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Subject Perceptions of Confidence and Predictive Validity in Financial Information Cues

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Traditional financial theory holds that financial decision makers make choices based on an asset's mean return and its standard deviation in the context of the normal distribution. These statistics, however, may be vague concepts to decision makers, and more difficult to use relative to specific details of a simple discrete probability distribution. Therefore, this study shows which of ten information cues subjects use in making decisions designed to look like simplified bonds, stocks, and options. The cues consist of the mean, standard deviation, and other distribution features such as highest payoff.

More importantly, this study relates subjects' usage of various information cues in making financial valuation judgments to their self-assessments of 1) an information cue's ability to best reveal the value of an asset (its predictive validity), and 2) their confidence in using that information cue. The results are related to the overconfidence literature in psychology.

Introduction

Mainstream financial theory is based on decisions being made within the context of the mean-variance criterion. Investors are assumed to be risk averse. Given choices with equal expected returns, they will select the investment with the lowest variance; given choices with equal variances, they will select the investment with the highest expected return. Capital market theory (the underpinning of portfolio theory) is based on the mean-variance criterion. Hence, whether decision makers use information conveyed by the mean and variance to make financial decisions is highly relevant.

Evans [1993] conducted economic experiments designed to capture the types of information cues subjects preferred when making lottery choices based on capital budgeting choices. She found the mean and variance were among the least selected information cues when making decisions about asset values.

This study evaluates subject information cue choices in the context of simplified bonds, stocks, and options. But, more importantly, we address how decision makers assess the predictive validity of different information cues, as well as their confidence in their ability to use the cues properly. These assessments are significant because of the growing interest in how investor overconfidence may influence financial market outcomes (for examples, see De Long et al. [1990], Odean [1998], Benos [1998], Barber and Odean [1999], Gervais and Odean [2001], and Hvide [2002]).

Previous psychological studies have related overconfidence to flaws in information processing. Our assessment data permit the testing of several hypotheses related to information processing flaws. We describe and test the hypotheses in this financial experimental context.

We proceed with a review of the literature in the second section. The third section describes the experimental design used to gather the data, and the fourth section provides an analysis and discussion of the results.

Literature Review

Fundamental financial theory is based on the mean-variance criterion. At its foundation, we define risk aversion using indifference curves formed from expected return preferences traded off against the variance of those returns (e.g., Copeland and Weston [1988]). We then apply risk aversion to such corporate finance topics as capital budgeting and liquidity management (e.g., the Miller-Orr [1966] model). In investments, the efficient frontier within capital market theory is defined by risk-averse investors using the mean and variance to identify the efficient set of portfolios. From capital market theory, of course, springs portfolio theory.

Evans [1993] used an economics experiment to examine the risk levels and information preferences of subjects in lotteries resembling capital budgeting decisions in the early screening stage. The screening stage

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occurred before formal cash flows were estimated as inputs to computing the net present value (NPV) or the internal rate of return (IRR). Thus Evans was able to explore what types of information decision makers considered most important when deciding whether to continue the study.

The subjects' information cues were chosen from three general categories: replacement decisions, decisions on expanding in a current market, or decisions to expand into newer, lesser-known markets. Subjects could select three cues from a list of ten to partially complete lottery information.[1] The information cues included: the cost of the lottery, the highest probability payoff, the lowest probability payoff, the highest probability, the lowest probability, the highest payoff, the lowest payoff, the mean payoff, the median payoff, and the standard deviation of the payoff. Subjects then chose a lottery to play for money using the information they had selected.

Evans [1993] found little support for the mean-variance model. The information cues her subjects chose varied by type of capital budgeting project analyzed. The most frequently selected were the cost of the lottery, the highest probability, the lowest probability, the highest payoff, and the lowest payoff. The least selected cues were the mean payoff, the median payoff, and the standard deviation of the payoff.

Others have also studied subject information preferences. Slovic and Lichtenstein [1968] found that the relative weights subjects place on probability and payoff information depend on the task. Subjects choose different strategies as tasks change in order to simplify decision making.

Schoemaker [1989] demonstrated mathematically the optimal preferences for payoff and probability information in two-stage experimental decision making contexts. He showed that risk-averse decision makers should prefer information on probabilities, while risk-seekers should prefer information on payoffs. Contrary to his expectations, however, Schoemaker found that subject preferences for payoff and probability information were not related to risk preference.

But focusing on how decision makers choose the information they use to make decisions, as well as determining how confident they are that they can use that information to make the best decisions, is new to the study of information cues. These data provide the core of our contribution. The data are particularly relevant now, because the phenomenon of overconfidence in financial markets has grown dramatically in recent years.

Psychologists generally regard people as overconfident when they perceive their traits or abilities to be better than they really are. As decision makers, overconfident individuals assume they have more information or knowledge than they actually do. Some argue that overconfidence is such a widespread and robust psychological phenomenon that experience may not be sufficient to eliminate its bias. See Barber and Odean [1999] for a broad summary of documented overconfident behaviors and attitudes.

Many psychologists suggest that overconfidence relates to flaws in a person's ability to process information. For example, Fischhoff, Slovic, and Lichtenstein [1977] document that people use inadequate information processing and retrieval methods.

Griffin and Tversky [1992] claim that overconfidence originates in biased evaluations of evidence. They argue that evidence has two dimensions: strength and weight. Strength refers to the extremity of the evidence (e.g., a person writes an exceedingly glowing reference letter about an applicant's job skills); weight refers to the predictive validity of the evidence (e.g., the person hardly knows the job applicant). Griffin and Tversky suggest that overconfident people tend to focus on the strength of the evidence and adjust inadequately for its weight. When strength is high but weight is low, people tend to be overconfident.

Kahneman and Tversky [1973] have found greater overconfidence when experimental subjects were asked to evaluate relatively abstract information versus more specific and distinctive information. For example, reading a paragraph of statistical summary information about an issue is more abstract. Hearing an anecdote about a particular example relevant to the issue is more distinctive. In the case of information cues, more specific information may include items such as the cost of the lottery and its highest payoff. More abstract information may be the mean and standard deviation.

This study addresses whether the information cues preferred by subjects in financial settings fit the mean-variance criterion, whether the preferred information cues vary in different financial settings, whether the strength and weight of information play a role in subject overconfidence, and whether abstract information cues are associated with greater overconfidence than specific cues. The design of the experiment and the data collected are described below.

Experimental Design and Data

The information cue and lottery selection data are the same as in Evans [1993] (see the appendix for a copy of the instructions given to subjects). However, we analyze this basic data for different purposes. Our context is security investment decision making, with the critical addition of the subject assessment information cues.

Subjects (n = 185) were randomly assigned to one of three types of security decisions – bonds (n = 65), stocks (n = 51), or options (n = 69). The lotteries and their probabilities, payoffs, and other basic information are reported in Table 1-A, Panels A-C in the appendix. The group of three bond lotteries is comprised of a risk-free bond (one branch), and two low-risk bonds (two branches). The highest probabilities are always set in favor of a gain from the cost of the bond, consistent with the notion that investors may decide to hold a bond to maturity, guaranteeing a positive return.

The three stocks on each screen contain one no-risk stock (two branches), in which a subject may earn a low or moderate gain. The other two stocks (three branches) entail the possibility of a sizable loss but also bigger gains than are possible with bonds. The three options on a screen (each with three branches) all include the possibility of losing the entire cost of the lottery, a break-even outcome, and a very large gain, consistent with a covered option. Together, the loss and break-even outcomes are more likely than the large gain. The three lotteries on a screen were designed to have means within one or two cents of the others in order to have a clear indication of which lottery was the optimal risk-averse choice in a mean-variance context.

