his most intense learning environments the error rate seldom drops much below 50%; the overall error rate was about 70%. Page (1998) finds that even subjects trained in a rather transparent version (with hundred doors) typically revert to the error in the standard three door version. Slembeck and Tyran (2002) and Palacios-Huerta (2003)

[2] Friedman (1998) notes some gaps between this stylized version and the actual game show.

show that social learning (e.g., with group decisions) can be effective in overcoming the error, but confirm that the error persists in individual learning environments.

Kluger and Wyatt (2004) embed the Monty Hall problem into a financial asset in order to study whether the Monty Hall error aggregates into market prices. The asset features a conversion option that corresponds to switching doors. They find that asset prices do not reflect the Monty Hall error in sessions where two or more subjects are identified as understanding the problem based on their performance in the individual experiments.

Two results from these studies are especially pertinent to our experiment. First, Friedman's (1998) experiments demonstrate that repetition alone does not quickly eliminate the error. Friedman's control group repeated the Monty Hall exercise 25 times. Their switch rate over the first three repetitions was only 17%. Their final switch rate, based on the last three repetitions was only 37%. A one-tailed paired t-test rejects the null hypothesis that the final and initial switch rates are equal only at the 10% level. The Wilcoxon signed-rank test also rejects this null hypothesis at the 10% significance level. Subjects learn to avoid the error very slowly, if at all.

Second, the Kluger and Wyatt (2004) experiments demonstrate that simply translating the decision into the context of a financial asset does not automatically reduce the incidence of the Monty Hall error. In cases where there aren't two subjects who understand the Monty Hall problem, prices reflected the probability judgment error. The convertible asset design alone did not noticeably reduce the error.

3. Experimental design

We conducted an individual choice experiment with 40 subjects recruited from the undergraduate population at the University of California at Santa Cruz. Each of the five sessions lasted approximately ninety minutes, including instructions, with average payouts of about twenty dollars per subject, paid in cash at the end of the session.

<u>**Table 1**</u>

Table 1 presents the experimental design. Each session consists of five separate blocks, with each block containing one to sixteen periods of a given task. There are two types of tasks, choice tasks and valuation tasks, which we now describe.

3.1 Choice task

Our choice task is a modified version of the Monty Hall problem. As in Friedman (1998) and subsequent laboratory studies, each period the subjects see three ordinary playing cards, placed face-down on a mat. They are informed that two of the cards are red (hearts or diamonds), and one is black (clubs or spades). One of the subjects (selected on a rotating basis) chooses one of three face-down cards to be the set-aside card, and the card is moved to the marked position on the mat. Then, the person conducting the experiment looks privately at the two remaining cards, and always reveals one of them to be a red card. Finally, subjects are asked to choose either the set-aside card, or the remaining card. All subjects privately mark their choice on a form. After collecting the form, the conductor turns over both of the face-down cards. If a subject correctly chose the black card, he or she earns sixty cents. If incorrect, the subject earns nothing. The sequence of events for a choice task period is presented in Figure 1.

<u>**Figure 1**</u>

Choosing the remaining card in this choice task corresponds to switching doors in the Monty Hall problem. The remaining card has a two-thirds probability of winning, while the set-aside card has only a one-third chance of winning. Therefore, a subject who correctly assesses the probabilities should always choose the remaining card. The common judgment error is to believe that each card is equally likely to win. Subjects with this erroneous belief would regard all choices as having the same expected payoff, and so might indulge in any choice pattern.

3.2 Valuation task

The choice task requires subjects to decide whether or not to switch cards. The valuation task alters the Monty Hall problem, no longer requiring subjects to choose between the set-aside and the remaining card, but instead requiring subjects to determine a price at which they will sell a claim that pays cash if one of the unpicked cards is black. We use a choice menu procedure that can be regarded as a simplified version of the Becker-DeGroot-Marschak (1964) procedure for eliciting subjects' valuations. The task has three variants, which we call R (revealed), U (unrevealed) and U+R (both).

At the start of each R period, each subject is given one share of an asset that pays the bearer sixty cents if the remaining card that period is black and pays nothing otherwise. As in the choice task just described, three cards are placed face-down on the mat, one of the subjects chooses the set-aside card, and the conductor reveals a red remaining card. Each subject is then given the chance to sell his or her share. The set of possible prices is 27, 29, 31, 33, 35, 37, 39, 41 or 43 cents, with the actual price determined by a random drawing from a bingo cage. Subjects fill out a form asking them to choose whether or not to sell their share at each of the possible prices. The random drawing then determines the share price for the period. Finally, as before, the face-down cards are turned over. Subjects who chose to sell at the price drawn receive that amount. Subjects who decided to keep the share will receive sixty cents only if the remaining card is black.

If a subject correctly assesses the probabilities, then the expected value of the share is forty cents; it is the sixty cent payoff if the remaining card is black times the two-thirds probability of that event. An incorrect belief that the black card is equally likely to be either the set-aside card or the remaining card leads to the incorrect expected value of thirty cents.

The U (unrevealed) periods are identical to the R periods, except that both remaining cards stay face-down until the last step; U periods skip the step where the conductor reveals a red set aside card. Therefore both remaining cards are face down when the subject is asked to value the asset, which will in effect pay sixty cents if either of the two remaining face-down cards is black. Of course, determining value while both remaining cards are face-down does not affect the true valuation of the share, because revealing a red card is always feasible whether or not one of the remaining cards is black.

The U+R (both) periods require the subjects to value the shares twice. Exactly as in the other periods, one of the subjects chooses the set-aside card. Subjects then value their shares by circling either "keep" or "sell" at each of the possible prices. Next, one of the remaining cards is turned over, always revealing a red card. Subjects again value their shares by circling "keep" or "sell", but on a second form. However, only one of the forms will count. A subject spins a six-sided die to determine whether the earlier form (a roll of 1, 2 or 3) or the later form (4, 5, or 6) will be active. Finally the price is determined according to a bingo drawing. Subjects who circled sell at that price on the active form will then sell their share.

The sequences of events for the R, U, and U+R periods are diagrammed in Figure 2.

<u>**Figure 2**</u>

4. Results

The results for each block of the experiment are presented in sequence. We will see that the Monty Hall error is prevalent in the beginning, but declines considerably by the end of the session. We focus on when in the intermediate blocks most of the subjects learn to behave optimally.

4.1 Initial choice task

In Block A, subjects chose either the set-aside card, or the remaining card. The remaining card is the optimal choice, giving the subject twice the chance of picking the black card and earning the sixty cent payoff. The results are presented in Table 2.

<u>**Table 2**</u>

R% represents the percentage of the time (out of eight periods) that a subject chose the remaining card, the optimal choice. Across all subjects, the average R% was 58%, significantly higher than in some previous studies. (Possible reasons are discussed in section 4.4 below). There are no obvious time trends within Block A; by period the average R% were 67.5%, 52.5%, 37.5%, 53.5%, 52.5%, 80%, 60%, and 65%. Seven of the forty subjects picked the remaining card every time (R% = 100%).[3] Three subjects

[3] We cannot safely assume that all of these subjects understand the correct probabilities. If a subject believes that the remaining and the set-aside card are equally likely, then the expected payoff is the same

had an R% of zero. The remaining thirty subjects sometimes chose the set-aside card, and other times chose the remaining card.