Each subject began their decision making with three blank decision trees on a computer screen. Each subject could select three information cues from the list of ten:

- The cost of the lottery.
- The highest probability payoff.
- The lowest probability payoff.
- The highest probability.
- The lowest probability.
- The highest payoff.
- The lowest payoff.
- The mean payoff.
- The median payoff.
- The standard deviation of the payoff.

The probabilities were revealed on the "branches" of the trees. The payoffs were shown at the ends of the branches. The cost was revealed at the base of the tree. Mean payoff, median payoff, and standard deviation of the payoff were given underneath each lottery. The payoff schemes are clearly different for the bonds, stocks, and options. According to Fischhoff, Slovic, and Lichtenstein [1977], subjects are assumed to use different information cue strategies with different types of securities.

Once the subjects revealed their three information cue choices, they had to either choose one of the lotteries to play for money, or not select any lottery. Full information on all three lotteries was revealed only when a lottery decision had been made. Subjects could study the information at their own pace. In all, the subjects worked on fifteen screens of three lotteries each.

Besides the $4 subjects received for showing up to the experiment on time, they were also given $5 with which to purchase the lotteries. At the end of the experiment, the computer program randomly selected a number of lotteries to resolve for payment. If the subject had not selected that lottery, there was no change in wealth. If the subject had selected the lottery, he or she was paid the difference between the cost of the lottery and the payoff determined by a computer-selected random probability.

After the computerized portion of the experiment, subjects completed a paper survey. On a scale of 1 (not very predictive) to 7 (very predictive), they rated how well each of their information cues did in predicting lottery value. The survey also sought information on how confident the subject was in using the information cue on a scale of 1 (not very confident) to 7 (very confident). We describe the results from the experiment next.

Analysis of Results

Table 1 shows the mean number of times the subjects selected each information cue by type of security. A review of the table suggests the mean, median, and standard deviation of the payoffs were among the least selected information cues for all three types of securities.

A chi-square analysis reveals that at least one of the information cues was selected more often in one of the security types than in the others ($\chi^2 = 620$, with 18 degrees of freedom, p-value < 0.005). The data in the table suggest the cost of the lottery is the most obvious difference. It was used 10.2 times out of 15 on average by subjects in the bond-type lotteries. The highest probability is also a likely contributor to the chi-square results. It was used 11.32 times on average in the option-type lotteries. It is not surprising that the highest probability cue would be useful in the options, as it always tells the subject the chance of losing the entire purchase price.

The lowest payoff is used 5.45 times on average in the stock-type lotteries, much more frequently than in the option-type lotteries (mean of 1.64). The lowest payoff, in combination with the cost, tells the subjects the maximum loss in stocks they can incur. The lowest payoff in options is always zero. Therefore, it is not a useful information cue. The results are consistent with the expectations of Fischhoff, Slovic, and Lichtenstein [1977] that subjects would use different strategies in different contexts.

Table 2 contains subject mean ratings for each information cue for each security type. Ratings range from 1 (no confidence/predictive validity) to 7 (very high confidence/very high predictive validity).

Table 2 also includes the differences between the confidence and predictive validity ratings, along with the p-values of the t-statistics computed on the significance of the mean rating differences. Within the bond

Table 1. *Mean Number of Information Cues Selected by Subjects, Reported by Security Type (standard deviations in parentheses)*

Information Cue	Bond	Stock	Option	All Types
Cost	10.20 (5.44)	7.55 (5.78)	4.09 (4.85)	7.19 (5.91)
Highest Probability Payoff	5.43 (5.36)	3.92 (4.69)	2.36 (3.28)	3.87 (4.65)
Lowest Probability Payoff	3.32 (4.32)	2.55 (4.37)	3.30 (4.40)	3.10 (4.35)
Highest Probability	7.40 (5.54)	7.55 (5.83)	11.32 (4.26)	8.90 (5.49)
Lowest Probability	5.35 (5.44)	5.61 (5.69)	8.75 (5.53)	6.69 (5.74)
Highest Payoff	5.45 (5.46)	5.67 (5.13)	7.86 (5.54)	6.41 (5.49)
Lowest Payoff	2.92 (4.15)	5.45 (5.43)	1.64 (2.70)	3.14 (4.36)
Mean	2.14 (4.10)	3.16 (4.49)	2.30 (4.02)	2.48 (4.18)
Median	1.51 (3.35)	1.18 (2.55)	1.14 (2.55)	1.28 (2.85)
Standard Deviation	1.28 (3.14)	2.37 (4.09)	2.23 (4.38)	1.94 (3.91)

security, subject mean confidence ratings for the mean payoff ($p = 0.00$) and the standard deviation of the payoff ($p = 0.01$) are significantly lower than the predictive validity ratings. Within stocks, the same two information cues, mean payoff ($p = 0.05$) and standard deviation of payoff ($p = 0.01$), have significantly lower confidence ratings than predictive validity ratings at the 95% confidence level.

Within options, there is only one significant difference. The subjects' confidence in using the standard deviation of the payoff is significantly lower than their assessment of its predictive validity ($p = 0.01$). Therefore, in all three security classes, subject confidence is lower than predictive validity for one or both variables at the foundation of the mean-variance criterion.[2]

We next conducted independent MANOVAs to test whether the confidence and predictive validity ratings differ significantly by security type. The MANOVA results for the confidence ratings indicate that they differ significantly across security classes. The Wilks' lambda was 0.712, with an F-statistic of 2.96 and a p-value of < 0.0001. The individual ANOVAs for each information cue indicate three cues are responsible for differences across security types: cost ($p < 0.0001$), highest probability payoff ($p = 0.0045$), and lowest payoff ($p = 0.0427$).

The mean confidence ratings in Table 2 illustrate that confidence in the use of all three cues are lowest for options. This makes sense, as options are significantly more risky than bonds and stocks. Thus confidence may have been shaken in this high-risk, high-payoff context.

The MANOVA results for the predictive validity ratings of the information cues indicate no significant differences across security type. The Wilks' lambda is 0.842, the F-statistic is 1.48, and the p-value is 0.0848. The predictive validity ratings are clearly measuring a different construct than the confidence ratings.

We find more evidence of how distinctive the confidence and predictive validity ratings are from a series of covariance analyses, shown in Table 3. The number of times each information cue was selected is tested as a function of subject confidence ratings for the cue, their predictive validity ratings, an interaction term between the confidence and predictive validity rating, the security type, and the risk group (designed to capture general risk preferences).

Each subject was assigned a risk group, a categorical variable based on the average risk level of the lotteries chosen. On each screen of the three lotteries, the low-risk lottery took a value of 1, the medium-risk lottery had a value of 2, and the high-risk lottery had a value of 3. Recall that the mean of the three lotteries was approximately equal, but the standard deviations varied. We used the standard deviation to assign the risk level of the lottery. Subjects who did not choose one of the three lotteries were assigned a 0 risk level. The mean of these risk levels was then calculated for each subject as follows. Subjects with a mean risk value of less than or equal to 1 were assigned to the low-risk category, those with a mean risk value less than or equal to 2 but greater than 1 were assigned to the medium-risk level, and those with less than or equal to 3 but greater than 2 to the high-risk level.

The results in Table 3 show that all the F-statistics for the ANOCOVAs are significant at $p = 0.0001$. The confidence ratings given an information cue significantly explain the variation in the number of times each cue was chosen. The predictive validity rating is significant in seven of the cues: cost, lowest probability payoff, highest probability, lowest probability, highest payoff, lowest payoff, and standard deviation. The significance of the predictive validity ratings when the confidence ratings are already in the model underscores the separate role played by each.

Table 4 contains the correlations between the confidence and predictive validity ratings and the frequency of the information cue usage. The correlations indicate that the relationships revealed in the ANOCOVAs are positive. That is, the higher the subjects assessed the predictive validity of the cues, and the higher their confidence in using the cues, the more frequently they selected the cues (all other variables held constant).

Table 2. *Mean Subject Rating of Confidence and Predictive Validity of Each Information Cue by Security Type (standard deviations in parentheses except where p-values are given)*

	Bonds			Stocks			Options		
	Confidence	**Predictive Validity**	**Difference (p-Value)**	**Confidence**	**Predictive Validity**	**Difference (p-Value)**	**Confidence**	**Predictive Validity**	**Difference (p-Value)**
Cost	4.89 (1.70)	4.48 (1.99)	0.44 (0.07)	4.39 (1.81)	4.06 (2.00)	0.20 (0.35)	3.24 (1.64)	3.20 (1.69)	–0.01 (0.94)
Highest Probability Payoff	4.75 (1.58)	4.65 (1.63)	0.14 (0.43)	4.14 (1.58)	4.25 (1.44)	–0.06 (0.82)	3.77 (1.56)	4.00 (1.56)	–0.26 (0.26)
Lowest Probability Payoff	4.37 (1.58)	3.94 (1.75)	0.33 (0.11)	3.90 (1.48)	3.82 (1.35)	0.04 (0.85)	3.72 (1.53)	3.88 (1.70)	–0.17 (0.38)
Highest Probability	5.17 (1.35)	5.05 (1.40)	0.10 (0.57)	4.98 (1.51)	4.96 (1.47)	0.10 (0.70)	5.03 (1.56)	5.33 (1.37)	–0.30 (0.15)
Lowest Probability	4.81 (1.40)	4.61 (1.71)	0.13 (0.52)	4.31 (1.52)	4.33 (1.75)	–0.10 (0.68)	4.86 (1.56)	4.96 (1.40)	–0.09 (0.64)
Highest Payoff	4.54 (1.57)	4.50 (1.82)	0.11 (0.64)	4.76 (1.63)	5.16 (1.61)	–0.40 (0.07)	4.38 (1.81)	4.67 (1.52)	–0.26 (0.16)
Lowest Payoff	4.37 (1.46)	4.05 (1.70)	0.29 (0.20)	4.33 (1.72)	4.51 (1.75)	–0.24 (0.28)	3.70 (1.80)	3.60 (1.87)	0.08 (0.75)
Mean	3.33 (1.71)	4.05 (1.76)	–0.62 (0.00)	3.57 (1.70)	3.98 (1.73)	–0.49 (0.05)	3.63 (1.66)	3.78 (1.57)	–0.15 (0.37)
Median	2.95 (1.62)	3.41 (1.81)	–0.31 (0.17)	3.20 (1.85)	3.31 (1.77)	–0.08 (0.77)	3.19 (1.54)	3.19 (1.51)	0.03 (0.85)
Standard Deviation	3.24 (2.05)	3.91 (2.01)	–0.57 (0.01)	3.39 (1.87)	3.78 (1.79)	–0.45 (0.01)	3.33 (1.86)	3.75 (1.92)	–0.48 (0.01)

Note: Scale is 1 = no confidence/predictive validity to 7 = highest degree of confidence/predictive validity.

Table 3. *Results of Covariance Analyses with Each Information Cue as a Function of Shown Independent Variables*

	p-Values							
Information Cue	**Confidence**	**Predictive Validity**	**Confid* Predict**	**Security Type**	**Risk Group**	**N**	**R^2**	**F (p-Value)**
Cost	< 0.0001	0.0023	0.1680	0.0003	0.0100	178	0.40	16.51 (< 0.0001)
Highest Probability Payoff	< 0.0001	0.0729	0.0881	0.0426	0.8617	177	0.18	5.47 (< 0.0001)
Lowest Probability Payoff	< 0.0001	0.0015	0.0097	0.7565	0.9938	176	0.18	5.16 (< 0.0001)
Highest Probability	< 0.0001	<0.0001	0.6809	< 0.0001	0.1569	177	0.30	10.61 (0.0001)
Lowest Probability	< 0.0001	<0.0001	0.5653	0.0026	0.1111	176	0.26	8.41 (0.0001)
Highest Payoff	< 0.0001	0.0037	0.5782	0.0070	0.0269	175	0.27	8.91 (0.0001)
Lowest Payoff	< 0.0001	0.0246	0.0118	0.0001	0.3352	176	0.27	8.95 (< 0.0001)
Mean	< 0.0001	0.3447	0.1431	0.2431	0.9750	178	0.31	11.15 (< 0.0001)
Median	0.0178	0.5019	0.1252	< 0.0001	0.0041	174	0.25	8.15 (< 0.0001)
Standard Deviation	< 0.0001	0.0212	< 0.0001	0.0292	0.9621	178	0.45	19.85 (< 0.0001)

Table 4. *Correlations Between Ratings of Predictive Validity and Confidence and Information Cue Usage by Security Type (p-value in parentheses)*

	Bonds		Stocks		Options		Overall	
	Confidence	**Predictive Validity**	**Confidence**	**Predictive Validity**	**Confidence**	**Predictive Validity**	**Confidence**	**Predictive Validity**
Cost	0.412 (0.0008)	0.243 (0.0512)	0.438 (0.0016)	0.413 (0.0026)	0.430 (0.0003)	0.481 (< 0.0001)	0.520 (< 0.0001)	0.442 (< 0.0001)
Highest Probability Payoff	0.260 (0.0399)	0.244 (0.0497)	0.426 (0.0023)	0.421 (0.0021)	0.246 (0.0466)	0.075 (0.5425)	0.349 (< 0.0001)	0.276 (0.0001)
Lowest Probability Payoff	0.264 (0.0366)	0.381 (0.0017)	0.461 (0.0010)	0.328 (0.0187)	0.233 (0.0579)	0.344 (0.0041)	0.302 (< 0.0001)	0.353 (< 0.0001)
Highest Probability	0.346 (0.0055)	0.547 (< 0.0001)	0.376 (0.0084)	0.252 (0.0739)	0.191 (0.1216)	0.408 (0.0005)	0.273 (0.0002)	0.418 (< 0.0001)
Lowest Probability	0.283 (0.0256)	0.255 (0.0406)	0.170 (0.2427)	0.329 (0.0185)	0.372 (0.0021)	0.649 (< 0.0001)	0.300 (< 0.0001)	0.420 (< 0.0001)
Highest Payoff	0.494 (< 0.0001)	0.358 (0.0036)	0.292 (0.0415)	0.394 (0.0047)	0.444 (0.0002)	0.405 (0.0006)	0.400 (< 0.0001)	0.366 (< 0.0001)
Lowest Payoff	0.219 (0.0853)	0.226 (0.0722)	0.550 (< 0.0001)	0.363 (0.0088)	0.234 (0.0567)	0.193 (0.1156)	0.358 (< 0.0001)	0.305 (< 0.0001)
Mean	0.478 (< 0.0001)	0.373 (0.0022)	0.633 (< 0.0001)	0.403 (0.0034)	0.519 (< 0.0001)	0.325 (0.0064)	0.538 (< 0.0001)	0.364 (< 0.0001)
Median	0.568 (< 0.0001)	0.200 (0.1130)	0.358 (0.0114)	0.195 (0.1693)	0.406 (0.0007)	0.454 (0.0001)	0.443 (< 0.0001)	0.274 (0.0002)
Standard Deviation	0.434 (0.0004)	0.422 (0.0005)	0.564 (< 0.0001)	0.434 (0.0015)	0.7111 (< 0.0001)	0.645 (< 0.0001)	0.570 (< 0.0001)	0.503 (< 0.0001)

In Table 3, the confidence and predictive validity ratings interaction term is significant for only three information cues: the lowest probability payoff, the lowest payoff, and the standard deviation. The security type is significant in all but two cases, again reflecting Fischhoff, Slovic, and Lichtenstein's [1977] conclusions that subjects select an information strategy based on the context of the decision being made. The risk group, or subject risk preference, is significant for only three cues, suggesting it is not especially important to information cue selection.