Table 2 includes a chi-square goodness-of-fit test of the null hypothesis that R% follows a binomial distribution (with p = 50%); i.e., that subjects are equally likely to make either choice each period. The test rejects the null hypothesis at a significance level of .001. The reason is that both tails, R% = 100% and R% =0, occur far too often in the sample. However, if the tails are dropped, i.e., we exclude the subjects who always choose remaining and who always choose set-aside, then the p-value becomes .14, and we cannot reject the null hypothesis. That is, many of the subjects appear to choose randomly in the first block.

4.2 Valuation tasks

Block B consists of sixteen periods of the valuation task, alternating between R periods (where one of the remaining cards is revealed before eliciting values) and U periods (where both remaining cards are left face-down). Of course, each subject's response on the menu determines a range of values, not an exact value. For our analysis, we assigned the midpoint of the range for intermediate choices. For example, if a subject kept the share at 33 cents but sold at 35 cents and above, then the assigned value is 34 cents. For extreme choices the value is conservatively assigned to be a penny past the endpoint. Thus if the subject sold at every price, his or her value is between zero and 27 cents, and we assigned the value of 26 cents. Likewise, a subject who kept at every price is assigned the value of 44 cents.

<u>*Table 3**</u>

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for any R%. In fact, three of these seven subjects did not choose the remaining card every time in the subsequent choice-task periods at the end of the session.

Recall that the rational expected value is 40 cents and that the Monty Hall error implies an expected value of 30 cents. In U periods, the error should not arise because both of the remaining cards are face-down. Table 3 shows that indeed the average valuation for the U periods in Block B is 39.50 cents, very close to the expected value of forty cents. The table also reports the results of two Wilcoxon signed-rank tests. The "L40" tests the null hypothesis that the subject's valuation is forty against the one-sided alternative hypothesis that the subject's valuation is less than forty. The null hypothesis is rejected at a p-value of .05 in U periods for only ten of the forty subjects. The "G30" tests the null that the subject's valuation is thirty against the one-sided alternative hypothesis that the subject's valuation is greater than thirty. For the U periods, the null is rejected for 39 of 40 subjects at a p-value of .05. Thus all evidence indicates that subjects value shares correctly in U periods of Block B.

In the R periods, some subjects are making the Monty Hall error, but others are not. The average valuation is 37.68 cents. The rational null hypothesis in the "L40" test is rejected for one-half of the subjects in the direction of the Monty Hall error. However, the irrational null hypothesis in the "G30" test is rejected for 35 of 40 subjects in the rational direction. Apparently the error is present in Block B but in diluted form.

Table 4

The experimental design permits another diagnostic test in Block B, comparing each subject's valuations in the R periods to his or her valuation in the U periods. The null hypothesis, that the values are the same, corresponds to rational beliefs. Table 4 shows that the null hypothesis is rejected using either the paired t-test, or the Wilcoxon signed-rank test. Once again we conclude that the Monty Hall error is present in this block, at least to some degree.

Table 5

In the next Block, each subject's valuation was elicited twice per period, both before and after one of the remaining cards was revealed to be red. Table 5 shows that the averages are almost the same: 39.36 cents before, and 39.57 after. The averages are very close to forty, the true expected payoff value. The rational L40 null hypothesis is rejected for 16 subjects in the before data and for 13 in the after data, fewer than in the R periods of Block B but more often than in the U periods.[4] Overall, there is less evidence of the Monty Hall error in Block C. Indeed, the irrational G30 null hypothesis that the asset value equals 30 is rejected for thirty-eight of forty subjects before, and thirty-nine of forty after, the remaining card is revealed to be red. Virtually all subjects have learned that the shares are worth more than thirty.

Table 6

The experimental design permits another diagnostic test in Block C, comparing each subject's before and after valuations. Table 6 shows that we cannot reject the null hypothesis using either the paired-t or the Wilcoxon test. In conjunction with the result that average valuations are near forty, as well as the L40 and G30 results, this result confirms that the incidence of the Monty Hall error has declined further by Block C.

4.3 Solving the Monty Hall problem

In Block D, subjects return to the choice task of choosing either the remaining or the set-aside card. Table 7 shows that eight subjects are now choosing the remaining card

[4] Perhaps some subjects who make the Monty Hall error in Block B realize in Block C that the U and R valuations are inconsistent but make the incorrect adjustment of decreasing the before value towards 30. Evidently other subjects resolve the inconsistency correctly, adjusting the after value towards 40.

every time (R% = 100%), and only one subject is choosing the set-aside every time (R% = 0). The average R% has increased to 72%, well above the 58% rate in Block A. The binomial null hypothesis, that subjects are randomly choosing set-aside and remaining with equal likelihood, is now rejected, even when the R% = 0 and R% = 100% extremists are excluded.

Table 7

Table 8

Figure 3

Table 8 compares each subject's R% in Block A with their corresponding R% in Block D. The relation is plotted in Figure 3. Subjects above the forty-five degree line in Figure 3 chose the remaining card more often in Block D than they did in Block A. Twenty-five subjects are in this category. Seven subjects had the same R% in Block D and Block A, and only eight subjects had a lower R% in Block D than they did in Block A. Statistical tests confirm the increase in R%. The null hypothesis that R% is the same is rejected with $p < .01$ using either a paired t-test or a Wilcoxon signed-rank test.

Finally, Block E consists of a single period of the choice task, identical to earlier choice task periods except that the payoff for correctly choosing the black card is multiplied by ten. Almost 78% of the subjects chose the remaining card in Block E. The incidence of the Monty Hall error is significantly diminished by the end of the session.[5]

Table 8 also addresses the crucial question of exactly when subjects are learning to avoid the Monty Hall error. It contains the R% by subject for the choice task blocks, as well as both the initial and final period valuations by subject for the valuation task

[5] In the Friedman (1998) data and some other published data there is an unexplained and puzzling tendency for subjects to backslide towards irrationality in the last trial. Thus the 78% rationality rate in Block E is especially impressive.

blocks. By the end of Block B, the average valuation is already 39.15, very close to the correct expected value of forty. Statistical tests of the null hypotheses that the valuation is increasing during/across blocks are reported in Table 9.

Table 9

There is a statistically significant increase in valuation from the start of Block B to the end of Block B, but no subsequent significant increase. It seems that the majority of subjects who learn to solve the Monty Hall problem tend to do so in Block B.

4.4 Designating the set-aside card

The choice of the initial card may represent an important difference between our laboratory tasks and those of many other Monty Hall studies. For example, Friedman (1998) has each subject personally choose a card, and then decide later whether or not to switch. In our experiment only one subject (of 4 to 11 subjects in our sessions) picks a card each period, and the card is given the rather neutral label "set-aside." Subjects are not told that the initial card is theirs, nor do they have the opportunity to switch per se. It is possible that these differences in how the Monty Hall problem is presented are responsible for our lower initial error rate. Our procedures may reduce the force of regret avoidance, illusion of control and/or status quo bias (Camerer, 1995).[6]

Table 10

Table 11

Our experiment provides some indirect evidence on this issue. Recall that subjects took turns designating the set-aside card. Tables 10 and 11 respectively summarize

[6] Illusion of control refers to a subject's belief that his or her actions somehow influence random events. Status quo bias refers to an endowment effect where a subject will prefer (all else the same) his or her current choice simply because he or she already has it. See Slembeck (2001) for additional discussion of the relevance of these biases to the Monty Hall decision error.

subjects' choices and valuations, according to whether or not they designated the set-aside card. Table 10 reports a Fisher's exact test of the null hypothesis that the designators' likelihood of choosing the remaining card is the same as the non-designators.' The null hypothesis is never rejected. We do not detect any difference between designators' and non-designators' choices in any of the choice blocks.