The literature review described some of the psychology studies on overconfidence. In order to capture overconfidence, we created a ratio of the confidence rating relative to the predictive value rating (c/p ratio) given to each cue by the subjects. When subjects are more confident than their own assessment of the predictive value of the cue, the ratio is greater than 1 and a sign of overconfidence. The reverse indicates underconfidence.

According to Kahneman and Tversky [1973], abstract cues relative to specific and distinctive cues should be more attractive to people who are overconfident. We use the c/p ratio to evaluate their results within the context of this financial dataset. The mean of the c/p ratio for the three information cues that are more abstract (the mean payoff, the median payoff, and the standard deviation of the payoff) is compared with the mean c/p ratio for the seven other, more specific information cues. If Kahneman and Tversky [1973] are correct in this setting, the c/p ratio for the abstract cues should be larger than the ratio for the specific cues.

The c/p ratios are shown in Table 5 for each information cue by security type and overall. We conducted a MANOVA with the c/p ratios for all the information cues as a function of security type. The Wilks' lambda is 0.866, the F-statistic is 1.14, and the p-value is 0.304, indicating that the c/p ratios do not vary significantly across security type. Therefore, we focus exclusively on the overall results.

The mean c/p ratio for the three abstract cues is 1.019, and for the seven specific cues it is 1.173. That makes a difference of –0.162, which is statistically significant (t = –3.52 and p-value = 0.0006). Thus confidence is *higher* for specific information cues, which means the results are contrary to those predicted by Kahneman and Tversky [1973]. Perhaps the subjects realize that the mean, median, and standard deviation are important in predicting validity, but they do not feel confident they can use them effectively. That lack of confidence is also illustrated in the relative infrequency with which subjects selected the abstract cues (see Table 1).

As we discussed, Griffin and Tversky [1992] suggest overconfidence is caused when people incorrectly process information about the strength of the evidence versus its weight (how its actual likelihood). They conclude that overconfidence occurs when the strength of information is considered more important than its weight. This result should translate into subjects who rely more on payoff cues (highest and lowest payoff) having higher c/p ratios than probability cues (highest and lowest probability).

However, the mean c/p ratio for the highest and lowest probability is 1.193; the mean c/p ratio for the highest and lowest payoff is 1.107. The difference of 0.088 is insignificant (t = 1.33 and p-value = 0.1847). The cues most closely related to strength and weight do not appear to reflect any differences in subject overconfidence.

Discussion and Conclusion

This study evaluated the information choices of subjects making lottery decisions designed to mimic bonds, stocks, and options. The results indicate, as per Fischhoff, Slovic, and Lichtenstein [1977], that subjects use different information selection strategies in different contexts. Contrary to financial theory, subjects clearly prefer information cues about cost, probabilities, and payoffs under specific conditions over cues that summarize a probability distribution, such as the mean, median, and standard deviation. Subjects had trouble making decisions according to the mean-variance criterion, which lies at the core of basic

Table 5. *Mean Confidence to Predictive Validity Ratio for Each Information Cue by Security Type (standard deviations in parentheses)*

Information Cue	Bonds	Stock	Options	Overall
Cost	1.398 (1.082)	1.212 (0.818)	1.235 (1.137)	1.286 (1.037)
Highest Probability Payoff	1.120 (0.453)	1.083 (0.549)	1.155 (1.095)	1.123 (0.771)
Lowest Probability Payoff	1.235 (0.613)	1.088 (0.445)	1.095 (0.534)	1.143 (0.543)
Highest Probability	1.073 (0.376)	1.124 (0.550)	1.010 (0.433)	1.063 (0.449)
Lowest Probability	1.208 (0.892)	1.159 (0.957)	1.081 (0.802)	1.147 (0.875)
Highest Payoff	1.347 (1.231)	0.965 (0.334)	0.982 (0.442)	1.106 (0.814)
Lowest Payoff	1.381 (1.189)	1.017 (0.392)	1.356 (1.335)	1.271 (1.102)
Mean	0.931 (0.498)	1.011 (0.643)	1.029 (0.432)	0.990 (0.518)
Median	1.048 (0.591)	1.234 (1.128)	1.103 (0.495)	1.121 (0.753)
Standard Deviation	0.930 (0.481)	0.942 (0.401)	0.974 (0.537)	0.950 (0.481)

financial decision making, because they did not have the necessary information. It is, of course, possible that the subjects developed a crude sense of the mean and variance from the more specific information cues they selected, however.

The information cues that the subjects chose depended primarily on their confidence in their ability to use those cues to select the highest value lottery. Secondarily, subjects relied on the ability of the information cues to accurately predict value. Their confidence ratings in specific cues varied by the type of security, but their ratings of the predictive validity of the cues did not. This latter result reinforces the notion that subjects believe some cues are better at predicting value regardless of the context, but that their confidence in using them changes according to the context. Risk preferences had very little impact on choice of information cue.

Overconfidence, a long-researched topic in psychology, has become a growing topic of financial interest as well. Most of the finance literature thus far, relying on conclusions from psychology, has been analytical in nature, and based on the assumption that most people are overconfident. This study, however, measures overconfidence by subject for each information cue. Overconfidence is defined as when a subject's confidence in an information cue is greater than his rating of its predictive validity. There have been very few financial studies in which overconfidence is measured, rather than assumed (see, for example, Bloomfield, Libby, and Nelson [2000] and Camerer and Lovallo [1999]).

Psychologists often portray overconfidence as a failure in information processing. Kahneman and Tversky [1973] found that overconfidence is greater when people are dealing with abstract information versus specific and distinct information. Here, the mean payoff, median payoff, and standard deviation of the payoff, which are summary statistics, constitute the more abstract information about a lottery. Other more specific information cues are the cost of the lottery, its highest payoff, and its lowest probability. Our results from statistical tests showed the opposite result from Kahneman and Tversky [1973], perhaps because the abstract information is also more complex in nature.

Griffin and Tversky [1992] concluded that overconfident people tend to focus more on the strength of evidence (the extremes of its outcomes), and not enough on its weight (the probability of its being correct). They found that high strength and low weight led to overconfidence.

In the context of our experiment, the highest and lowest payoffs of the lotteries become the extremes of outcomes, and the highest and lowest probabilities become the weight of the evidence. Subject overconfidence should be higher for the payoff information cues than for the probability cues if subjects focus more on payoffs. But our results indicated the opposite. Thus Griffin and Tversky's [1992] results may be context-sensitive.

The analytical research in finance on overconfidence suggests it can have an enormous impact on how financial markets operate. More studies are needed that focus on how overconfidence in real people manifests itself in market settings. This study suggests that overconfidence may affect which information cues people pay attention to when evaluating investments. And those information cues are least likely to be the mean and variance, upon which basic financial models are founded.

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Notes

1. In one type of replacement decision, subjects could reveal complete information.
2. The differences between confidence and predictive validity in the table may not sum correctly due to the different number of observations for the variables.

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Table 1-A. *Full Information on Administered Lotteries*

Panel A. Bond Information

Lottery	Cost	Probability of First Branch	Payoff of First Branch	Probability of Second Branch	Payoff of Second Branch	Mean	Median	Standard Deviation	Risk Level
1a	$2.65	0.87	$3.10	0.13	$2.30	$3.00	$2.70	$0.27	medium
1b	$2.65	1.00	$3.00	—	—	$3.00	$3.00	$0.00	low
1c	$2.65	0.75	$3.55	0.25	$2.00	$3.01	$2.68	$0.58	high
2a	$2.70	0.73	$3.45	0.27	$1.95	$3.05	$2.70	$1.95	high
2b	$2.70	1.00	$3.05	—	—	$3.05	$3.05	$0.00	low
2c	$2.70	0.86	$3.20	0.14	$2.25	$3.05	$2.72	$0.33	medium
3a	$2.75	0.85	$3.25	0.15	$2.35	$3.12	$2.80	$0.43	medium
3b	$2.75	0.74	$3.45	0.26	$2.05	$3.09	$2.75	$0.61	high
3c	$2.75	1.00	$3.10	—	—	$3.10	$3.10	$0.00	low
4a	$2.50	1.00	$2.85	—	—	$2.85	$2.85	$0.00	low
4b	$2.50	0.89	$2.95	0.11	$2.25	$2.87	$2.60	$0.22	medium
4c	$2.50	0.70	$3.25	0.30	$1.90	$2.85	$2.58	$0.62	high
5a	$2.95	0.85	$3.45	0.15	$2.40	$3.30	$2.92	$0.14	medium
5b	$2.95	1.00	$3.30	—	—	$3.30	$3.30	$0.00	low
5c	$2.95	0.75	$3.70	0.25	$2.10	$3.30	$2.90	$0.48	high
6a	$2.40	0.70	$3.05	0.30	$1.85	$2.69	$2.45	$0.30	high
6b	$2.40	0.80	$2.85	0.20	$2.00	$2.68	$2.42	$0.12	medium
6c	$2.40	1.00	$2.70	—	—	$2.70	$2.70	$0.00	low
7a	$2.85	1.00	$2.85	—	—	$3.15	$3.15	$0.00	low
7b	$2.85	0.60	$3.90	0.40	$2.00	$3.14	$2.95	$0.98	high
7c	$2.85	0.70	$3.45	0.30	$2.50	$3.17	$2.98	$0.19	medium
8a	$2.40	0.95	$2.90	0.05	$2.05	$2.86	$2.48	$0.19	medium
8b	$2.40	0.80	$3.10	0.20	$1.90	$2.86	$2.50	$0.48	high
8c	$2.40	1.00	$2.85	—	—	$2.85	$2.85	$0.00	low
9a	$2.90	0.70	$3.70	0.30	$2.25	$3.27	$2.98	$0.66	high
9b	$2.90	0.85	$3.40	0.15	$2.45	$3.26	$2.92	$0.34	medium
9c	$2.90	1.00	$3.25	—	—	$3.25	$3.25	$0.00	low
10a	$2.40	1.00	$2.75	—	—	$2.75	$2.75	$0.00	low
10b	$2.40	0.90	$2.85	0.10	$2.00	$2.77	$2.42	$0.26	medium
10c	$2.40	0.75	$3.05	0.25	$1.85	$2.75	$2.45	$0.52	high
11a	$2.65	0.75	$3.35	0.25	$2.00	$3.01	$2.68	$0.58	high
11b	$2.65	1.00	$3.00	—	—	$3.00	$3.00	$0.00	low
11c	$2.65	0.87	$3.10	0.13	$2.30	$3.00	$2.70	$0.27	medium
12a	$2.50	0.89	$2.95	0.11	$2.25	$2.87	$2.60	$0.22	medium
12b	$2.50	0.70	$3.25	0.30	$1.90	$2.85	$2.58	$0.62	high
12c	$2.50	1.00	$2.85	—	—	$2.85	$2.85	$0.00	low
13a	$2.40	1.00	$2.70	—	—	$2.70	$2.70	$0.00	low
13b	$2.40	0.80	$2.85	0.20	$2.00	$2.68	$2.42	$0.12	medium
13c	$2.40	0.70	$3.05	0.30	$1.85	$2.69	$2.45	$0.30	high
14a	$2.85	0.70	$3.45	0.30	$2.50	$3.17	$2.98	$0.19	medium
14b	$2.85	1.00	$3.15	—	—	$3.15	$3.15	$0.00	low
14c	$2.85	0.60	$3.90	0.40	$2.00	$3.14	$2.95	$0.98	high
15a	$2.40	0.90	$2.85	0.10	$2.00	$2.70	$2.42	$0.26	medium
15b	$2.40	0.75	$3.05	0.25	$1.85	$2.75	$2.45	$0.52	high
15c	$2.40	1.00	$2.75	—	—	$2.75	$2.75	$0.00	low