Table 11 reports a paired t-test comparing individual subjects' valuations when they designated to their valuations when they did not designate the set-aside card. We find a small (less than a penny) but statistically significant difference in the before treatment in Block C. We detect no difference in the other three comparisons.

5. Summary

Subjects in our experiment learn to overcome the Monty Hall error, and the key learning experience appears to be practice in valuing an engineered financial asset. Before this learning experience, subjects in the Monty Hall choice task made the irrational choice (the "set-aside" card) 42% of the time overall. After the learning experience, the irrational choice rate fell to 28% overall and 22% in final choices. Of the 40 subjects, 13 made the irrational choice more than half of the time before the learning experience and only 5 after, while the number making the irrational choice no more than a quarter of the time rose from 14 to 26. Many studies have demonstrated the amazing strength and persistence of the Monty Hall error, and we are not aware of any individual learning treatment that reduced the error rate as much as our valuation task.

Would subjects have learned to solve the Monty Hall problem without the experience of valuing the financial asset? Our results indicate that the majority of subjects no longer made the Monty Hall error by the end of Block B. By this point subjects had performed a total of 24 repetitions (8 repetitions of the choice task, 8 U-period valuations, and 8 R-period valuations). In Friedman (1998), most of the control group subjects made the Monty Hall error throughout 25 repetitions of the choice task. Further, subjects in one or more of Friedman's learning treatments frequently made the decision error, even though many of the treatments did reduce the error rate. Even if subjects might learn to avoid the Monty Hall error after a sufficient number of repetitions of the choice task, our results suggest that experience with the valuation task speeds learning considerably.

Would valuing any financial asset have similar impact? The Kluger and Wyatt (2004) study suggests otherwise. Their subjects traded a convertible asset. In terms of our parameters, if not converted their asset pays 60 cents when the set-aside card is black (and nothing otherwise), while if converted it pays 60 cents when the remaining card is black. This more complex asset is equivalent to ours in terms of the uncertainty space spanned, and trading it helped to aggregate information. However, it did not noticeably reduce individuals' tendency to commit the Monty Hall error. We conclude that appropriate financial engineering can promote learning, above and beyond its ability to provide a wider span of securities at lower price.

Although our experiment shows that a particular asset design lowers the Monty Hall error rate, it does not explain why this design is effective. We only observe subjects' choices and valuations, not their reasoning. Nonetheless, the evidence is consistent with the following explanation. While all cards are still face-down, the majority of subjects probably believe that there is a one-third chance that the set-aside card is black. Subjects who are prone to the error likely believe that when the red card is revealed, there is an equal chance of either the remaining or set-aside card being black. Subjects who make this error therefore mistakenly believe that revealing the red card affects the chance that the set-aside card is black. We conjecture that designing the asset to pay based on the color of the remaining card makes it easier to see that revealing a red card has no effect on the probability. Once subjects realize this, they can correctly value the experimental asset. The convertible asset does not appear to encourage the same learning process.

Our results illustrate that security design can help subjects learn to avoid the Monty Hall error. Of course, the connection between financial engineering and learning may be a two-way street. If breaking down or combining assets to create new ones can promote rationality, the reverse must also be true. Recombining assets can also potentially promote irrationality.

The extent to which cognitive errors affect financial decisions and asset prices is an important question. Even though the Monty Hall anomaly is not a typical financial decision-making problem, it is a useful tool for studying cognitive errors, because the Monty Hall error is common, and it is very easy to detect. Our results suggest that in at least this setting, financial engineering can help foster individual rationality. Whether or not financial engineering has a similar effect in other laboratory or field financial markets requires further study. But it no longer seems safe to assume that financial engineering has no effect on market biases.

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TABLE 1
Experimental Design

A session of the experiment consists of five blocks, with each block consisting of one or more periods. The choice-task periods required subjects to choose between the set-aside card and the remaining card. The valuation-task periods required subjects to value the remaining card(s) using a simplified version of the Becker-DeGroot-Marschak method.

Block	Task	Number of Periods	Treatment
A	Choice	8	A red remaining card is always revealed.
B	Valuation	16	In R (odd-numbered) periods, a red remaining card is always revealed. In U (even-numbered) periods, both remaining cards are face-down.
C	Valuation	8	The valuation task is performed both before and after a red remaining card is revealed.
D	Choice	8	A red remaining card is always revealed.
E	Choice	1	A red remaining card is always revealed. Payoffs are times ten.

TABLE 2
Initial Incidence of the Monty Hall Error

Panel A

R% is the percentage over eight periods that a subject chooses the remaining card. Across all subjects, the average R% was 58.44% The row labeled Sample Frequency reports the number of subjects with each R%. The row labeled Expected Frequency contains the expected number of each R% if the subjects' choice was a binomial random variable with probability of one-half.

	R%								
	0%	12.5%	25%	37.5%	50%	67.5%	75%	87.5%	100%
Binomial Probability	0.00	0.03	0.11	0.22	0.27	0.22	0.11	0.03	0.00
Expected Frequency	0.16	1.25	4.38	8.75	10.94	8.75	4.38	1.25	0.16
Sample Frequency	3	1	3	6	4	9	4	3	7

Panel B

Chi-Square goodness-of-fit tests for the sample following a binomial distribution.

N = 40	χ^2	Prob
H_O Subjects ARE choosing remaining or set-aside randomly with equal probability.		
H_A Subjects ARE NOT choosing remaining or set-aside randomly with equal probability.		
	359.8	<.001

N = 30 (excluding observations with R% = 0% and R% = 100%)	χ^2	Prob
H_O Subjects ARE choosing remaining or set-aside randomly with equal probability.		
H_A Subjects ARE NOT choosing remaining or set-aside randomly with equal probability.		
	8.2	.14

TABLE 3
Average Valuations by Subject in Block B

Valuations are equal to the midpoint of the interval on the valuation forms, except for the endpoints, which are 26 (low) and 44 (high). In R periods, one of the remaining cards was revealed to be red prior to valuation. In U periods, both remaining cards were face-down. The L40 column reports a Wilcoxon signed-rank test that the subject's valuation equals 40, against the alternative that the valuation is less than 40. G30 tests the null that the subject's valuation is 30 against the alternative that the valuation is greater than 30. One asterisk (or two) rejects the null at p = .05 (or p = .01).

	R Periods				U Periods			
Subject	Average Valuation	Standard Deviation	L40	G30	Average Valuation	Standard Deviation	L40	G30
1	35.25	1.04	**	**	35.50	0.87	**	**
2	39.25	2.60		**	36.75	3.99	*	*
3	38.25	4.95		**	40.00	0.00		**
4	38.75	6.98		*	36.75	4.79		**
5	39.50	5.10		**	40.75	4.35		**
6	44.00	0.00		**	44.00	0.00		**
7	31.50	2.33	**		32.75	7.07	*	
8	36.50	4.50	*	**	39.25	2.63		**
9	42.00	1.51		**	44.00	0.00		**
10	39.00	4.41		**	42.00	3.87		**
11	34.75	2.12	**	**	40.50	2.18		**
12	36.00	3.55	*	**	44.00	0.00		**
13	34.50	4.24	*	**	31.50	1.32	**	*
14	40.00	0.00		**	40.00	0.00		**
15	35.00	4.94	*	*	35.50	0.87	**	**
16	37.50	2.78	*	**	44.00	0.00		**
17	39.50	0.93		**	40.50	0.87		**
18	41.75	6.36		**	44.00	0.00		**
19	42.75	3.54		**	41.50	4.33		**
20	39.25	6.58		**	40.50	5.17		**
21	37.75	6.45		*	37.50	5.36	**	*
22	37.00	3.70	*	**	33.25	3.60	**	*
23	42.75	1.04		**	41.75	1.20		**
24	39.75	3.77		**	40.00	3.46		**
25	37.75	0.71	**	**	38.25	0.66		**
26	35.75	2.49	**	**	39.00	3.32		**
27	41.25	4.13		**	39.50	4.77		**
28	30.75	2.38	**		38.50	4.77		**
29	39.25	3.54		**	38.25	3.38		**
30	32.25	2.92	**		39.25	1.98		**
31	31.00	6.41	**		44.00	0.00		**
32	38.50	0.93	*	**	38.50	0.87	*	**
33	36.00	3.55	*	**	38.75	2.99		**
34	34.13	2.03	**	**	35.50	5.55	*	*
35	39.75	3.77		**	39.25	1.39		**
36	43.50	1.41		**	44.00	0.00		**
37	42.25	4.95		**	44.00	0.00		**
38	35.50	6.02	*	*	41.50	2.18		**
39	35.25	4.89	*	*	41.50	6.61		**
40	32.00	3.70	**		34.00	4.00	**	**
ALL	37.68	5.05	20	35	39.50	4.65	10	39

TABLE 4
Comparing R and U Period Valuations in Block B

Paired t-test and Wilcoxon Signed rank test comparing a subject's average valuation in R periods to his or her average valuation in U periods. In R periods, one of the remaining cards was revealed to be red prior to valuation. In U periods, both remaining cards were face-down.

N = 40	t	Prob	Signed rank	Prob
H_O Subject average valuations in the R period EQUAL their average valuations in the U periods.				
H_A Subject average valuations in the R period are LESS THAN their average valuations in the U periods.				
	3.35	<.01	198	<.01

TABLE 5
Average Valuations by Subject in Block C

Valuations are equal to the midpoint of the interval on the valuation forms, except for the endpoints, which are 26 (low) and 44 (high). Valuations were elicited first before, and then after, one of the remaining cards was revealed. The L40 column reports a Wilcoxon signed-rank test that the subject's valuation equals 40, against the alternative that the valuation is less than 40. G30 tests the null that the subject's valuation is 30 against the alternative that the valuation is greater than 30. One asterisk (or two) rejects the null at p = .05 (or p = .01).

Subject	Average Valuation	After Standard Deviation	L40	G30	Average Valuation	Before Standard Deviation	L40	G30
1	39.75	0.71		**	39.50	1.41		**
2	39.75	0.71		**	39.25	1.49		*
3	40.00	0.00		**	40.00	0.00		**
4	41.50	3.51		**	38.25	1.28	*	**
5	44.00	0.00		**	44.00	0.00		**
6	44.00	0.00		**	44.00	0.00		**
7	39.25	5.44		**	35.75	7.13	*	*
8	39.25	5.55		**	39.50	3.34		**
9	43.75	0.71		**	44.00	0.00		**
10	44.00	0.00		**	44.00	0.00		**
11	43.50	1.41		**	43.50	1.41		**
12	37.50	0.93	**	**	44.00	0.00		**
13	31.25	1.49	**	**	30.75	1.49	**	
14	40.00	0.00		**	40.00	0.00		**
15	36.00	0.00	**	**	35.75	0.71	**	**
16	36.00	0.00	**	**	44.00	0.00		**
17	40.00	0.00		**	40.00	0.00		**
18	41.75	6.36		**	44.00	0.00		**
19	42.50	4.24		**	44.00	0.00		**
20	38.25	6.36		**	44.00	0.00		**
21	41.75	0.71		**	41.75	0.71		**
22	36.50	2.56	*	**	34.50	2.33	**	**
23	42.00	0.00		**	42.00	0.00		**
24	35.00	5.01	**	*	38.00	0.00	**	**
25	38.25	0.71	**	**	37.75	0.71	**	**
26	36.25	1.98	**	**	37.00	1.51	**	**
27	44.00	0.00		**	42.50	4.24		**
28	33.25	5.12	*		34.50	5.42	*	*
29	38.25	3.92		**	35.75	1.98	**	**
30	38.50	6.30		**	31.75	0.71	**	**
31	36.00	8.94			44.00	0.00		**
32	38.00	0.00	**	**	38.00	0.00	**	**
33	37.75	3.45		**	37.00	3.70	*	**
34	36.25	0.71	**	**	34.00	0.00	**	**
35	38.25	0.71	**	**	37.38	3.50	*	**
36	44.00	0.00		**	44.00	0.00		**
37	44.00	0.00		**	44.00	0.00		**
38	40.75	3.20		**	38.75	2.60		**
39	34.50	5.43	**	*	37.00	4.66		**
40	39.00	6.41		**	34.75	1.83	**	**
ALL	39.36	4.57	13	38	39.57	4.37	16	39

TABLE 6
Comparing Before and After Valuations in Block C

Values are elicited both before and after one of the remaining cards is revealed to be red. Paired t-test and Wilcoxon signed-rank test compare averages across subjects.

	N = 40	t	Prob	Signed rank	Prob
H_O Subject average valuations after the red card is revealed EQUAL average valuations before the card is revealed.					
H_A Subject average valuations after the red card is revealed are LESS THAN average valuations before the card is revealed.					
		.45	.33	-7.0	.56

TABLE 7
Incidence of the Monty Hall Error in Block D

Panel A

R% is the percentage over eight periods that a subject chooses the remaining card. Across all subjects, the average R% was 72.19%. The row labeled Sample Frequency reports the number of subjects with each R%. The row labeled Expected Frequency contains the expected number for each R% if the subjects' choice was a binomial random variable with probability of one-half.

	R%								
	0%	12.5%	25%	37.5%	50%	67.5%	75%	87.5%	100%
Binomial Probability	0.00	0.03	0.11	0.22	0.27	0.22	0.11	0.03	0.00
Expected Frequency	0.16	1.25	4.38	8.75	10.94	8.75	4.38	1.25	0.16
Sample Frequency	1	1	1	2	5	4	8	10	8

Panel B

Chi-Square goodness-of-fit tests for the sample following a binomial distribution.