Panel B. Stock Information

Lottery	Cost	Probability of First Branch	Payoff of First Branch	Probability of Second Branch	Payoff of Second Branch	Probability of Third Branch	Payoff of Third Branch	Mean	Median	Standard Deviation	Risk Level
1a	$2.35	0.52	$2.35	0.41	$4.50	0.07	$0.70	$3.14	$2.35	$1.23	medium
1b	$2.35	0.60	$3.30	0.40	$2.95	—	—	$3.16	$3.12	$0.17	low
1c	$2.35	0.51	$2.60	0.33	$5.45	0.16	$0.20	$3.16	$2.60	$1.81	high
2a	$2.20	0.55	$3.15	0.45	$2.80	—	—	$2.99	$2.98	$0.17	low
2b	$2.20	0.50	$2.70	0.35	$4.60	0.15	$0.30	$3.01	$2.70	$1.43	high
2c	$2.20	0.50	$2.40	0.45	$3.90	0.05	$0.80	$3.00	$2.40	$0.80	medium
3a	$2.15	0.51	$3.10	0.49	$2.80	—	—	$2.95	$2.95	$0.15	low
3b	$2.15	0.50	$2.35	0.40	$4.25	0.10	$0.85	$2.96	$2.35	$1.14	medium
3c	$2.15	0.52	$2.65	0.32	$4.80	0.16	$0.25	$2.95	$2.65	$1.52	high
4a	$2.10	0.52	$2.35	0.40	$4.05	0.08	$0.80	$2.91	$2.35	$1.02	medium
4b	$2.10	0.50	$2.70	0.33	$4.60	0.17	$0.20	$2.90	$2.70	$1.49	high
4c	$2.10	0.60	$3.00	0.40	$2.75	—	—	$2.90	$2.88	$0.12	low
5a	$2.25	0.55	$2.50	0.25	$6.30	0.20	$0.25	$3.00	$2.50	$2.09	high
5b	$2.25	0.65	$3.10	0.35	$2.80	—	—	$3.00	$2.95	$0.14	low
5c	$2.25	0.55	$2.40	0.35	$4.60	0.10	$0.75	$3.01	$2.40	$1.27	medium
6a	$1.95	0.80	$3.20	0.20	$2.15	—	—	$2.99	$2.68	$0.42	low
6b	$1.95	0.50	$2.25	0.35	$5.30	0.15	$0.15	$3.00	$2.25	$1.83	high
6c	$1.95	0.55	$2.10	0.40	$4.55	0.05	$0.60	$3.01	$2.10	$1.30	medium
7a	$2.05	0.90	$3.05	0.10	$2.60	—	—	$3.01	$2.85	$0.14	low
7b	$2.05	0.55	$2.20	0.35	$4.90	0.10	$0.70	$3.00	$2.20	$1.46	medium
7c	$2.05	0.45	$2.35	0.30	$6.25	0.25	$0.30	$3.01	$2.35	$2.28	high
8a	$2.40	0.45	$2.90	0.30	$5.45	0.25	$0.20	$2.99	$2.90	$1.92	high
8b	$2.40	0.50	$2.75	0.35	$4.35	0.15	$0.65	$3.00	$2.75	$1.22	medium
8c	$2.40	0.60	$3.15	0.40	$2.80	—	—	$3.01	$2.78	$0.17	low
9a	$2.20	0.65	$3.00	0.30	$3.50	0.05	$0.40	$3.02	$3.00	$0.74	medium
9b	$2.20	0.60	$3.20	0.25	$4.25	0.15	$0.15	$3.01	$3.20	$1.28	high
9c	$2.20	0.65	$3.20	0.35	$2.60	—	—	$2.99	$2.90	$0.29	low
10a	$1.90	0.65	$3.20	0.35	$2.40	—	—	$3.00	$2.80	$0.35	low
10b	$1.90	0.55	$2.45	0.25	$6.15	0.20	$0.60	$3.01	$2.45	$1.95	high
10c	$1.90	0.50	$2.30	0.40	$4.40	0.10	$0.85	$3.00	$2.30	$1.22	medium
11a	$2.20	0.50	$2.40	0.45	$3.90	0.05	$0.80	$3.00	$2.40	$0.80	medium
11b	$2.20	0.55	$3.15	0.45	$2.80	—	—	$2.99	$2.98	$0.17	low
11c	$2.20	0.50	$2.70	0.35	$4.60	0.15	$0.30	$3.01	$2.70	$1.43	high
12a	$2.25	0.63	$3.10	0.35	$2.80	—	—	$3.00	$2.95	$0.14	low
12b	$2.25	0.55	$2.40	0.35	$4.60	0.10	$0.75	$3.01	$2.40	$1.27	medium
12c	$2.25	0.55	$2.50	0.25	$6.30	0.20	$0.25	$3.00	$2.50	$2.09	high
13a	$2.40	0.50	$2.75	0.35	$4.35	0.15	$0.65	$3.00	$2.75	$1.22	medium
13b	$2.40	0.45	$2.90	0.30	$5.45	0.25	$0.20	$2.99	$2.90	$1.92	high
13c	$2.40	0.60	$3.15	0.40	$2.80	—	—	$3.01	$2.98	$0.17	low
14a	$2.35	0.60	$3.30	0.40	$2.95	—	—	$3.16	$3.12	$0.17	low
14b	$2.35	0.51	$2.35	0.42	$4.50	0.07	$0.70	$3.14	$2.35	$1.23	medium
14c	$2.35	0.51	$2.60	0.33	$5.45	0.16	$0.20	$3.16	$2.60	$1.81	high
15a	$2.20	0.65	$3.00	0.30	$3.50	0.05	$0.40	$3.02	$3.00	$0.74	medium
15b	$2.20	0.65	$3.20	0.35	$2.60	—	—	$2.99	$2.90	$0.29	low
15c	$2.20	0.60	$3.20	0.25	$4.25	0.15	$0.15	$3.01	$3.20	$1.95	high

Panel C. Options Information

Lottery	Cost	Probability of First Branch	Payoff of First Branch	Probability of Second Branch	Payoff of Second Branch	Probability of Third Branch	Payoff of Third Branch	Mean	Median	Standard Deviation	Risk Level
1a	$1.65	0.45	$0.00	0.40	$6.90	0.15	$1.65	$3.01	$1.65	$3.23	low
1b	$1.65	0.55	$0.00	0.30	$9.15	0.15	$1.65	$2.99	$1.65	$4.07	medium
1c	$1.65	0.70	$0.00	0.20	$14.15	0.10	$1.65	$3.00	$1.65	$5.60	high
2a	$1.70	0.45	$0.00	0.40	$6.75	0.15	$1.70	$2.96	$1.70	$3.15	low
2b	$1.70	0.68	$0.00	0.20	$13.75	0.12	$1.70	$2.95	$1.70	$5.43	high
2c	$1.70	0.55	$0.00	0.30	$9.00	0.15	$1.70	$2.96	$1.70	$3.98	medium
3a	$1.75	0.43	$0.00	0.25	$7.10	0.12	$1.75	$3.19	$1.75	$3.32	low
3b	$1.75	0.55	$0.00	0.35	$8.65	0.10	$1.75	$3.20	$1.75	$4.03	medium
3c	$1.75	0.65	$0.00	0.25	$12.10	0.10	$1.75	$3.20	$1.75	$5.16	high
4a	$1.80	0.70	$0.00	0.20	$13.35	0.10	$1.80	$2.85	$1.80	$5.28	high
4b	$1.80	0.53	$0.00	0.35	$7.55	0.12	$1.80	$2.86	$1.80	$3.49	medium
4c	$1.80	0.45	$0.00	0.40	$6.45	0.15	$1.80	$2.85	$1.80	$3.00	low
5a	$1.50	0.58	$0.00	0.32	$8.90	0.10	$1.50	$3.00	$1.50	$4.07	medium
5b	$1.50	0.68	$0.00	0.24	$12.00	0.08	$1.50	$3.00	$1.50	$5.07	high
5c	$1.50	0.48	$0.00	0.40	$7.05	0.12	$1.50	$3.00	$1.50	$3.34	low
6a	$1.15	0.45	$0.00	0.43	$6.25	0.12	$1.15	$3.00	$1.15	$3.19	low
6b	$1.15	0.55	$0.00	0.30	$9.45	0.15	$1.15	$3.01	$1.15	$4.23	high
6c	$1.15	0.50	$0.00	0.40	$7.20	0.10	$1.15	$3.00	$1.15	$3.45	medium
7a	$1.40	0.50	$0.00	0.30	$9.05	0.20	$1.40	$3.00	$1.40	$4.02	medium
7b	$1.40	0.45	$0.00	0.35	$7.75	0.20	$1.40	$2.99	$1.40	$3.53	low
7c	$1.40	0.65	$0.00	0.20	$13.95	0.15	$1.40	$3.00	$1.40	$5.50	high
8a	$3.00	0.50	$0.00	0.35	$7.30	0.15	$3.00	$3.01	$3.00	$3.31	low
8b	$3.00	0.60	$0.00	0.30	$9.00	0.10	$3.00	$3.00	$3.00	$4.02	medium
8c	$3.00	0.70	$0.00	0.25	$11.40	0.05	$3.00	$3.00	$3.00	$4.89	high
9a	$0.85	0.55	$0.00	0.25	$11.30	0.20	$0.85	$3.00	$0.85	$4.81	high
9b	$0.85	0.40	$0.00	0.35	$7.95	0.25	$0.85	$3.00	$0.85	$3.65	low
9c	$0.85	0.50	$0.00	0.30	$9.45	0.20	$0.85	$3.01	$0.85	$4.23	medium
10a	$1.00	0.45	$0.00	0.30	$8.00	0.25	$1.00	$3.00	$1.00	$3.69	low
10b	$1.00	0.65	$0.00	0.25	$11.60	0.10	$1.00	$3.00	$1.00	$4.94	high
10c	$1.00	0.55	$0.00	0.30	$9.50	0.15	$1.00	$3.00	$1.00	$4.27	medium
11a	$1.80	0.45	$0.00	0.40	$6.45	0.15	$1.80	$2.85	$1.80	$3.00	low
11b	$1.80	0.53	$0.00	0.35	$7.77	0.12	$1.80	$2.86	$1.80	$3.49	medium
11c	$1.80	0.70	$0.00	0.20	$13.35	0.10	$1.80	$2.85	$1.80	$5.28	high
12a	$1.65	0.70	$0.00	0.20	$14.15	0.10	$1.65	$3.00	$1.65	$5.60	high
12b	$1.65	0.55	$0.00	0.30	$9.15	0.15	$1.65	$2.99	$1.65	$4.07	medium
12c	$1.65	0.45	$0.00	0.40	$6.90	0.15	$1.65	$3.01	$1.65	$3.25	low
13a	$1.15	0.45	$0.00	0.43	$6.65	0.12	$1.15	$3.00	$1.15	$3.19	low
13b	$1.15	0.50	$0.00	0.40	$7.20	0.10	$1.15	$3.00	$1.15	$3.45	medium
13c	$1.15	0.55	$0.00	0.30	$9.45	0.15	$1.15	$3.01	$1.15	$4.23	high
14a	$1.00	0.55	$0.00	0.30	$9.50	0.15	$1.00	$3.00	$1.00	$4.27	medium
14b	$1.00	0.65	$0.00	0.25	$11.60	0.10	$1.00	$3.00	$1.00	$4.94	high
14c	$1.00	0.45	$0.00	0.35	$8.00	0.20	$1.00	$3.00	$1.00	$3.69	low
15a	$1.50	0.58	$0.00	0.32	$8.90	0.10	$1.50	$3.00	$1.50	$4.07	medium
15b	$1.50	0.68	$0.00	0.24	$12.00	0.08	$1.50	$3.00	$1.50	$5.07	high
15c	$1.50	0.48	$0.00	0.40	$7.05	0.12	$1.50	$3.00	$1.50	$3.34	low