N = 40	χ^2	Prob
H_O Subjects ARE choosing remaining or set-aside randomly with equal probability.		
H_A Subjects ARE NOT choosing remaining or set-aside randomly with equal probability.		
	476.2	<.001
N = 30 (excluding observations with R% = 0% and R% = 100%)	**χ^2**	**Prob**
H_O Subjects ARE choosing remaining or set-aside randomly with equal probability.		
H_A Subjects ARE NOT choosing remaining or set-aside randomly with equal probability.		
	77.9	<.001

TABLE 8
Responses by Block

R% is the average rate (out of eight periods) of a subject choosing the remaining card. Block B valuations are for the R periods only (when one of the remaining cards is revealed to be red). Block C valuations are the after (the red remaining card is revealed) valuations. Block E is a single period of the choice task. "Yes" signifies that the subject chose the remaining card. "No" signifies he or she chose the set-aside card.

Subject	Block A R%	Block B Initial Valuation	Block B Final Valuation	Block C Initial Valuation	Block C Final Valuation	Block D R%	Block E R
1	62.5%	34	36	38	40	75.0%	YES
2	75.0%	40	40	38	40	87.5%	YES
3	37.5%	26	40	40	40	75.0%	YES
4	50.0%	32	44	44	36	75.0%	YES
5	25.0%	34	44	44	44	87.5%	YES
6	50.0%	44	44	44	44	87.5%	YES
7	37.5%	32	32	36	30	62.5%	NO
8	75.0%	30	40	40	42	87.5%	NO
9	62.5%	40	44	44	44	50.0%	YES
10	25.0%	38	44	44	44	75.0%	YES
11	87.5%	34	40	44	44	100.0%	YES
12	0.0%	44	36	36	38	100.0%	YES
13	12.5%	34	34	32	30	25.0%	YES
14	100.0%	40	40	40	40	100.0%	YES
15	87.5%	34	36	36	36	87.5%	YES
16	75.0%	38	36	36	36	87.5%	YES
17	100.0%	38	40	40	40	100.0%	YES
18	62.5%	44	44	44	26	87.5%	YES
19	37.5%	34	44	44	44	75.0%	YES
20	50.0%	44	32	32	44	75.0%	YES
21	37.5%	30	42	42	42	50.0%	YES
22	75.0%	40	36	38	42	87.5%	YES
23	100.0%	44	42	42	42	100.0%	YES
24	25.0%	44	40	36	38	12.5%	NO
25	0.0%	36	38	38	40	0.0%	YES
26	62.5%	32	36	36	36	50.0%	NO
27	37.5%	34	36	44	44	50.0%	NO
28	62.5%	32	34	28	26	75.0%	YES
29	87.5%	36	44	40	38	62.5%	NO
30	100.0%	30	38	44	38	62.5%	NO
31	62.5%	26	44	26	44	75.0%	NO
32	50.0%	40	38	38	38	100.0%	YES
33	100.0%	34	34	36	36	37.5%	NO
34	62.5%	30	34	36	38	87.5%	YES
35	0.0%	40	40	40	38	100.0%	YES
36	100.0%	44	44	44	44	100.0%	YES
37	100.0%	44	44	44	44	87.5%	YES
38	37.5%	38	40	40	44	50.0%	YES
39	62.5%	36	34	36	40	37.5%	YES
40	62.5%	30	38	36	44	62.5%	YES
AVERAGE	58.4%	36.35	39.15	39.00	39.45	72.2%	77.5%

TABLE 9
Hypothesis Tests for the Monty Hall Error by Block

Panel A

Paired t-test and Wilcoxon signed rank test compare a subject's R% in Block A (at the start of the session) to his or her R% in Block D (at the end of the session). R% is the average rate (out of eight periods) of a subject choosing the remaining card.

N = 40	t	Prob	Signed rank	Prob
H_O A subject's R% in Block D EQUALS his or her R% in Block A H_A A subject's R% in Block D is GREATER THAN his or her R% in Block A				
	2.80	<.01	150.5	<.01

Panel B

Paired t-test and Wilcoxon signed rank test compare a subjects' initial R-period valuation (period 1) in Block B to his or her final R-period valuation (period 15) in Block B.

N = 40	t	Prob	Signed rank	Prob
H_O A Subject's last valuation in Block B EQUALS his or her first valuation in Block B. H_A A Subject's last valuation in Block B is GREATER THAN his or her first valuation in Block B.				
R periods	2.97	<.01	133.0	<.01

Panel C

Paired t-test and Wilcoxon Signed rank test compare a subjects' final R-period valuation (period 15) in Block B to his or her initial valuation (period 1, after the red card is revealed) in Block C.

N = 40	t	Prob	Signed rank	Prob
H_O A Subject's first valuation in Block C EQUALS his or her last valuation in Block B. H_A A Subject's first valuation in Block C is GREATER THAN his or her last valuation in Block B.				
R periods in Block B and After Valuations in Block C	-.25	.60	4.0	.57

Panel D

Paired t-test and Wilcoxon Signed rank test compare a subjects' final valuation (period 8, after the red card is revealed) in Block C to his or her initial valuation (period 1, after the red card is revealed) in Block C.

N = 40	t	Prob	Signed rank	Prob
H_O A Subject's last valuation in Block C EQUALS his or her first valuation in Block C. H_A A Subject's last valuation in Block C is GREATER THAN his or her first valuation in Block C.				
R periods in Block B and After Valuations in Block C	.54	.30	22.5	.22

TABLE 10
Choice Task and Designating the Set-Aside Card

Each period, one of the subjects had his or her turn to designate which card is the set-aside card. Fisher's exact test is used to test the hypothesis:

H_O Subjects who designated have an EQUAL probability of choosing the remaining card as subjects who did not designate.

H_A Subjects who designated have an UNEQUAL probability of choosing the remaining card as subjects who did not designate.

BLOCK A	Chose Remaining	Chose Set-Aside	Fisher's Exact Test Probability
Designated Set -Aside	22	18	
Did Not Designate	165	115	
			0.73

BLOCK D	Chose Remaining	Chose Set-Aside	Fisher's Exact Test Probability
Designated Set -Aside	25	15	
Did Not Designate	206	74	
			0.19

BLOCK E	Chose Remaining	Chose Set-Aside	Fisher's Exact Test Probability
Designated Set -Aside	4	1	
Did Not Designate	27	8	
			0.99

TABLE 11
Valuation Task and Designating the Set-Aside Card

Each period, one of the subjects had his or her turn to designate which card is the set-aside card. Block C valuations are the after (the red remaining card is revealed) valuations. Paired t-tests are used to test the hypothesis:

> H_O Subject's average valuation when designating EQUALS his or her average valuation when not designating.
>
> H_A Subject's average valuation when designating is NOT EQUAL to his or her average valuation when not designating

BLOCK B	Average* Valuation Designating	Average* Valuation Not Designating	t-statistic	Prob	Signed Rank	Prob	N
R Periods	36.33	36.98	0.92	0.37	-14	0.71	26
U Periods	39.96	40.07	0.28	0.78	2.5	0.91	26
BLOCK C							
Before	40.14	39.25	2.13	0.04	53.5	0.03	35
After	39.77	39.35	0.84	0.41	24	0.48	35

*These averages are calculated as follows. First the average valuations (for designating and not-designating periods) for each subject are calculated. These numbers are then averaged across subjects. For each block, only subjects who designated in some periods and did not designate in others are included.

FIGURE 1
The Sequence of Events for a Period of the Choice Task

Three ordinary playing cards are placed face-down on a mat with positions labeled 1, 2, and 3. Two of the cards are red (diamonds or hearts), and one is black (club or spade). One subject (a volunteer) chooses one of the cards, which is then designated as the set-aside card. The other two cards are designated as the remaining cards.

↓

The conductor looks at the two remaining cards and reveals one of them. The revealed card is always a red card.

↓

Each subject privately chooses either the set-aside card, or the remaining card. If the subject correctly chooses the black card, he or she wins sixty cents. If incorrect, the subject does not earn anything this period.

↓

Both the set-aside card and the remaining card are revealed.

FIGURE 2
The Sequence of Events for a Period of the Valuation Task

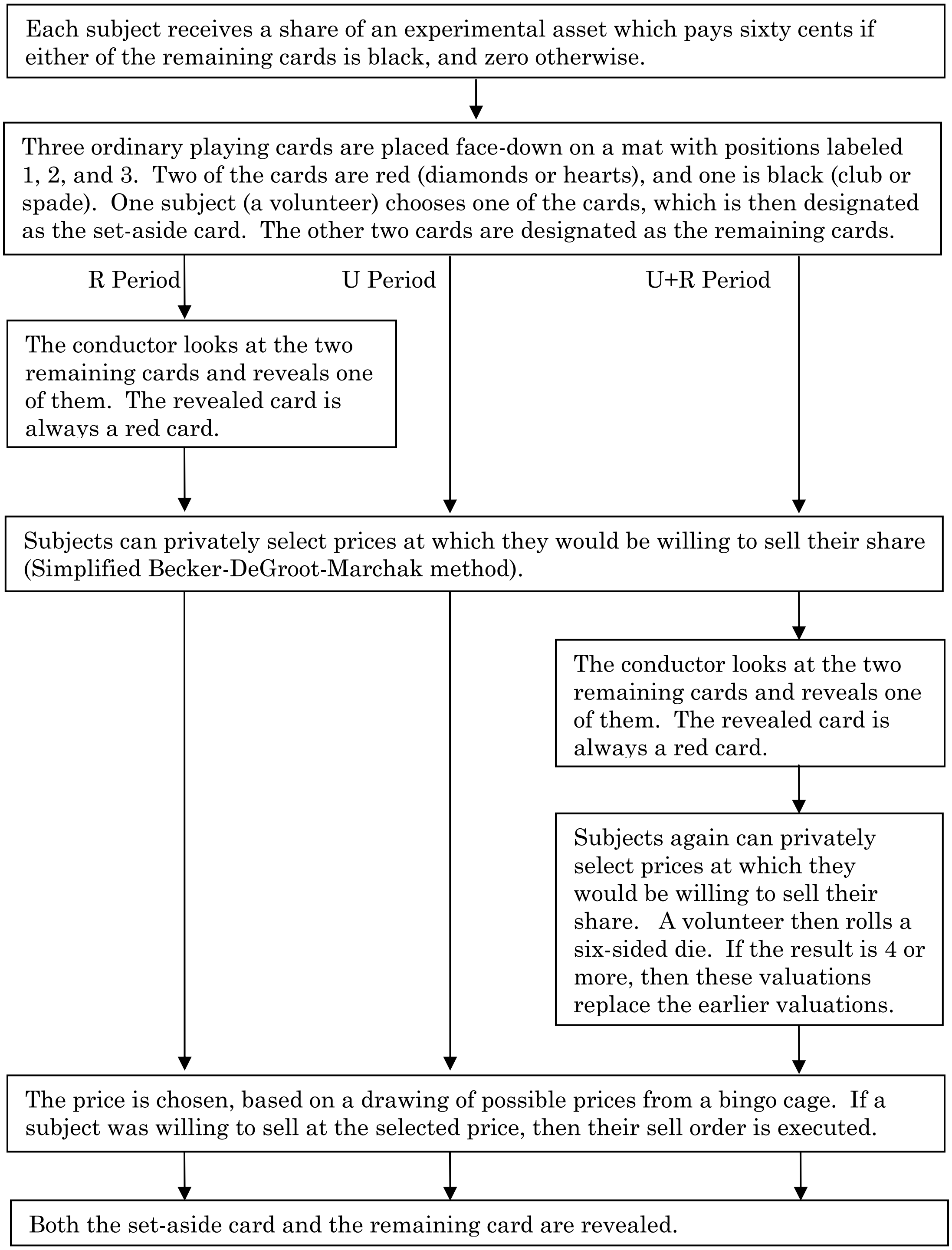
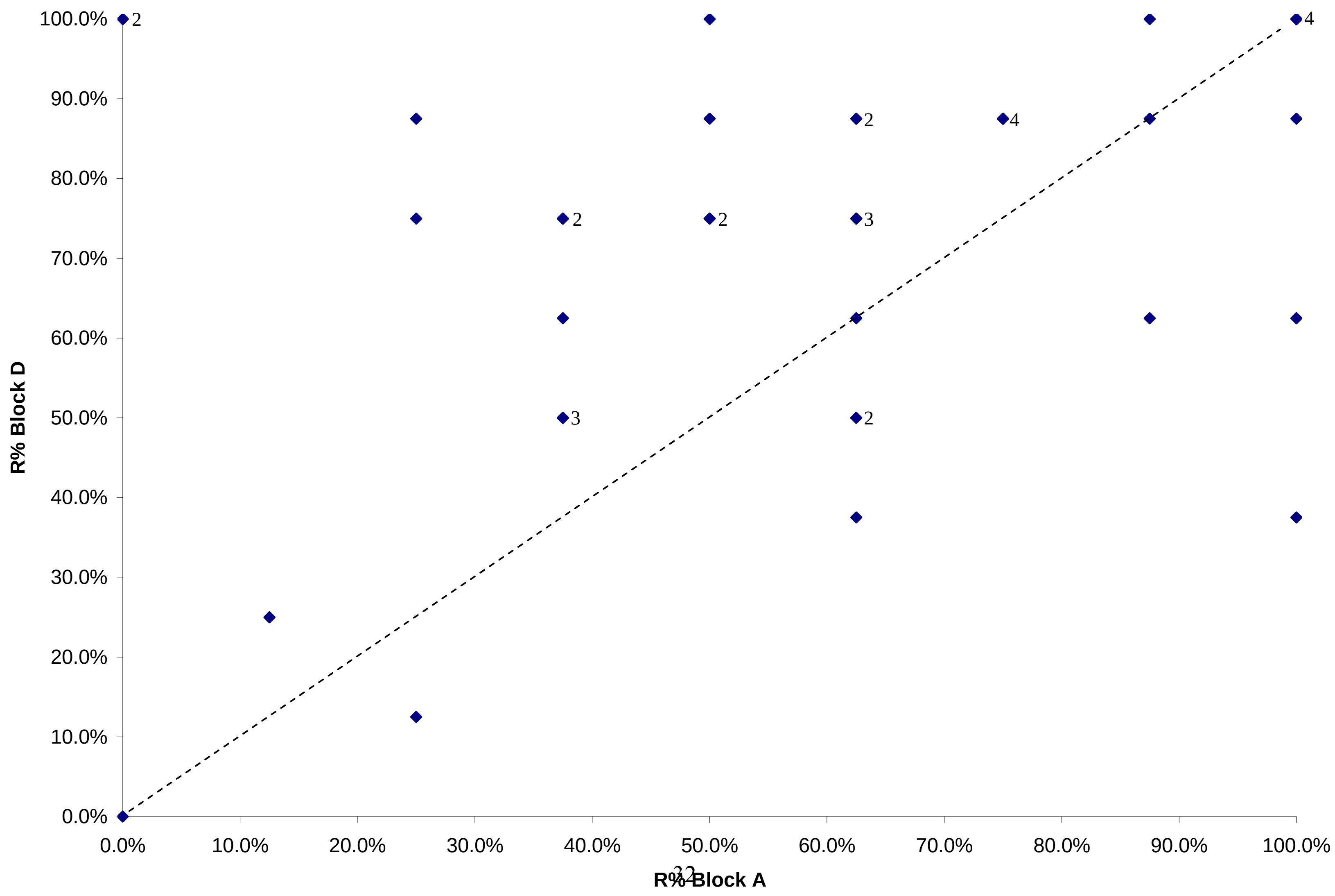