Appendix
Instructions to Subjects

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WELCOME TO THE DECISION MAKING EXPERIMENTS

****

Instructions for the experiment are on the computer screen. Use the PgUp and PgDn keys to read the entire set of instructions.

I. INTRODUCTION TO LOTTERIES

The experiment will use lotteries. A lottery describes the outcome of a decision and gives the probability of each outcome. See the lottery below:

```
   p = 0.20
+--------------- $500
|  p = 0.80
+--------------- $100
```

This lottery shows two outcomes:

1. A 20% probability of winning $500.
2. An 80% probability of winning $100.

NOTE: The sum of the probabilities always equals 100%.

Another example of a lottery is:

```
          p = 0.50
        +--------------- $0
        |  p = 0.30
        +--------------- $10
$40---|  p = 0.15
        +--------------- $50
        |  p = 0.05
        +--------------- $100
```

This lottery has a cost to play, $40, and has four outcomes:

1. A 50% probability of winning nothing (or a net loss of $40).
2. A 30% probability of winning $10 (or a net loss of $30).
3. A 15% probability of winning $50 (or a net gain of $10).
4. A 5% probability of winning $100 (or a net gain of $60).

II. LOTTERIES IN THE EXPERIMENT

In this experiment, you will not see lotteries as previously shown. You will instead see blank lotteries, and you will be given a list of items of information that will "fill in" the lotteries. For example:

```
   +---------------
   |
   +---------------
---|
   +---------------
   |
   +---------------
```

You will be allowed to ask for three items of information on the lotteries on each screen. We will explain this information in a few minutes. To have an item of information revealed, type the number associated with the item where the computer screen cursor is flashing, and then press Enter. The computer will ask if you are sure before it reveals the information. Type y and press Enter if you are sure, or type n and press Enter if you made a mistake. You can then make another selection.

You will repeat this process of typing in the item of information you want, confirming you typed the correct number, and seeing the revealed information until you are not allowed to reveal any more information. The computer keeps count of how many more items of information you may see and displays that number at all times.

By choosing one item of information at a time, you should be able to reveal the items of information you want. You will not be able to completely reveal the lottery before you are required to make a decision about which lottery you would like to have resolved. More about choosing a lottery is on the next screen.

To choose a lottery to resolve, type the lottery number in the position where the cursor is flashing. The computer will ask if you are sure of your choice. If you are, type y and press Enter. If you made a mistake, type n and press Enter. If you typed n, you will be able to make a new choice. At this point, all the information that was still hidden on the lotteries is revealed. This allows you to see everything before you begin to ask for information on the next set of lotteries.

III. LOTTERY RESOLUTION AND PAYMENT

Now that you know what lotteries look like and what is expected of you (the items of information will be explained shortly), we will now show you how you will be paid for your decisions.

Several important points must be stressed about your payments:

1. You will receive a participation fee of $4 regardless of any outcomes in the experiment.
2. You will be given $5 to use for the cost of any lottery you choose. You may decide on each

screen whether to keep this $5 instead of choosing a lottery that pays you.

3. If you choose any lotteries, only a few of the lotteries will be resolved for payment to you. Because the computer-selected lotteries are all resolved simultaneously, the $5 balance is sufficient to cover any costs you may incur.
4. The resolutions of the lotteries will occur AFTER you have completed the entire experiment.

If you choose a lottery, your payment will be calculated as described in the next few screens. A random probability (between 1% and 100%) will be given by the computer. The computer will compare the random probability to the cumulative probability (added probabilities) in your chosen lottery to determine which branch of your lottery will be paid to you.

You will be paid your participation fee of $4 plus your $5 balance. Your gains or losses from resolving your chosen lotteries will be netted against the $5 balance.

Let's look at an example. Suppose the full information from three lotteries on a screen is shown below:

```
      p =  0.45                   p = 0.55                    p =  0.65
   +---------------  $0        +---------------  $0        +---------------  $0
$1-- I   p = 0.25         $1--I  p = 0.35           $1-- I    p = 0.30
   +---------------  $30       +---------------  $50       +---------------  $80
   I   p = 0.30                I  p = 0.10                 I   p = 0.05
   +---------------  $65       +---------------  $100      +---------------  $150
```

Depending on which of the three lotteries you chose to be resolved, if any, and depending on which random probability was generated, your payment will differ. In the next few screens, we will display each of the above lotteries in sequence to show you how your payment would differ.

If you had chosen the first lottery, the computer would look at the probabilities as follows:

```
                          Cumulative Probability      Payoff Numbers
      p =  0.45                 p = 0.45                  1 - 45
   +---------------  $0
$1-- I   p = 0.25               p = 0.70                  46 - 70
   +---------------  $30
   I   p = 0.30                 p = 1.00                  71 - 100
   +---------------  $65
```

If the randomly generated probability were between:

1 and 45, you would lose $1 ($0 - $1 cost) from your $5 balance.

46 and 70, you would add $29 ($30 - $1 cost) to your $5 balance.

71 and 100, you would add $64 ($65 - $1 cost) to your $5 balance.

NOTE: As you will see in the next two screens, your payoff may differ even when the randomly generated probability is the same.

If you had chosen the second lottery, the computer would look at the probabilities as follows:

```
                          Cumulative Probability      Payoff Numbers
      p =  0.55                 p = 0.55                  1 - 55
   +---------------  $0
$1-- I   p = 0.35               p = 0.90                  56 - 90
   +---------------  $50
   I   p = 0.10                 p = 1.00                  91 - 100
   +---------------  $100
```

If the randomly generated probability were between:

1 and 55, you would lose $1 ($0 - $1 cost) from your $5 balance.