FIGURE 3
The Monty Hall Error in Block A and Block D

R% is the average rate (out of eight periods) of a subject choosing the remaining card. The number to the right of the diamond represents the number of subjects with the corresponding values for R% in Blocks A and D. A diamond without a number denotes one subject.



Appendix A: Instructions

Part 1

You are about to participate in an experiment in financial decision-making. If you follow these instructions carefully, and make good decisions, you may earn a considerable amount of money. Today's session will consist of three parts. Your overall earnings will be the total of your earnings in each part. At the end of the experiment, you will receive your overall earnings in cash.

This part of the experiment will consist of several separate periods. At the start of each period, three playing cards will be placed face down in random order in the 1, 2, and 3 spot on a mat. The face-down cards are ordinary playing cards. Two of the cards will be red (diamonds or hearts) and one of the cards will be black (clubs or spades).

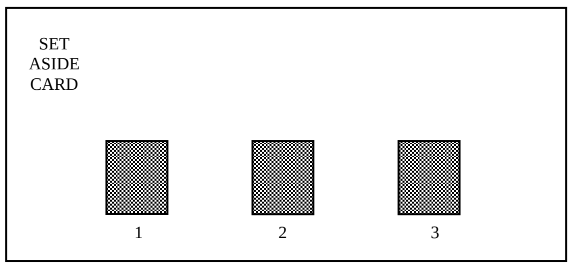


Figure 1

A volunteer will then choose a number: "1", "2", or "3". The number chosen will be used to designate a card as the "set-aside" card. For example, if the volunteer chooses "3", the mat would appear as:

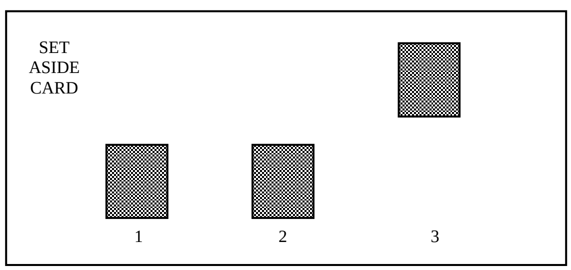


Figure 2

The next step will be to reveal one of the two remaining cards. We will not reveal the set-aside card. The conductor will look at the other two remaining cards and always reveal a red card. Continuing the example in Figure 2, the conductor will look at cards 1 and 2, and reveal one of them. The revealed card will always be a red card. Suppose the conductor turns over card 2.

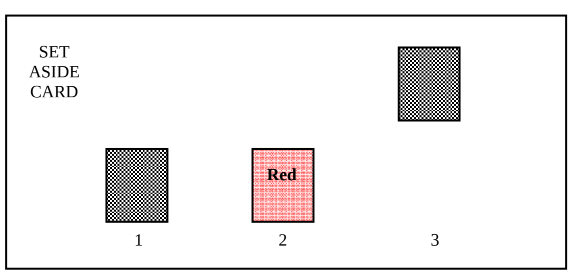


Figure 3

At this point, you will be asked to choose a card. Your goal will be to choose the black card. If you choose the black card, you will win 60 cents, but if you choose the red card, you will not win any money this period.

SUBJECT
ID ______
PERIOD ______

YOUR GUESS FOR THE BLACK CARD:

☐ **SET ASIDE CARD**

☐ **REMAINING CARD**

Figure 4

Fill in the form by checking the appropriate box. If you check "set aside", then you will win 60 cents if the "set-aside" card is black, and nothing otherwise. If you check "remaining", then you will win 60 cents if the "set aside" card is red, and nothing otherwise. Continuing the example from Figure 3, if you choose "set aside", you will win if card 3 is black. If you choose "remaining" you will win if card 1 is black.

The conductor will then collect the forms and reveal both of the cards. If you correctly chose the black card, your winnings will be added to your earnings for this part of the experiment.

Frequently Asked Questions:

Q: Is this some kind of psychology experiment with an agenda you haven't told us?
A: No. It is an economics experiment. If we do anything deceptive, or don't pay you cash as described, then you can complain to the campus Human Subjects Committee and we will be in serious trouble. These instructions are on the level and our interest is in seeing how people make decisions in certain situations.

Q: Is my performance in any way linked to that of other people in the room?
A: No, this is an experiment in individual decision making. Your actions do not in any way affect the payoffs of other subjects, nor do their actions affect yours.

Q: Is it possible to lose money in this experiment? Will I have to pay you?
A: No, you cannot lose money. Each time you can correctly choose the black card, you will earn money. Conversely, each time you guess incorrectly, you will not earn any money.

Part 2

This part of the experiment will consist of several periods, and each period will have several steps. The sequence of events for a period is listed and explained below.

1 Receive new share
2 Card placement
3 Selection of the set-aside card
4 Sometimes a red card is revealed
5 Chance to sell your share
6 All cards are revealed and earnings are calculated

1. Receive new share.
You will receive one new share of an experimental asset. The share will be redeemed at the end of each period. The value of the shares will depend on whether or not the remaining card is a black card (this will be explained further below). The share will pay 60 cents if the remaining card is black, and will pay zero otherwise.

2. Card placement.
As, in Part 1, three playing cards will be placed face down in random order in their position on a mat. The face-down cards are ordinary playing cards. Two of the cards will be red (diamonds or hearts) and one of the cards will be black (clubs or spades). There are three positions on the mat, labeled "1", "2", and "3".

3. Selection of the set-aside card.
Just as in Part 1, a volunteer will pick a number in order to designate a card as the "set-aside" card. The other two cards are the designated as the remaining cards.