56 and 90, you would add $49 ($50 - $1 cost) to your $5 balance.

91 and 100, you would add $99 ($100 - $1 cost) to your $5 balance.

Using the PgUp key, you will see that if the randomly generated probability was 92% and you had selected the first lottery, you would be paid $64. But if you had selected the second lottery, you would be paid $99.

BE SURE TO SELECT YOUR LOTTERY CAREFULLY. YOUR PAYMENT DEPENDS ON IT!

If you had chosen the third lottery, the computer would look at the probabilities as follows:

```
                          Cumulative Probability      Payoff Numbers
      p =  0.65                 p = 0.65                  1 - 65
   +---------------  $0
$1-- I   p = 0.30               p = 0.95                  66 - 95
   +---------------  $80
   I   p = 0.05                 p = 1.00                  96 - 100
   +---------------  $150
```

If the randomly generated probability were between:

1 and 65, you would lose $1 ($0 - $1 cost) from your $5 balance.

66 and 95, you would add $79 ($80 - $1 cost) to your $5 balance.

96 and 100, you would add $149 ($150 - $1 cost) to your $5 balance.

If you decide not to choose any of the three lotteries, you will keep your $5 balance. No money will be added to or subtracted from the balance. At the end of the experiment, you will be paid your $4 participation fee plus your $5 balance net any gains or losses from the outcomes of your decisions. In no case can you earn less than $4.

A payment screen will appear at the end of the experiment. It will show your participation fee of $4 plus the amount netted against your $5 balance. To get your total payment, you will have to make a calculation. Examples are shown on the next few screens.

An example of the payment screen is shown below:

Participation fee	$ 4.00
Total payoff from probability trees	$80.00
	$84.00

Your payment is actually $4 plus zero or the sum of $80 and your $5 balance, whichever is larger.

In this case, $80 + $5 is larger than $0, so you would be paid $89: $4 + ($80 + $5) = $89.

A second example of how to calculate your payment is shown below:

Participation fee	$ 4.00
Total payoff from probability trees	-$10.00
	$ 4.00

Your actual payoff is $4 plus zero or the sum of -$10 plus your $5 balance, whichever is greater. Since zero is greater than -$5 ($5 - $10), your payment is calculated as follows:

$4 + $0 = $4

If you made no choices from the lotteries the computer selected to resolve, your payment screen may look like this:

Participation fee	$ 4.00
Total payoff from probability trees	$ 0.00
	$ 4.00

Your actual payoff is $4 plus zero or the sum of $5 and zero, whichever is larger. Since $5 plus $0 is greater than $0, your payment is calculated as follows:

$4 + ($5 + $0) = $9

If you do not understand how your payment is calculated based on your decisions, please ask a monitor to help you now.

IV. ITEMS OF INFORMATION

Now that you have some understanding of how the lotteries work and how you are to be paid based upon your decisions, we will define each item of information available to you. There is no need to memorize the information because it is always available during the experiment by pressing the F1 key. The computer will remind you how to retrieve this information whenever you need it.

Although you need not memorize the information, it is very important that you understand what each item of information is providing you. The following lottery will be used in order to define the information items.

```
             p = 0.45
          +--------------  $0
   $1 --|    p = 0.25
          +--------------  $30
          |    p = 0.30
          +--------------  $65
```

Remember, this lottery is an example and not necessarily like the lotteries you will see in the experiment.

1. COST—Cost of participating in the lottery, $1 in the example.
2. HIGHEST PROBABILITY PAYOFF—PAYOFF associated with the highest probability branch in the lottery. The top branch has the highest probability in the example. The payoff associated with this branch is $0, which would be revealed to you.
3. LOWEST PROBABILITY PAYOFF—PAYOFF associated with the lowest probability branch in the lottery. The middle branch has the lowest probability in the example. The payoff associated with this branch is $30, which would be revealed to you.
4. HIGHEST PROBABILITY—Highest PROBABILITY on the lottery. Since p = 0.45 is the highest probability, it would be revealed.
5. LOWEST PROBABILITY—Lowest PROBABILITY on the lottery. Since p = 0.25 is the lowest probability, it would be revealed.
6. HIGHEST PAYOFF—Highest PAYOFF on the lottery. In the example, $65 would be revealed.
7. LOWEST PAYOFF—Lowest PAYOFF on the lottery. In the example, $0 would be revealed.
8. MEAN PAYOFF—If the lottery were resolved many times, on average the mean PAYOFF would be paid out. This figure is calculated. In the example lottery, the mean payoff is calculated as:

   ($0) (0.45) + ($30) (0.25) + ($65) (0.30) = $27

   If the example lottery were resolved many times, $27 on average would be paid in each trial.
9. MEDIAN PAYOFF—The middle PAYOFF if there is an odd number of payoffs, or the simple average of the two middle payoffs if there is an even number of payoffs. Since the example lot-

tery has an odd number of payoffs, the median payoff is the middle one, \$30.

10. STANDARD DEVIATION OF THE PAYOFF—A dollar measure of how much the actual PAYOFF may vary from the payoff expected from many resolutions of the lottery. This figure is also calculated. For the example, it is calculated as:

$$(\$0 - \$27)(\$0 - \$27)(0.45) + (\$30 - \$27)(\$30 - \$27)(0.25)+(\$65 - \$27)(\$65 - \$27)(0.30) = 763.50$$

Square root of 763.50 = \$27.63, the standard deviation. In other words, the actual payoff may easily vary from the expected payoff of \$27 (the mean) by \$27.63.

The first seven items of information (called cues in the experiment) will be displayed ON the blank lottery. The last three (the mean payoff, the median payoff, and the standard deviation of the payoff) will be displayed BELOW the lottery because these three items are calculated; that is, they do not have a place ON the lottery.

If you do not understand any item of information available to you, please ask the monitor to help you.

SUMMARY

1. You will be shown a series of three blank lotteries on the computer screen. You must reveal three items of information on the three lotteries. To reveal an item, type the item number where the cursor is flashing, press Enter, and confirm your choice.
2. When you have revealed three items of information, you must make a choice: (a) resolve for payment lottery 1, 2, or 3, or (b) keep your \$5 balance by not choosing a lottery for payment. In the second case, you will choose lottery 0 (zero). To make your selection, type the appropriate lottery number where the cursor is flashing, press Enter, and confirm your choice.
3. After your lottery choice is made, all the information on each lottery is revealed to you. Press the space bar to continue to the next screen.
4. Use the numbers along the top of the keyboard to enter your choices. The number pad on the right-hand side should not be used.
5. When you have completed ALL the decisions, SOME of the lotteries you chose, if you chose any, will be resolved. The computer will randomly choose the lotteries to resolve and will provide the random probabilities to calculate your payment.
6. There will be a practice session for you to test your understanding of the instructions. If after the practice session you feel you don't understand what to do, please ask a monitor for help. No money will be at stake in the practice session.
7. Work at your own pace. When you are done, follow the instructions: remove the diskette, turn off the computer, and bring your diskette to the monitor. You will be given a survey to answer. When you are done with the survey, you will receive your money.

Once you have left one screen to enter another, you cannot return to the first screen. Blank lotteries have been provided for you to use in any way you wish, if at all. These are not part of the experiment and will not be checked in any way. In addition, you have a typed copy of the instructions to review if necessary.

To end the tutorial and to enter the practice session, press the ESC key. If you want to review the instructions, use the PgUp and PgDn keys.

THANK YOU FOR YOUR PARTICIPATION

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