4. Sometimes a red card is revealed.
In some of the periods, the conductor will look at the two remaining cards, and reveal one of them. The conductor will not reveal the set-aside card and will always reveal a red card. In some of the periods, this step will be skipped; the conductor will not look at or reveal any of the remaining cards.

5. Chance to sell your share.
In this step, you may make an offer to sell your share. The offer may or may not be accepted. The offer is made by filling out the following form.

id
period
Circle the choices you prefer:

	Sell your share for:
Keep your share	27 cents
Keep your share	29 cents
Keep your share	31 cents
Keep your share	33 cents
Keep your share	35 cents
Keep your share	37 cents
Keep your share	39 cents
Keep your share	41 cents
Keep your share	43 cents

Figure 1

Fill out the form by circling your preferred choices. If you are willing to sell your share for 27 cents, then circle the 27 cents in the first row. If not, circle “Keep your share.” Similarly, if you are willing to sell for 29 cents, then circle 29. If not, circle “Keep your share,” and so on for each row of the form.

For example, if you are willing to sell your share for a price of 33 cents or higher, fill in your form as in Figure 2.

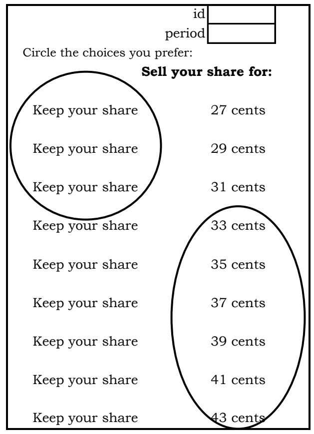


Figure 2

The actual price is decided by a drawing from a bingo cage containing a distribution of balls, labeled 27, 29, 31, 33, 35, 37, 39, 41 and 43. A volunteer will spin a bingo cage and randomly choose a ball. The number on the ball chosen will represent the price for this period.

Continuing the example, suppose the volunteer randomly selects a “41.” Since you circled 41, you will sell your share for 41 cents. If instead a “27” was selected, you do not sell because you circled “Keep you share” if the price is 27 cents.

6. All cards are revealed and earnings are calculated.
The face-down cards are turned over. Each share of the asset will pay the bearer 60 cents if one of the remaining cards was black, and pays nothing if both were red.

If you sold your share, then your earnings for the period will simply be the sale price. For example, if you sold your share in step 5 for 41 cents, then your earnings for the period will be 41 cents, regardless of whether or not the remaining card(s) is black.

If you did not sell your share, then you will earn 60 cents for the period if the remaining card(s) is black and nothing if the set-aside card is black. If step 4 was not skipped, then there will only be one “remaining” card still face-down. If step 4 was skipped, there will be two remaining face-down cards. In this case, you will earn 60 cents if either of the two remaining cards is the black card.

After the cards are revealed, your share is liquidated, so it doesn’t carry over to the next period. You will receive a new share at the start of the next period. Your earnings for the period will be added to your overall earnings, and the next period will start.

```
Frequently Asked Questions:

Q:  Can I affect the share price?
A:  No.  Remember that the share price is determined by a drawing from
a bingo cage.  The price you circle will not affect which ball is drawn
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from the cage. The prices you circle will only affect whether or not you will sell if one of those prices are chosen.

Q: Is it ever profitable to circle “sell” at a price that is lower than the amount I think the share is worth?
A: No. Suppose your value for a share is 36 cents. If so, you should circle “keep your share” at 27, 29, 31, 33, or 35, and you should circle “sell your share” at 37, 39, 41 and 43 cents. Let’s call this the original strategy. To see why this is best, consider an alternate strategy, where you make a single change. Now you select “sell your share” at 35 cents. If the price (determined by the bingo drawing is 27, 29, 31, or 33, you will keep your share regardless of whether you choose the original or the alternate strategy. Similarly, if the price is 37, 39, 41, or 43, you will sell you share regardless which strategy you choose. The only time there will be a difference is when the price is 35 cents. With the original strategy, you keep the share, but with the alternate strategy, you will sell. Keeping the share is better because if it is worth 36 to you, you would rather keep the share than sell it for 35 cents.

Q: Is it ever profitable to circle “sell” at a price that is higher than the amount I think the share is worth?
A: No. A similar example will show you why. Suppose your value for a share is 36 cents. If so, you should circle “keep your share” at 27, 29, 31, 33, or 35, and you should circle “sell your share” at 37, 39, 41 and 43 cents. Let’s call this the original strategy. Now, consider an alternate strategy where you now change your response to “keep your share” at 37 cents. The only time there will be a difference is when the price is 37 cents. With the original strategy, you sell the share, but with the alternate strategy, you will keep. Keeping the share is worse because if it is worth 36 to you, you would rather sell the share for 37 cents than keep it.

Part 3

Just as in the previous part, the experiment will consist of several periods, and each period will have several steps. The sequence of events for a period is modified from the sequence that you have just completed as shown below.

1	Receive new share
2	Card placement
3	Selection of the set-aside card
4a	Chance to sell your share
5	A red card is revealed
4b	Chance to sell your share
6	All cards are revealed and earnings are calculated

1. Receive new share.
You will receive one new share of an experimental asset. The shares will be redeemed at the end of each period. The value of the shares will depend on whether or not the remaining card is a black card. As in part 1, each share you own will pay 60 cents if the remaining card is black, and will pay zero otherwise.

2. Card placement.
Three playing cards will be placed face down in random order in their position on a mat. The face-down cards are ordinary playing cards. Two of the cards will be red (diamonds or hearts) and one of the cards will be black (clubs or spades). There are three positions on the mat, labeled “1”, “2”, and “3”.

3. Selection of the set-aside card.
A volunteer will choose a number to designate a card as the “set-aside” card. The other two cards are the designated as the remaining cards.

4a. Chance to sell your share.
Just as in part 1, you may now make an offer to sell your share. However, in this part of the experiment, you will make two offers to sell. The first offer is made in this step, and the second offer will be in step 4b (see below). Only one of these offers will be used to determine whether or not you sell your share. Exactly as before, the first offer is made by circling your preferred choices. The actual price will be determined in step 4b.

5. A red card is revealed.
The conductor will look at the two remaining cards, and reveal one of them. The conductor will not reveal the set-aside card and will always reveal a red card.

4b. Chance to sell your share.
In this step, you may make another offer to sell your share. Fill out a second form by circling your preferred choices.

Before the price is determined, a volunteer will roll an ordinary six-sided die. If a “1”, “2” or “3” is rolled, then the first form (from step 4a) will be used, and the second form (from step 4b) will be discarded. If a “4”, “5” or “6” is rolled, then the second form will be used and the first form will be discarded.

The actual price is now decided by a drawing from a bingo cage containing a distribution of balls, labeled 27, 29, 31, 33, 35, 37, 39, 41 and 43. A volunteer will spin a bingo cage and randomly choose a ball. The number on the ball chosen will represent the price for this period.

6. All cards are revealed and earnings are calculated.

The face-down card is now turned over. Each share of the asset will pay the bearer 60 cents if one of the remaining cards was black, and pays nothing if both were red.

After the cards are revealed, your share is liquidated, so it doesn't carry over to the next period. You will receive a new share at the start of the next period. Your earnings for the period will be added to your overall earnings, and the next period will start.